Nano-Power Africa

2 Year Project Implementation Plan

August, 2010

Higher Education for Development Program

United States Agency for International Development

Collaborative Project Between:

The University of Cincinnati
Oak Ridge National Laboratory
Argonne National Laboratory
Eclipse Film Technologies

The University of Cape Town, South Africa
Haramaya University, Ethiopia
Kigali Institute of Technology, Rwanda

http://www.eng.uc.edu/~gbeaucag/NanoPowerAfrica.html

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August 24, 2010

Table of Contents for the Implementation Plan

Appendices

From African soil excellence is possible
Excellence is to be preserved

Graça Machel
Chancellor University of Cape Town
Commencement Speech December 14, 2009

Section 1
Ten-Year Vision and Overview

The Nano-Power Africa Project (NPA) seeks to create self-sustainable, technical and scientific MS and PhD programs in sub-Saharan Africa through a research effort that develops low-cost, indigenously produced photovoltaic devices based on nanomaterials that can be manufactured in the challenging business environments of sub-Saharan Africa. The project is based on a two-hub model with the University of Cincinnati and the University of Cape Town serving as U.S. and African coordinators. NPA will initiate graduate degree granting and entrepreneurial centers at second-generation campuses, initially at Haramaya University in Ethiopia and Kigali Institute of Technology in Rwanda. Future campuses will be selected in a competitive process based on contacts with local USAID missions, technical criteria and on the potential for participating in entrepreneurial activities. Low cost solar panel production startup facilities can be developed from the photovoltaic technology. The project will collaborate with U.S. based NGO's such as Solar Light for Africa, that currently import solar panels from the U.S. and China for use in African villages. The project plans to develop interactions with African business development experts from UCLA's Anderson School of Management who will participate in annual workshops with technical and education experts. Anderson may also provide other educational content and consulting.

Nano-power Africa (NPA) will strengthen the capacity of African higher education institutions in science and technology and increase the engagement of U.S. higher education and government research labs in Africa. NPA seeks to make Africa a "*destination*" for science and engineering researchers. The project will develop a new entrepreneurial model for MS and PhD Science and Engineering education that will produce local opportunities and long-term funding for self-sufficient academic programs that act as catalysts for economic development aimed at local markets. The success of this program promises to present a new paradigm for financial and academic success for young scientists and engineers when considering career paths in Africa.

The partnership will achieve these goals through a focused project aimed at the scientific and technological development of inexpensive and indigenously produced solar cells on flexible substrates for use in isolated and impoverished regions of sub-Saharan Africa where off-grid power is a vital need. These devices will produce sufficient electricity to provide energy for lighting, heating, cooking, recharging electronic devices and refrigeration at a cost that can be supported by local economic situations. Nanomaterials lie at the center of new solar technology, and a fundamental understanding of the relationship between nanostructure and electronic properties is a focus of the research arm of NPA. The project will leverage knowledge gained in African research towards solving technical problems in the application of nanomaterials to provide off-grid power at a low cost using technologies that will be implemented in the African host countries. Scientists and engineers will be trained to take advantage of their knowledge to develop entrepreneurial endeavors in their home countries.

NPA will use a *two-hub model* taking advantage of expertise and ties to second-generation universities at the University of Cape Town (UCT) and leveraging expertise and the U.S. based research and corporate network at the University of Cincinnati (UC). Faculty at UCT, in close collaboration with UC faculty, will train faculty to build independent and self-sustaining academic programs through curriculum development, net-based teaching, entrepreneurial training and exposure to cutting-edge scientific research aimed at providing viable energy sources for off-grid power in Africa. Faculty at UCT and UC, as well as researchers at U.S. national laboratories and from U.S. industry will assist young faculty and potential faculty in developing a scientific basis for growth of their educational and entrepreneurial programs. NPA will initially work with two partners in Ethiopia and Rwanda, and select further second generation campuses through a competitive proposal process based on interaction with local USAID missions and scientific and entrepreneurial potential as determined by the Advisory Board and the Executive Council made up of the 3 PI's and the national lab and industrial representatives. The African education programs at the second-generation universities will become self-sustaining as the centers mature and develop capabilities to engineer and market the results of their scientific research.

NPA will build on the strength of the South African economic and scientific infrastructure as a model for sustainable growth of higher education in other African countries. In the US, the University of Cincinnati will serve as a hub to link program participants with unique research facilities at the University as well as at Argonne National Laboratory and Oak Ridge National Laboratory that are both within driving distance of Cincinnati. The project involves a partnership with a Cincinnati based plastic-film processing company for the development of reel-to-reel technology for solar cell production as well as with two Cincinnati-based pigment companies one of which manufactures conducting inks for solar and other devices, while the other is interested in magnetic nanoparticles for other technical applications. We are currently negotiating funding from the Air Force Office of Scientific Research (AFOSR) for research aspects of the project involving printed electronics and we have a proposal pending with the National Science Foundation through the *Materials World Network* program for scientific research into the electrical nature of nano-scale aggregates that are important to development of photovoltaic devices and other low-cost electronic devices. Both of these projects will complement the NPA project. We are also involved in discussions with P&G and ExxonMobil concerning collaboration in the project. The project will leverage an existing market for solar panels in Africa driven by several NGO's including Solar Light for Africa who may be the first customers for African solar panels. A representative of SLA will be on the Advisory Board for NPA helping to ensure that research targets the correct market. The project will also seek to involve the Anderson School of Management at UCLA in presenting a workshop on the development of startup companies in sub-Saharan Africa at the annual NPA workshop. Further interaction with the UCLA group is expected, especially in Ethiopia, where both HED projects have a presence. The NPA project parallels interests of USAID in South Africa in development of higher education and has strong overlap with USAID interests in the development of small businesses for local and export markets. We plan to pursue direct collaboration with the USAID mission in South Africa, Rwanda and Ethiopia as the business development aspects of the project unfold. Cathy Moore, Deputy Mission Director of USAID for Southern Africa has agreed to serve on the Advisory Board.

The goals of NPA are parallel and complementary to the goals of its stakeholders. The USAID mission in Southern Africa has as some of its primary directives economic development and education. NPA offers a unique complementary combination of education and development that offers to raise the level of both higher education and the economic production while contributing to a resolution to the energy problem and improving the standard of living. NPA also parallels both the strategic goals of the South African National Development Strategy as well as the targeted goals of the University of Cape Town. Energy production is one of the two greatest hurdles to development in South Africa. The development of nanotechnology to provide local solutions to the energy crisis in NPA is in keeping with the development plans of the Republic of South Africa. The University of Cape Town has a long-term goal to be the hub of Higher Education in a increasingly unified continental Africa. The hub and second-generation university approach of this project is aligned with this goal and the University of Cape Town's long term plans. The University of Cincinnati's long-term goals are also parallel with the goals of NPA including the development of energy as an education and research center of excellence, and continued enhancement of interactions with national laboratories and corporations. The corporate associates in the NPA project have generally narrower focus goals pertaining to the technological and commercial developments of the project. Participation of these corporations follows their targeted areas of commercial interest. Federal funding agencies such as the U.S. Air Force and the U.S. National Science Foundation are interested in developing international interactions that can lead to the advancement of science and technology, which are consistent with the goals of this project. Both NSF and AFOSR have programs that involve international research interactions in Africa. The Millennium Development Goals of the World Bank include environmental sustainability and sustainable development as well as creating a global partnership for development. The NPA project offers a complementary approach to alleviating some of the issues involved in the Millennium Development goals through sustainable development of higher education and small business aimed at local markets.

The project will be coordinated and operated by the Board of Directors composed of the three PI's and the main contributors to project functions. The project will be monitored and assessed primarily by an Advisory Board. The Advisory Board has high-ranking representatives from the two hub universities as well as administrative representatives of the major stakeholders: USAID; Oak Ridge National Laboratory; Argonne National Laboratory; corporate sponsors and NGO's. The advisory board members reflect the main sectors that the project will impact: 1) Higher education; 2) Scientific and technical research and development; 3) Entrepreneurial economic growth (private sector capacity building and sustainable growth); 4) Ecological sustainability and renewable energy; and 5) Quality of life in sub-Saharan Africa. The project will prepare quarterly progress reports as well as an Annual Report that will be assessed by the Board when it convenes for the Annual Meeting and Workshop. The quarterly and annual reports will include quantification of progress in terms of publications and degrees granted as well as current enrollment and progress towards the entrepreneurial goals. NPA will keep careful track of program graduates in order to assess the retention of program participants in sub-Saharan Africa and their career success. The Annual Report will assess the cost effectiveness of the program activities.

> *We recognize the value of encouraging original thinking by talented minds to confront known problems, with a view not only to solving these problems, but also to establishing viable enterprises on the strength of the solutions, thus creating jobs for a skilled workforce.*
>
> Derek Hanekom
> Deputy Minister of Science & Technology Republic of South Africa
> November 2009 Innovation and Entrepreneurship Conference

Section 2
An Overview of the Partnership

Figure 2.1. *Partnership members meeting at University of Cape Town, December 2009. Top to bottom Left to Right Girma Goro Gonfa KIT, Schadrack Nsengiyumva HU, Emmanuel Jonas UCT/Nigeria, Jan Ilavsky, ANL, Greg Smith ORNL, David Britton UCT, Margit Härting UCT, Greg Beaucage UC.*

2.1 Project Partners

The Nano-Power Africa Project is a partnership between the University of Cincinnati (UC) and the University of Cape Town (UCT). Cincinnati brings working relationships with two National Laboratories, Oak Ridge (ORNL) and Argonne (ANL) National Laboratories and a number of commercial collaborators with interest in photovoltaic's and printed electronics, Eclipse Film Technologies, Sun Chemicals and Collins Ink. Cape Town serves as the African hub with strong links to many universities in sub-Saharan Africa. The project will select second-generation universities for participation based on a competitive proposal process judged by the second-generation candidate's contact with local USAID missions, and their scientific and entrepreneurial potential as judged by the Advisory Board and by the Board of Directors. In the initial stages of this project Haramaya University in Ethiopia, and the Kigali Institute of Education (KIE) in Rwanda will be the participating second-generation universities. UCT also has close ties with the National Centre for Nanostructured Materials (NCNSM) in Pretoria that is mandated to support R&D capacity in South Africa. The partners for the first five years of the project are listed below. Curricula Vitae for the partners are given in Appendix A.

List of Project Partners

Board of Directors

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The proposed partnership offers several unique advantages:

1) A partnership between the University of Cincinnati and the University of Cape Town is ideal for the proposed work because a nascent collaborative relationship already exists between the two universities with several papers already in preparation dealing with production of silicon based photovoltaic cells and characterization of nanomaterials using advanced technologies at U.S. national user facilities. Beaucage served as external examiner for a Nigerian masters student under Britton and Härting, Emmanuel Ohieku Jonah. Emmanuel is now a PhD candidate and plans to teach in his native Nigeria on completion of his degree at Cape Town.

2) Since 2003 UCT has maintained its position as the highest ranked South African and African university in the Academic Ranking of World Universities (ARWU) conducted annually by the Institute of Higher Education at Shanghai Jiao Tong University. In every year since 2007 UCT has been the only African university to make it into the top 200 of the Times Higher Education Supplement (THES) World University Rankings conducted each year by the London-based newspaper The Times Higher Education Supplement and study-abroad specialists Quacquarelli Symonds. UCT is one of only four universities from the developing world in the list of top 200 universities.

The University of Cape Town is one of the most highly regarded institutions of higher learning in Africa and serves as a center for training as well as research for all of Africa. The use of such a center allows a small investment in this partnership to have a great impact across a wide spectrum of locations in Africa. As the junior scientists, currently based at the center, return to their home institutions in countries such as Rwanda, Ethiopia and Nigeria, they will take with them not only research experience and expertise, but also valuable networks. They will in turn serve as mentors and role models to the next generation of students. Furthermore, taking advantage of this center will allow resources and work to be distributed in the most efficient fashion allowing centralization of the essential technical aspects of the project as well as direct access to dispersion of the technology and field-testing at universities in other countries.

3) Prof. Beaucage at the University of Cincinnati has a broad range of industrial and national laboratory contacts who can be used in the project to open exposure of African researchers to centralized user facilities in the U.S. including facilities at Argonne National Laboratories in Chicago, at Oak Ridge National Laboratories in Oak Ridge, TN, both of which are about 4 hours by car from Cincinnati, and at the Air Force Research Laboratory in Dayton, OH, about 40 minutes from Cincinnati.

Beaucage has expertise in developing internationally recognized web-based courses. The College of Engineering at the University of Cincinnati has initiated a program and Center for Excellence in Energy Engineering that will emphasize solar and other alternative technologies. Prof. Beaucage as a member of this new program and will be developing related curricula that will be added to his suite of web-based courses.

4) The proposed work will focus on the development of both fundamental physics and materials science research aimed at simulation and modeling of nanoparticles as well as targeting development of a practical system with commercial development of an African solar cell for low cost and robust local solar power devices for heating, cooking and lighting uses. The project seeks to improve on an existing technology with high solar conversion efficiency through technical and scientific study and targeted development for uses in sub-Saharan Africa.

5) The project seeks to leverage expertise in modeling and printing of nanostructured materials at UCT, expertise in characterization and synthesis of nanostructures at Cincinnati, and expertise in processing at Eclipse Film Technology with regional needs for localized generation of electricity, local resources that highlight the advantage of solar power, local and global industrial support, and closer interactions with developed centers for scientific advancement in the U.S.

6) NPA will collaborate with existing NGOs, such as Solar Light for Africa (SLA), operating in Rwanda, Ethiopia and several other Sub-Sahara African countries for the installation of solar power in remote locations that do not currently have access to electric power. SLA's experience with off-grid power installation in Africa will be used to guide the research and development efforts. SLA's director, Carol Hathaway, will be a member of the Advisory Board for the project.

1) Qualifications of Partners:

a) Prof. Gregory Beaucage, University of Cincinnati

Prof. Beaucage works in the synthesis of nano-materials using flame synthesis in the production of catalysts and other materials. He is an expert in the characterization of nanomaterials using x-ray and neutron scattering and is a frequent user of synchrotron facilities in the U.S. and in Europe as well as neutron scattering facilities. He is on the external advisory board for the Intense Pulse Neutron Source at Argonne National Laboratories and has been past Chair of the Small Angle Scattering Group for the American Crystallographic Association. Beaucage has written over 110 peer reviewed publications and a number of book chapters. He is a Fellow of the American Physical Society. Beaucage has strong contacts both in industry as well as at national laboratories that will be used in the partnership to build a three-leg program based on scientific exchange and interaction with national user facilities in the US; interaction with industrial partners for the implementation of technologies developed from the partnership and academic research and educational resource dissemination between the U.S. and Africa.

Beaucage has extensively developed web-based courses that are widely used by faculty and students throughout the world with over 215,000 independent IP hits on his course web pages since 2000 (more than 70 new hits per day). Beaucage's suite of web courses includes 12 courses ranging from *Morphology of Complex Materials* to a course on *X-ray Scattering* (http://www.eng.uc.edu/~gbeaucag/BeaucageResearchGroup.html). Beaucage's experience in web based curriculum development will be used in the project to develop web based collaborative courses between universities in Africa and UC.

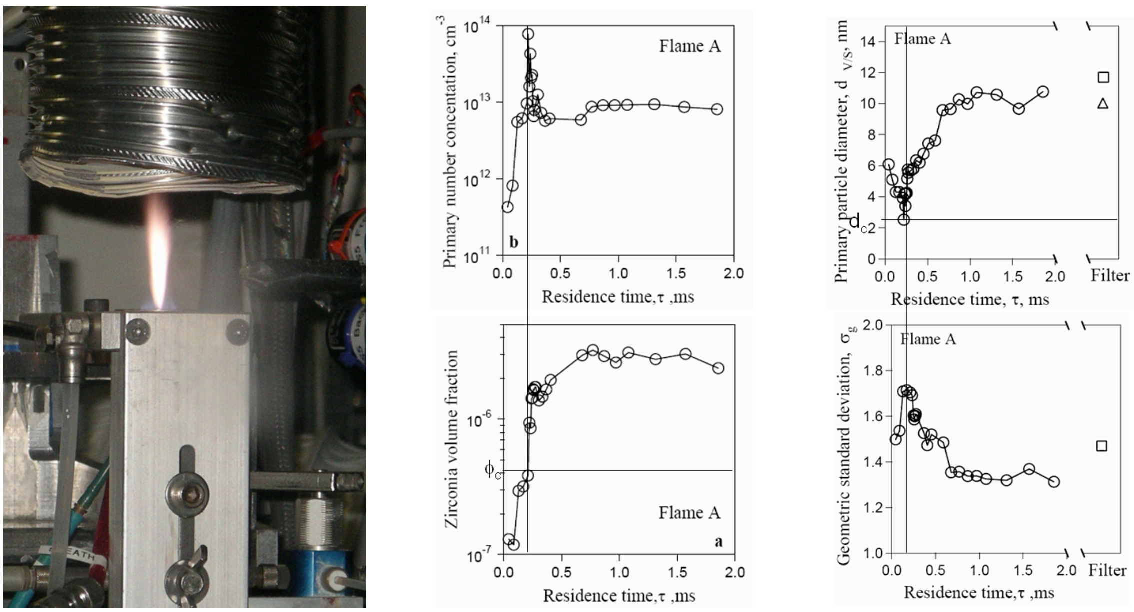


Figure 2.2. *Titania spray flame and plots of number density, volume fraction, Sauter mean diameter and geometric standard deviation. At a critical volume fraction ϕ_c, the number density peaks (log scale) particle size reaches a minimum and polydispersity reaches a maximum* [*Nano-material growth dynamics in jet flames.* Jossen R, Beaucage G, Heine MJ, Pratsinis SE *Adv. Mat.* submitted (2010).].

Beaucage is an expert at the synthesis of nanoparticles using flame synthesis. He has studied the production of titania in several flame geometries, for example, Figure 2.2 shows a spray flame synthesis of carbon coated titania nanoparticles of 10 nm Sauter mean diameter. Beaucage pioneered the technique of in situ measurement of particle size, size distribution and mass-fractal structure using synchrotron x-rays in flames [*Probing the dynamics of nanoparticle growth in a flame using synchrotron radiation.* Beaucage G, Kammler HK, Mueller R, Strobel R, Agashe N, Pratsinis SE, and Narayanan T *Nature Mater.* **3,** 370-373 (2004).]. In this method a 2d map of the flame cross section can be made using particle size as contrast or other structural parameters such as mass fractal dimension, number density and the like, Figure 2.3. From this information a detailed mapping of particle growth in flames can be generated enabling control over particle synthesis. In figure 2 it is seen that a nucleation event occurs where nanoparticles form in a burst of particle growth after initial liquid droplets evaporate in the spray flame. Through these mappings close to complete control over particle size distribution, state of mass fractal aggregation, branch content and aggregate density can be made. For example, these parameters control the conductivity of titania in a Grätzel Cell.

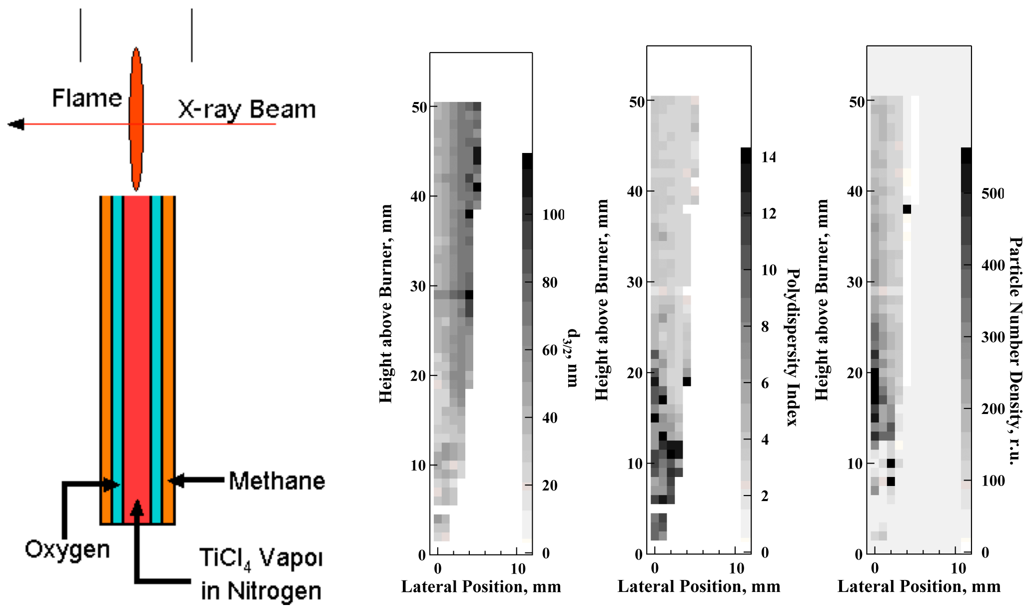


Figure 2.3. *Schematic of $TiCl_4$ diffusion flame and 2D maps of Sauter mean diameter, particle size polydispersity, and particle number density. The diffusion flame displays a combustion front away from the centerline (lateral position = 0). Higher flame temperatures lead to larger particles with lower polydispersity and lower particle number density.*

In addition to morphological control, control over the oxidation state of the flame can lead to the production of a carbon coating on titania nanoparticles, Figure 4. Through selective doping of this graphitic coating with copper, ruthenium and other metals via incorporation of metal 2-ethylhexanoate salts in the spray flame solution in a reducing flame modification of the

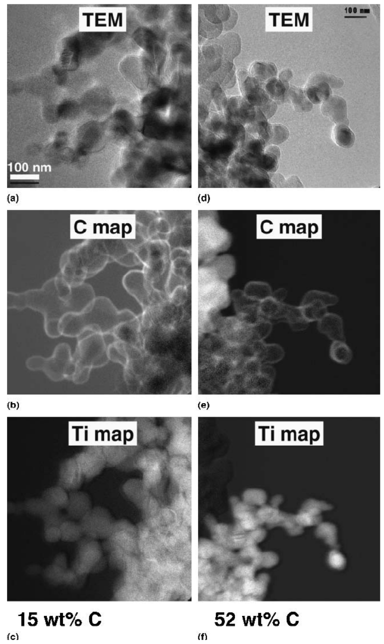
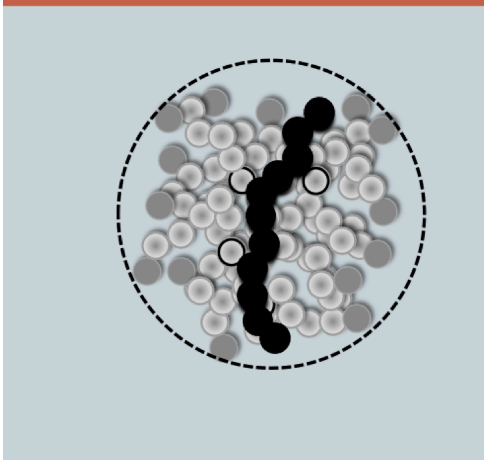


Figure 2.4. *Carbon coated titania nanoparticles produced in a diffusion flame by Kammler and Pratsinis (collaborators of Beaucage)* [*Carbon-coated titania nanostructured particles: Continuous, one-step flame-synthesis* Kammler HK and Pratsinis SE, *J. Mater. Res.* **18** 2670-76 (2003)].

graphitic conduction band can be made to match the band gap of titania similar to the prophorin/ruthenium dye used in the conventional Grätzel cell. Such a technical innovation could lead to a one-step process for the manufacture of inexpensive solar cells requiring only a syringe pump, spray aspirator and inexpensive precursor solutions, tin oxide coated plastic sheet, a platinum coated cathode and iodide electrolyte gel. There is no theoretical limit to the size of these inexpensive DSC devices.

The project will also involve development of analytic techniques involving national user facilities in the U.S. at Argonne National Laboratories and at Oak Ridge National Laboratories using small angle scattering of which Beaucage is a world expert. Beaucage has developed scattering methods for the characterization of nano-structured aggregates and particulates that are widely used (more than 500 combined citations on his scattering function work).

Silicon cluster



Extracted Parameters	
Fractal Dimension	2.64
Degree of Aggregation	47,600
Primary Particle Diameter	43 Å
Aggregate Diameter	368 Å
Minimum Dimension	1.14
Connectivity dimension	2.32
Number of branches	13,200
Branch fraction	0.998
Meandering fraction	0.733
Branches in minimum path	27
Number per branch	3.6

Figure 2.5. *Results of USAX analysis using University of Cincinnati instrument and printed silicon electronics from the group of Britton and Härting (2010).*

b) Prof. David Britton, University of Cape Town

Prof. Britton has worked in the development of nanoparticle printing for the production of a variety of devices and sensors including solar cells produced using nanoscale silicon. He has recently been active in modeling and simulating conductivity pathways through aggregates of nanoparticulate semiconductors. Britton is an expert at positron annihilation and has assisted in the development of the first African positron source as well as the first Arab positron source. Britton and his colleague at UCT, Prof. Margit Härting, have developed nanomilling methods for silicon, and in collaboration with a South research laboratory, a technology using hot wire CVD to produce uniform nanoscale silicon particles.

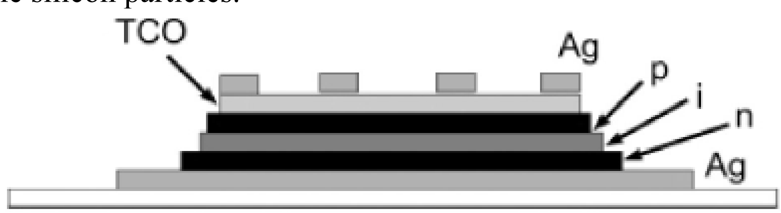
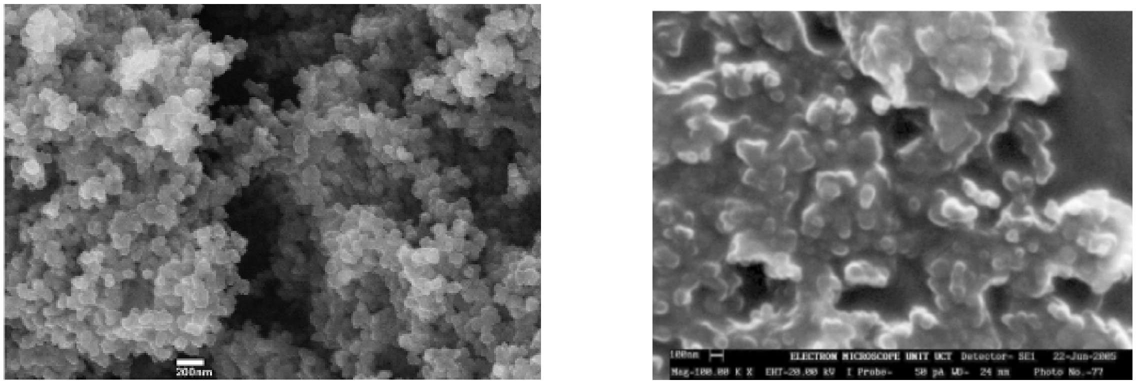


Figure 2.6. *Printing technology using silicon nanoparticles for a solar cell. Schematic diagram of a sample printed silicon device, using nanoparticulate silicon inks. A NIP photodiode structure is shown with the silver bottom contact, N-, I-, P-type silicon layers, the printed transparent semiconducting layer (TCO), and the painted front silver collecting grid.*

The UCT team has been active in the production of silicon-based solar cells using nano-particulate silicon in a printing technology, Figure 2.6. This technology has some similarities to the Grätzel Cell in that it uses nano-particulate aggregates of n, p and intrinsic silicon (p, n, i) in polymer binders for printing on flexible substrates such as paper or plastic. Figure 2.6 shows the construction of a solar cell using screen-printing technology and the p, i and n type silicon nanoparticles. The disadvantage of these nano-particulate silicon devices is that the efficiency is extremely low so far. Development continues in these devices partly aimed at understanding the conduction pathways and methods to manipulate the fractal structure of aggregated silicon nano-particles using small-angle scattering. This work can be enhanced through interaction with U.S. national user facilities and with Beaucage.



(a) (b)

Figure 2.7. *(a) a-Si:H nanoparticles as produced in a Hot-wire CVD process developed by Britton. (b) Nanoparticles as applied in ink jet printing process for the solar cell of Figure 5.* [*Hot-wire synthesis of Si nanoparticles* Scriba MR, Arendse C, Härting M, Britton DT, *Thin Solid Films* **516** 844-846 (2008).]

The partnership will develop courses based on aspects of expertise of the participating members. These courses will be disseminated by the world-wide web and by joint course offerings between the institutions. This includes training courses initiated at the partner universities and short courses delivered by the National laboratories and industrial partners. The flexibility of web based courses with local and team involvement will add a dimension to elective courses at the participating institutions. Moreover, the courses will be open to use on the WWW so that a wide range of institutions can access these educational tools. The PI's course web page averages more than 70 independent IP hits per day from users throughout the world.

2) Commitment of Partners:

Beaucage and Britton have already collaborated on a project involving the use of small-angle x-ray scattering to understand the structure and especially the conductive pathway of nanoscale aggregates. Beaucage served as external examiner for a masters student under Britton and Härting, Emmanuel Ohieku Jonah. Several joint papers are in preparation from this collaboration. Britton is involved with training of African faculty from other universities including Ethiopia, Nigeria and Rwanda.

The University of Cincinnati has provided significant cost share for the project including the support of a graduate student during the project. Not included in this cost share are costs provided by UCT for a graduate student associated with the project and other facilities and research support. Both universities are committed to projects aimed at enhancing international interactions among faculty and students.

2.2 The Problem Model.

The partnership will address the development of cheap and robust solar power cells for use in primitive conditions in Africa. The solar cells will be developed by Africans in collaboration with U.S. researchers and the goal is to develop African capacity for the production of inexpensive solar cells by coupling research results to capital investment by US, African and European corporations such as those directly involved in the project. The partnership will have a fundamental science base with the goal of utilizing U.S. based national user facilities such as those at Oak Ridge National Laboratory and Argonne National Laboratory for training of a new generation of African researchers able to apply fundamental scientific knowledge to African society with the potential to develop indigenous technical industries. Solar energy production offers a unique opportunity in this regard since it is of vital importance to many in Africa, since Africa offers many of the best environments for application of solar technology and because the delocalized nature of solar power generation has enormous advantages to poor countries with little infrastructure for electrical power distribution. Local power generation is expected to particularly enhance life for women in Africa since solar power could be used to replace traditional fuels for cooking and to provide electricity for lighting at night to extent the possible hours of education and reading. An economically viable, robust solar cell could alleviate environmental pressure leading to deforestation for fuel wood among other problems. The technical details of the problem model are described in Section 4.

South Africa has yet to mobilise innovation effectively in support of economic growth across the board. This absence of a culture of innovation is a major weakness in our system, and a serious impediment to our economic growth. This problem is highlighted by the inadequate links between the local market for medium to high-technology products and services, on the one hand, and local research, on the other. Inevitably, this leads to the extensive importation of technology and intellectual property, resulting in a skewed technology balance of payments.

Derek Hanekom
Deputy Minister of Science & Technology Republic of South Africa
September 2009
Advanced Manufacturing Technology Strategy (AMTS) Annual Symposium.

Section 3
Strategic Goals of the Center

During the planning stage we have made a needs assessment for success of science and technology based higher education in sub-Saharan Africa following the model proposed for Nano-power Africa. This needs assessment was conducted through two meetings of the Board of Directors in Cape Town in early December, 2009 and in Cincinnati and Oak Ridge in late February 2010. Participants in the planning meetings included the three PI's, representatives of Oak Ridge National Laboratory, Argonne National Laboratory and Eclipse Film Technologies. The meetings also included representatives from Haramaya University in Ethiopia and the Kigali Institute of Education in Rwanda as well as a Nigerian doctoral candidate from UCT who plans to pursue a career in higher education in Nigeria.

The Board discussed plans with Carol Hathaway and Emily Ridgeway from Solar Light for Africa, an NGO that installs solar panels in Tanzania, Rwanda and several other sub-Saharan countries. The Board met with Cathy Moore, Deputy Mission Director for USAID Office for Southern Africa and discussed potential synergy between USAID efforts and the project. Discussions were made with potential corporate participants, with the U.S. Air Force Office of Scientific Research (African Materials Initiative) where we have a pending white paper and with personnel at the Materials Research Directorate at Wright Patterson Air Force Base in Ohio. The Deputy Minster of Science and Technology of South Africa, Derek Hannekom held a meeting with the Board of Directors to discuss the relationship between this project and the goals of the South African Government. The PI's have also been in contact with the U.S. National Science Foundation (NSF) and the South African National Research Foundation (NRF) in discussion of a pending proposal under the Materials World Network program. The Board of Directors held a meeting with Manfred Scriba in December, a senior researcher at the National Centre for Nanostructured Materials (NCNSM) within the Council for Scientific and Industrial Research (CSIR) in Johannesburg.

Meetings were also made between second-generation university faculty and their administrations as well as with USAID Missions in Rwanda and in Ethiopia. In Rwanda the project was discussed with Molly Brostrom who spearheads educational issues at the Mission. In Ethiopia a meeting was held between Girma Goro Gonfa from Haramaya University and Dr. Kevin Smith, Supervisory Program Officer for USAID in Ethiopia. Input from all participants was considered in formulation of the Strategic Goals with the UCT PI's taking the lead role in formulation of the project and the U.S. partner acting as facilitator and offering an assessment of the project plans as well as putting together the final strategic plan.

The Nano-power Africa Project will address strategic goals aimed at enabling the project vision presented in Section 1 of this strategic plan. The goals will be used to formulate the 5-year work plan presented in Section 4. The strategic goals of Nano-power Africa are aimed at five main sectors impacted by the project, 1) Higher education; 2) Scientific and technical research and development; 3) Entrepreneurial economic growth (private sector capacity building and sustainable growth); 4) Ecological sustainability and renewable energy; 5) Quality of life in sub-Saharan Africa. The strategic goals are listed with reference to these sectors.

3.1 Strategic Goals

Sector 1: Higher Education

1) Development of the University of Cape Town as a hub for the growth of African education using the entrepreneurial model outlined in the project vision for MS/PhD research programs.

2) Create a strong "pipeline" between the University of Cincinnati and the University of Cape Town for exchange of students, faculty and for technical and scientific interactions and collaborations.

3) Selection of the initial three second-generation universities through a competitive proposal process based on the quality of their contacts with their local USAID mission, local institutional support, and scientific and entrepreneurial potential as judged by the Advisory Board and the Board of Directors.

4) Design and implement a formal program to bring women into MS and PhD programs aimed at entrepreneurial science and technology fields in Africa modeled after the WISE (Women in Science and Engineering) program at the University of Cincinnati.

5) Strengthen the initial three second-generation universities and develop similar regional hubs for further expansion of the entrepreneurial model to higher education.

6) Develop improved teaching and learning facilities at the second-generation institutions and in Cape Town.

7) Train in 5 years 40 MS students and 18 PhD students as well as 9 post-doctoral students targeting faculty positions in Africa.

8) PhD's for 20 existing faculties at the second-generation universities.

9) Demonstrate retention of high quality MS and PhD graduates in the Higher Education system of Sub-Saharan Africa.

10) Encourage women to become part of the new generation of entrepreneurial research scientists and professors.

11) Incorporate net-based courses in Energy Engineering and Solar Technology from the University of Cincinnati and the University of Cape Town in the curriculum of second generation institutions.

Sector 2: Science and Technology Development in sub-Saharan Africa

12) Make Africa a destination for scientists and engineers through development of international collaborative interactions aimed at entrepreneurial technical development targeting African markets with African technology.

13) Enhance the University of Cape Town's international recognition through visiting scholars and development of long-term institutional relationships with U.S. National Laboratories and the University of Cincinnati.

14) Develop capabilities for grant writing and acquiring funding from industry and governments at the second-generation universities and at UCT.

15) Develop curricula at the second-generation universities to groom undergraduate students for success in masters and PhD programs.

16) Deliver faculty development at the second-generation universities by increasing the number of PhD's and research programs.

17) Development of 3G network for Internet access at the second-generation universities.

18) Development of graduate curricula at the second-generation universities through interaction with the University of Cape Town and the University of Cincinnati. This will involve guest lectures, on-line courses. Internet-based courses at Cincinnati and Cape Town will be designed for use as supplemental curricula. Curricular interactions with Oak Ridge and Argonne National Laboratories will be developed.

19) Development of an administrative infrastructure at the second-generation universities that allows for sustaining equipment and maintenance of a research environment for technical development.

20) Development of workshops at National Laboratories for training of African students and scientists in the fundamentals of nanoscience.

21) Development of a scientific understanding of the relationship between nanostructure and electrical performance of layers of nano-structured materials for use in photovoltaic devices.

22) Encourage women to become part of science and technology development.

Sector 3: The African Entrepreneurial Model

23) Develop an African model for entrepreneurial research with self-sustaining research and development programs aimed at spurring economic growth through African technical advances.

24) Development of self-sustaining entrepreneurial centers at the second-generation institutions.

25) Encourage women to become part of the new generation of entrepreneurial research scientists and professors.

Sector 4: Ecological Sustainability and Renewable Energy

26) Development of technology for the production of solar panels for manufacture and use in sub-Saharan Africa.

Sector 5: Quality of Life in Sub-Saharan Africa

27) Develop synergistic interactions between NPA and existing NGO's targeting installation of solar panels in sub-Saharan Africa.

28) Design of solar technology targeting the needs of women in rural Africa.

In addition to these sector goals Nano-Power Africa also has several long-term goals that are cross sector in character.

10-Year Goals

29) Develop an African system of entrepreneurial research with cash feed backs between startup companies and universities.

30) Generate new hub universities from the original second-generation universities for further integration of African scientific research and entrepreneurial expansion.

31) Demonstrate the inclusion of women in higher education and the new entrepreneurial model.

3.2 Discussion of the Strategic Goals

3.2.1 Goals and Baseline in the Education Sector

Students in higher education institutions in Africa have a right to be taught by experts. Currently this is not the case for the second-generation institutions in this NPA project, Table 3.1. A long-term goal is therefore that all faculty in higher education (university level) should have experience in scientific research demonstrated by their holding a doctorate qualification or the equivalent experience.

Table 3.1. Qualifications (2009) of Faculty of Sciences, Haramaya University, Ethiopia.

Departments/Schools	*Qualification*												*Total*		
	PhD			*MSc/MEd*			*BSc/ BEd*			*Diploma Certificate*					
	M	*F*	*Total*	*M*	*F*	*Total*	*M*	*F*	*Total*	*M*	*F*	*Total*	*M*	*F*	*Total*
College of Natural And Computational Sciences															
Department of Biology	3	0	3	12	2	14	9	2	11	2	0	2	26	4	30
Department of Chemistry	2	0	2	10	0	10	14	1	15	0	1	1	16	2	18
Department of Mathematics	1	0	1	8	0	8	8	0	8	0	0	0	17	0	17
Department of Physics	3	0	3	3	0	3	7	0	7	1	0	1	14	0	14
Department of Sport Sciences	1	0	1	6	0	6	6	0	6	0	0	0	13	0	13
Institute of Technology															
Department Civil Engineering	0	0	0	3	0	3	17	1	18	3	0	3	23	1	24
Department of Electrical Engineering	0	0	0	1	0	1	14	0	14	2	1	3	17	1	18
Agricultural and Biological Engineering	7	0	7	7	2	9	37	3	40	7	1	8	58	8	64

In the immediate to short term, all senior faculty should hold doctorates and all junior faculty masters by research. This is the de facto standard at UCT for example. The Kigali Institute of Education (KIE) is meeting these requirements by a government program to send faculty abroad and through importing foreign contract lecturers. Haramaya University (HU) is currently not meeting these requirements, Table 3.1.

Universities should have the capacity – in terms of infrastructure and skills – to award their own postgraduate degrees. Neither of the second-generation institutions, neither HU nor KIE, have awarded a PhD in the last five years. Girma Goro Gonfa, at Haramaya University, has recently been instrumental in setting up a taught masters program in physics that was launched in October 2009. This is still poorly resourced by international standards, Figure 3.1.

All programs should be relevant to local needs, including national imperatives and strategies, and sensitive to local culture and traditions. We cannot simply import a U.S. or S.A. model and curriculum, which often occurs in third world universities. Similarly all material has to have its focus on the other sector goals of this project. The use of internet based resources and on-line publishing will help in the adaptation of study material.

Figure 3.1 *Physics Lab I, Haramaya University, Ethiopia.*

Faculty at degree awarding institutions should be active in research and their knowledge up-to-date in their field. In the long term they should be contributing actively to this body of knowledge. All degrees awarded should be comparable to international norms – in terms of both outcomes and the learning experience – students need hands-on experience. Graduating students should have the same opportunities as graduates in other part of the world.

Enough fully trained graduates at all levels should be produced to allow sustainable growth in the regional/national education sector. Low attrition should be achieved because of the quality of the experience and opportunities in Science and Technology – not because there are no other job opportunities. Both Rwanda and Ethiopia are rapidly expanding their HE sector (31 public universities in Ethiopia, new institutions like KIE in Rwanda). If the necessary capacity is not found, the bubble will burst.

Secondary and Primary education needs qualified teaches. All science teachers should have a tertiary qualification and have been exposed to real science at some stage of their tertiary education. This does not necessarily mean having performed research or having a post-graduate qualification, but it is essential that during their undergraduate education, these students have the opportunity to use scientific equipment, perform analysis, have access to the popular science literature AND INTERACT WITH PRACTISING SCIENTISTS. In this respect, the KIE model, with dual degree programs in science and science education with (eventually) all faculty holding higher qualifications and active in research, is worth investigating.

3.2.2 Goals and Baseline in the Science and Technology Sector

At present only three universities on the African continent are ranked in the top 500 according to the Academic Ranking of World Universities (http://www.arwu.org). All three of these are in South Africa, with the University of Cape Town being the highest ranked. With a relative point score of 15.75, compared to 100 for the top university, in 2009 UCT achieved a respectable position of 219th best university for research in the world. Using more general criteria, including undergraduate education and other subject areas, the Times Higher Education Supplement rankings placed UCT at 146th in the world. No other African university is ranked in the top 200 according to this list. While the methodologies of both lists are often called into question, it is obvious that there is a clear need to improve the research capacity and international recognition of higher education institutions in sub-Saharan Africa. (In the north of the continent, the University of Cairo, consistently hovers around the 500th position in the ARWU rankings).

A more detailed picture can be obtained through a comparison of the research outputs and doctoral graduations at the different universities. At first sight, such a comparison is equally discouraging. In the five-year period to 2010, neither Haramaya University nor Kigali Institute of Education graduated a single PhD student, whereas the two investigators at the University of Cape Town have produced a total of 6 PhD graduates. Similarly, the University of Cape Town published a total of 6,301 scientific papers listed by the Institute of Scientific Information, compared to 137 by Haramaya University and 7 by the Kigali Institute of Education.

However, these figures do not give a realistic picture of the potential of the scientists at these institutions and others in Africa. Three of the six PhD graduates from the research group at the University of Cape Town are faculty members at Haramaya University and Kigali Institute of Education, and two others are Nigerian citizens. Of the 7 papers published by KIE, five have been published in collaboration with UCT on work related to this project. This story is repeated throughout the continent, with gifted young scientists qualifying abroad, and those who return becoming rapidly frustrated. The limiting factor is not the ability, or even the motivation, of the African scientists, but a lack of opportunity and infrastructural capacity.

An important goal of the Nano-Power Africa initiative is therefore to improve the opportunities for productive, and satisfying, socially and economically relevant research, through a coordinated science-driven project. A key aspect of this will be the procurement of robust, easily manageable, research equipment to enable the development of on-site research programs. These will be complemented with, an all important, access to more advanced state-of-the art techniques at both of the two hubs, and at major international facilities such as the Advanced Photon Source.

Through supportive mentoring, the young scientists based at these institutions will be encouraged to find their place in the international science community through presentation at conferences, workshops, and continued participation in international collaborations. At all times the quality of the research outputs needs to be emphasized, and submission of publications to reputable peer-reviewed journals by the African scientists will be promoted actively. The long-term goal, must be the achievement of ARWU ranking by at least one university in each African country.

3.2.3 Goals and Baseline in the Entrepreneurial Economic Growth Sector

Since the transition to democracy in 1994, South Africa has developed a strong culture of entrepreneurship. However this had mainly occurred in the information technology sectors, because of the shorter lead times and lower resources needed for the innovation phase. Nevertheless, innovation has also been actively supported through government initiatives in other areas of science and technology, particularly the biological and health sciences. In the private sector, the Cape Town region, now referred to as the Silicon Cape, is very active for high technology business development. 5 of the 6 South African technology venture capital funds are based in Cape Town. To the best of our knowledge, similar opportunities do not currently exist in Rwanda and Ethiopia.

In all developing countries, including South Africa, there is a well-documented innovation chasm, which breaks the chain between applied research and product development. In South Africa, in common with other countries such as India and Brazil, there have been many government strategies introduced in various sectors, such as the National Nanotechnology Strategy or the Advanced Manufacturing Technology Strategy to close this gap. In the experience of the Cape Town researchers, such top-down approaches do not work effectively. For innovation, the main problem is not the availability of funds – with the right technology financing can always be found for business development. The missing factors are once again human capacity and the necessary infrastructure. To become entrepreneurial innovators, scientists need to be trained to

- See the potential of their work in the bigger picture
- Consider applications and how the process can be scaled up
- Communicate their work and ideas
- Work in a team
- Sell the idea to investors
- Set-up and manage a team of real people from different cultural, social and economic backgrounds
- Set-up and run a business
- Never give up

None of these skills are intrinsically instinctive, and all can be learned through training courses, on-line material and practical experience. However, it does require a change in attitude from both the academic culture and from many traditional cultures.

Even with the development of a new mind-set, taking a business out of a university requires a supportive environment and infrastructure. In particular both institutional support, in terms of technology-transfer professionals, to handle the mechanistic processes, and clear government legislation are essential prerequisites. However, most of the specific activities, such as patent searching, patent specification handling, finding appropriate partners, writing business plans, making presentation, and negotiating contracts, have to be driven by the entrepreneur. Nano-Power Africa presents an ideal opportunity to develop this skills base through the development and eventual commercialization of an indigenous novel technology for solar power, which is aligned to the needs of the local community.

Encouraging women to be part of this entrepreneurial model for scientific research is of vital importance given the historically low numbers of women involved in the sciences. In many cases in South Africa it has been women who have first broken the traditional mold and developed entrepreneurial enterprises.

3.2.4 Goals and Baseline in the Ecological Sustainability Sector

The goals in the Ecological Sustainability Sector relate specifically to the technology being developed – solar power for small to medium scale installations and off-grid power. Africa has become a continent of contrasts. Africa is the fastest growing mobile phone market in the world. In

Kenya for example, only 200,000 households have grid electricity while there are more than 10 million cell-phone subscribers. Rwanda has recently been in the news for the One Laptop per Child project. The Rwandan government has purchased 100,000 XO laptop computers, but the vast majority of the population lives with no access to grid power so recharging these laptops is already a major issue. Even in areas where grid power is available, such as Addis Ababa in Ethiopia, power is often lost for days at a time. When society is run from cell phones, the loss of grid power leads to mayhem as connectivity fades with battery life. Emmanuel Jonah, a PhD student at UCT, describes nighttime in Lagos Nigeria as the continual din of gas generators trying to power modern life in the absence of a reliable grid. In some parts of Nigeria, and South Africa for that matter, the grid power-line can be overhead but the people below have no access and if they did have access the power is not affordable since it is based on dwindling supplies of fossil fuel.

Locally produced solar and other forms of renewable energy offer a cheap, clean and reliable alternative to grid power with no transmission loss and virtually no greenhouse gas production. The technology for cheap solar power, to a large extent, already exists. Technologies using inexpensive semi-conducting powders that are sprayed on to plastic sheet with an electrolyte can be produced in Africa at a low cost. While these technologies may not have a large market in Europe or the U.S. where cheap grid power subsidized by national infrastructure easily displaces these low cost, environmentally benign alternatives, in Africa the market logistics are completely different. Africa may be the optimal local for introduction of mass produced solar electricity. Widely dispersed rural populations in countries like Ethiopia, Figure 3.2, make grid electrification impossible. Even having power for a few hours a day can have major impacts on deforestation and fire risks and can improve the quality of life. Solar Light for Africa has a story of how one solar powered light bulb, that they installed in a chicken coop, could double the egg productivity for a Tanzanian woman allowing her to expand her farm and climb out of poverty.

The long-term goal for NPA is clearly defined to be production of inexpensive, indigenously produced, reliable solar panels for use in a variety of conditions found in sub-Saharan Africa.

Figure 3.2. *The widely dispersed population in rural Ethiopia makes grid electrification impossible.*

3.2.5 Goals and Baseline in the Quality of Life Sector

Much of what we take as symbols of advanced society involves the use of electrical power. From computers, to cell phones, to the ability to control our indoor environment, to read at night, to keep food fresh are governed by access to grid power. For people with no access to grid power life is difficult and at times dangerous especially for women. The goal of improving the quality of life for sub-Saharan Africans will be met if the goal of an economically viable method to produce solar panels using indigenous production is met.

"However improbable it may sound to the skeptics, Africa will prosper! Whoever we may be, whatever our immediate interest, however much we carry baggage from our past, however much we have been caught by the fashion of cynicism and loss of faith in the capacity of the people, let us say—nothing can stop us now!"

Thabo Mbeki
President of South Africa, 1999-2008
"I am an African" Speech, Cape Town, South Africa May 8, 1996

Section 4
Two-Year Detailed Work Plan Addressing the Strategic Goals

4.1 Business Model

Figure 4.1 shows the business model for the NPA project. The partnership will involve two hubs at the University of Cincinnati and at the University of Cape Town. For the first two years a secretary at UCT will facilitate exchange between the two hubs.

Cincinnati Hub:

Cincinnati will serve as the link to two national laboratories in the U.S.; Oak Ridge National Laboratory in Tennessee and Argonne National Laboratory in Chicago. Two Cincinnati funded post-doctoral students will rotate between Cape Town and the two National Labs. They will initially be based at the two national laboratories to coordinate visits by project participants and to conduct research using the neutron scattering and synchrotron facilities as well as the Nanoscience Centers at the labs. In addition to use of these facilities, the post docs will visit the University of Cincinnati to use x-ray scattering facilities and the reel-to-reel pilot plant operations at Eclipse Film Technologies. In Cincinnati, Eclipse Film Technologies will provide facilities for the development of reel-to-reel polymer film processing development lab for the production of photovoltaic devices. A small-scale film processing machine will be purchased and equipped with flame particle production, coating and other unique processes with the goal of developing simple processes to mass produce photovoltaic devices in Africa. Graduate students, post docs and scientists will spend time at the Eclipse facility under the supervision of Ryan Breese. Personnel at Eclipse will train these researchers in safety of the industrial process. The NPA facility will have a separate key from the Eclipse facilities so as to distinguish between the two endeavors. Eclipse will fund facilities development to house the joint effort. Sun Chemical is also located in Cincinnati and will collaborate with the Cape Town in the development of silicon-based printed electronics. Sun manufactures conducting inks and other inks for production of photovoltaics and printed electronics. Sun will directly fund $100,000 per year of related research in Cape Town. In addition to Sun, Collins Ink in Cincinnati will participate in the project through the joint development of magnetic nanoparticles for magnetic inks to be used in printed electronics. These magnetic inks will be made using flame synthesis technology in the laboratory of Prof. Beaucage. Some of these components and similar synthesis methods will be used in solar cell production so there is a high degree of overlap in the Collins collaboration. Collins will provide in-kind support through staff salaries and materials.

The Nano-power Africa project has a parallel project with the Air Force Office of Scientific Research through the African Materials Initiative, Figure 4.3. A NSF proposal focused on scientific investigation of the relationship between nanoparticle structure and aggregate structure and electrical performance in layered devices such as printed electronics based photovoltaic's is planned for the fall. NPA also plans to develop a large proposal for the Department of Energy pertaining to the structure of aggregates and branched macromolecules as studied using small-angle neutron scattering for the fall. NPA will apply in September for funding from the State of Ohio through Third Frontier Photovoltaics Program with Eclipse Film Technologies to support the development of technologies to produce photovoltaics for the NPA project.

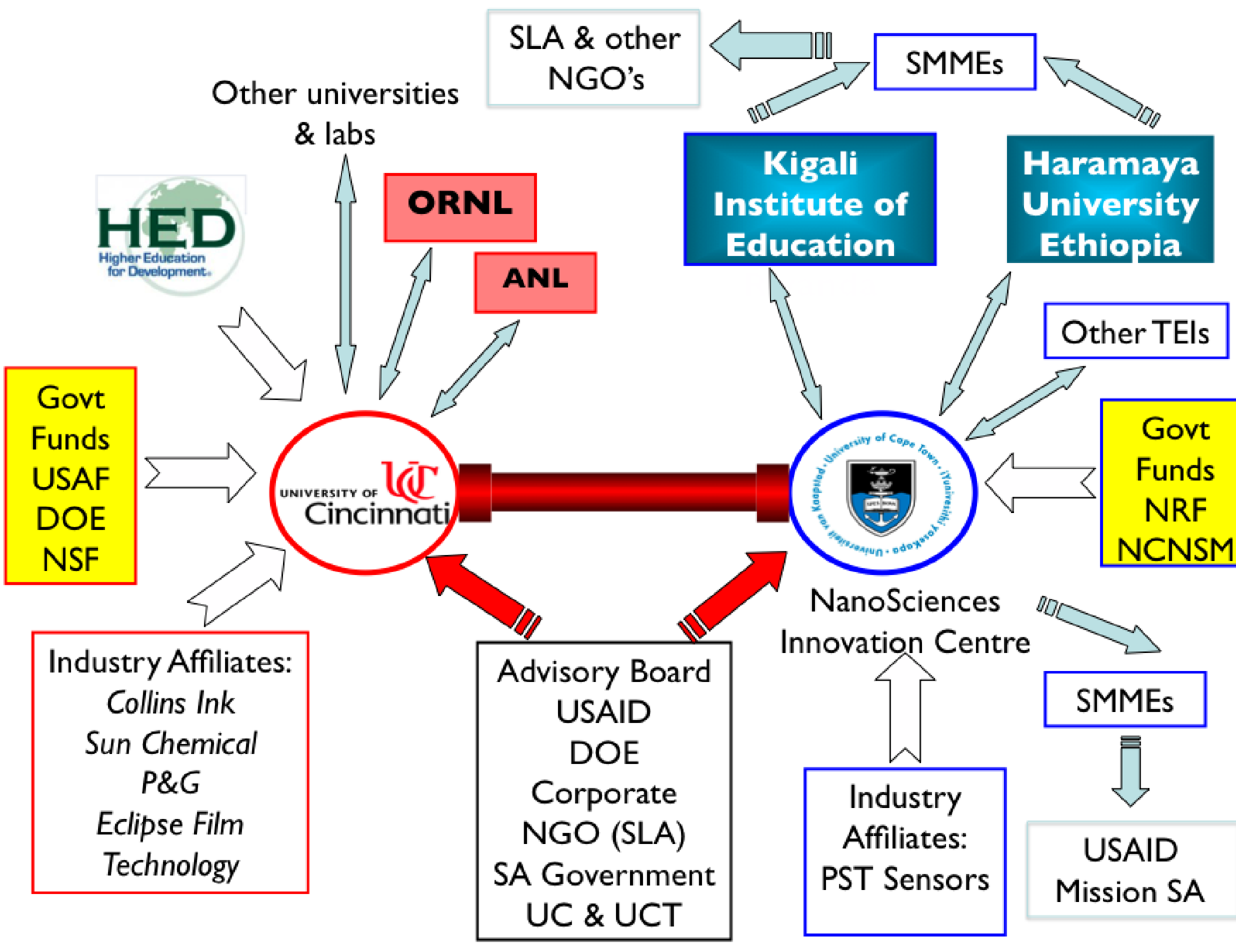


Figure 4.1. *Organizational chart for Nano-power Africa showing the two hub model.*

Cape Town Hub:

The African hub at the University of Cape Town will interact directly with the second-generation institutions. At the initial stages of the project two second-generation institutions, Kigali

Institute of Education and Haramaya University have been selected to work in the project. The main criterion is the direct connection with existing research in the Britton/Härting groups at Cape Town. With this strong basis for collaborative research there will be an initial boost in productivity from these two initial collaborations. However, the project seeks to have a competitive selection process for the second-generation universities so that during the first year of operation for the project a proposal system will be implemented. The initial two universities will compete with other institutions for participation in the NPA program. Participants for the second and following years will be based on institutional and proposed links to their home USAID Mission and compatibility with the strategic goals of the Mission, how well the proposed work technically compliments the two hub universities and the quality of plans for entrepreneurial development at the proposed second-generation university. This open competition will groom the second-generation universities for a competitive research environment.

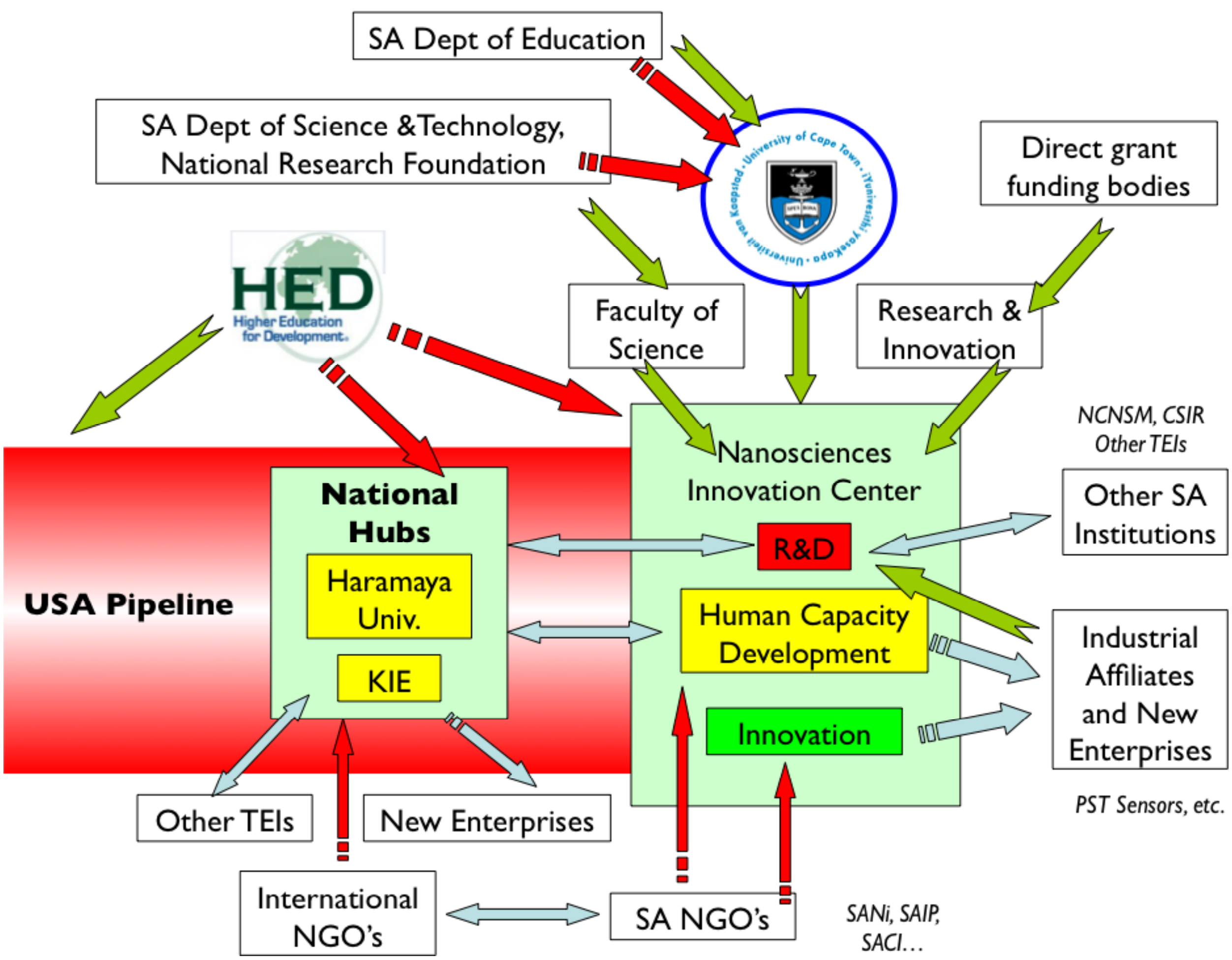


Figure 4.2. *Detail of the South African Hub.*

Figure 4.2 shows an expansion of the Cape Town hub showing the central role of the new Nanosciences Innovation Centre (NIC) that UCT has created partially in response to the Nano-power Africa program. The NIC will house research and development and entrepreneurial investments in nanosciences at UCT. NIC will have a strong link to startup companies such as PST Sensors which is in the process of developing production facilities for printed electronic thermistors based on printed silicon technology for export markets in Asia, North America and Europe. Similar technologies will be used in the development of inexpensive photovoltaic devices at the second-generation universities. The University of Cape Town will fund the Nanosciences Innovation Centre at $50,000 per year while industrial partners and other funding agencies are expected to fund the center at about $150,000 in additional income. These funds can be leveraged with the USAID support to enhance entrepreneurial training and technical development in the Nano-Power Africa project. Britton and Härting will also be funded by the National Research Foundation of South Africa and by other South African government sources for work synergistic to the NPA project as indicated in the budget. Second-generation universities will grow out of this system through interaction with the Cape Town hub.

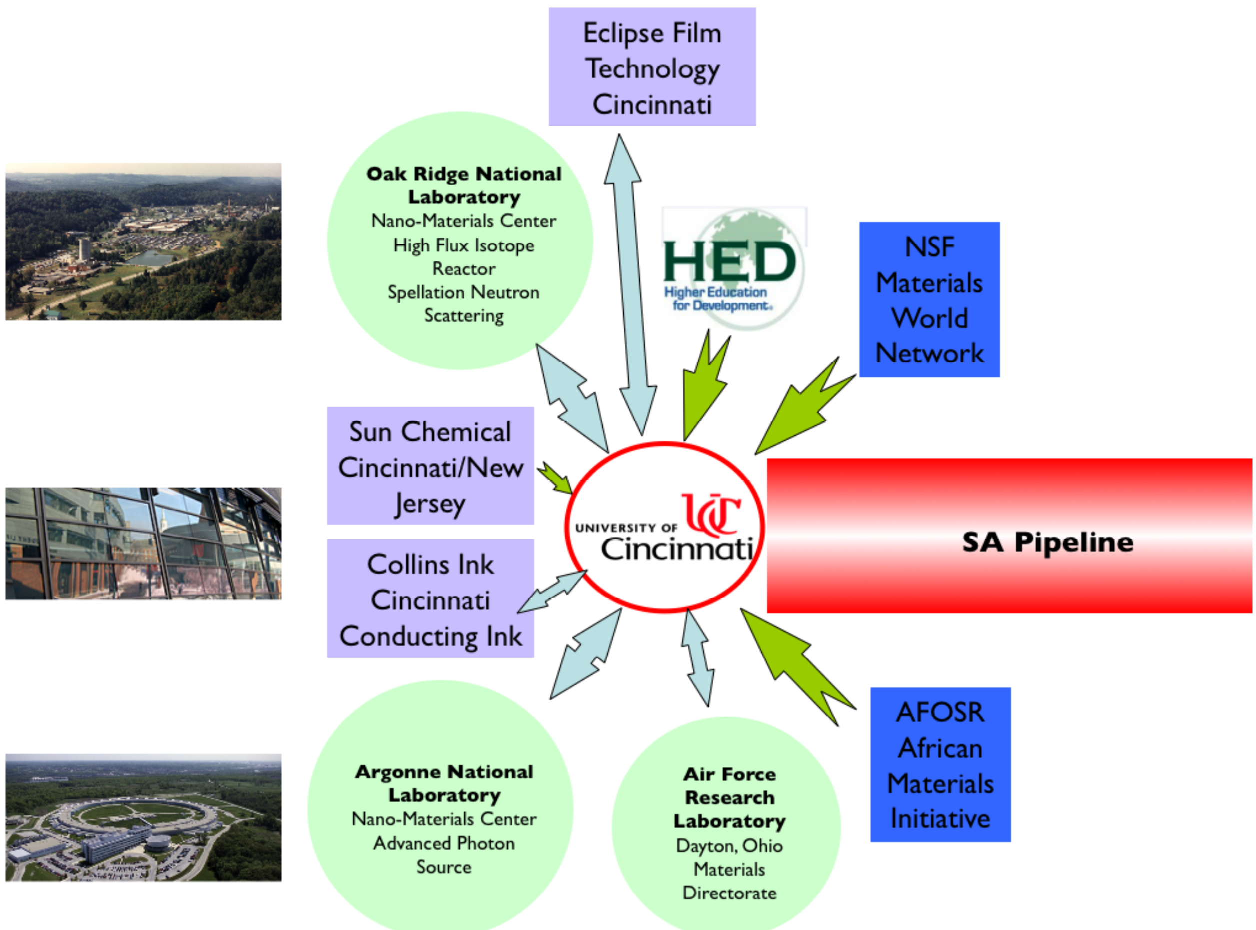


Figure 4.3. *Cincinnati hub for the Nano-power Africa project.*

4.2 Technical Road Map and Personnel

Figure 4.4 shows the Technical Road Map and staffing for the Nano-power Africa project during the first two years. The chart shows cost share funding sources in orange and blue for funding that will support Cincinnati and Cape Town respectively. Cincinnati will have three main technical functions in the project, production of nanoparticle and nanoparticle layers using flame synthesis, characterization and modeling of the structure of nanoparticle aggregates using small-angle scattering and development of reel-to-reel processes for production of photovoltaic devices at

Eclipse Film Technologies. Cape Town will produce screen printed silicon, silicon ink, models for aggregate structure and links between structure and electrical conductivity and technologies for screen printing and incorporation of silicon ink based processes with reel-to reel printing on plastic sheets. The actual process for photovoltaic production may be a hybrid between flame processes and printing processes in a reel-to-reel production operation. Box 1 in Figure 4.4 pertains to production of nanoparticles by flame processes at Cincinnati or by commutation at Cape Town. These particles will be characterized and modeled in box 2. The particles will be used to produce simple layers that can be examined in terms of their electrical performance and structure in boxes 3 and 4. The optimized layers will be used in device manufacture in box 5 based on the technology developed in boxes 1 to 4. Finally devices and technology will be produced for spin-off in box 6. After box 6 entrepreneurial scientists will bring these technologies to the market in their home countries.

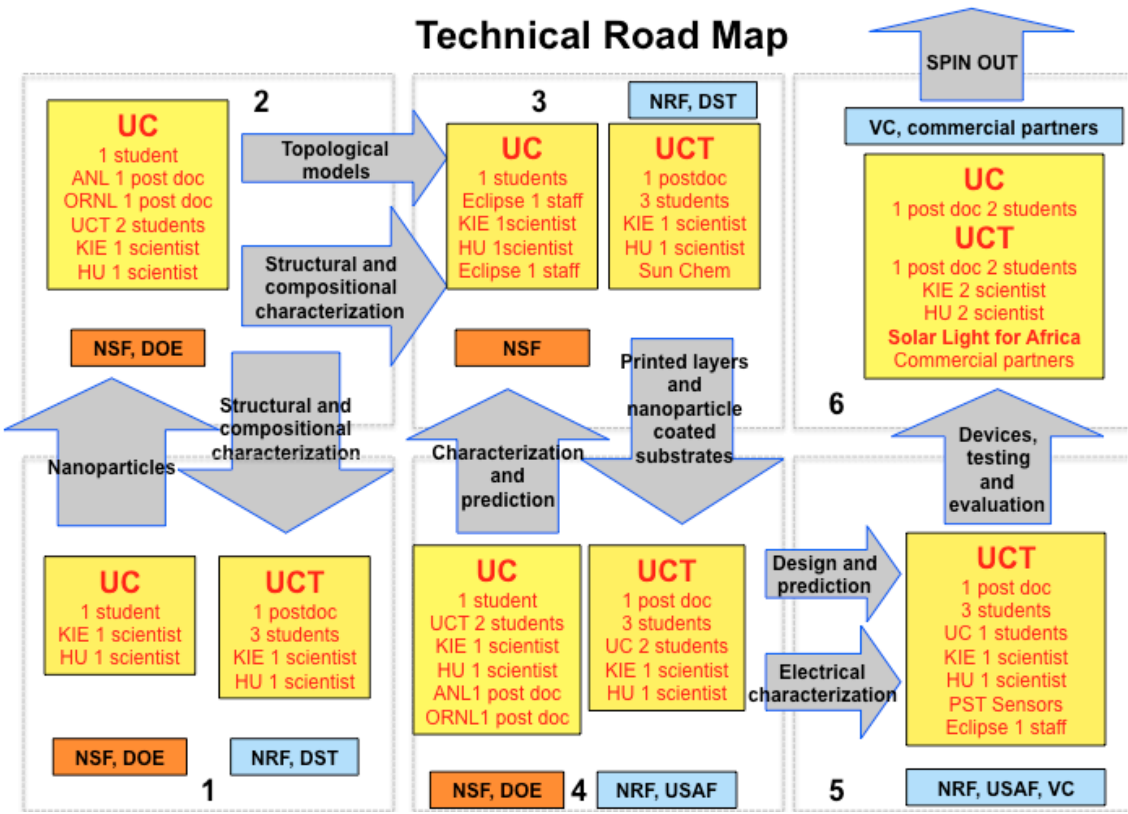


Figure 4.4 *Technical road map and staffing for Nano-Power Africa. Box 1) Nanoparticle production; 2) Nanoparticle characterization and modeling; 3) Production of printed layers and primary prototypes; 4) Characterization of electrical properties of layers; 5) Device manufacture, testing and evaluation; 6) Commercialization and delivery of devices to NGO partners. The first two years will involve Boxes 1-4.*

Table 4.1 lists the personnel involved in the NPA project for the first two years. The PI's will be involved in coordinating the work and managing the two hubs. In the first two years NPA will involve 2 post-doctoral scientists funded through the Cincinnati hub who will be rotated between the National Laboratories and UCT at 6-month intervals. The post-docs will be hired in the U.S. to alleviate problems with hiring quality post-doctoral scientists to work in

Africa. The post-docs will be African nationals with interest in returning to Africa with the intent to stem the tide of African diaspora through enhancement of research opportunities in Africa. The affiliation with UC and the U.S. National Laboratories will also be used to enhance the quality of graduate students at UCT through affiliation with U.S. Universities and National Laboratories for students working for NPA. The second-generation universities will, for the most part be involved in masters level education. The best achieving Masters students will be offered an opportunity to pursue a PhD at either UCT or UC.

Table 4.1. Table of Personnel for First Two Years

Personnel	Location	Time/year (Months)
PI/Beaucage	Cincinnati/UCT	3.23
PI/Britton	UCT	3.38
PI/Härting	UCT	3.38
Post Doc 1	ORNL	6
Post Doc 1	UCT	6
Post Doc 2	UCT	6
Post Doc 2	Argonne	6
Secretary	UCT	12
PhD 1	Cincinnati	12
PhD 2	UCT	12
MS 1	UCT	12
MS 2	UCT	12
Visiting Scientist	UCT	1
Second Generation University Scientist 1	UCT/Haramaya University	6
Second Generation University Scientist 2	UCT/Kigali Institute of Education	6
3 Undergraduates	Haramaya	9
3 Undergraduates	KIE	(Second year)
Matching Funds		
Smith	ORNL	1
Ilavsky	Argonne	1
Breese	Eclipse	1
Technician	Eclipse	2

Personnel and Activities at the Cape Town Hub during the First 2 Years:

The Cape Town Hub will be the center for activities associated with printed electronics and the first stages of commercialization in Africa of photovoltaic technology. UCT will also coordinate activities at the second-generation universities (HU and KIE). The Two PI's from these institutions will spend one month per year at UCT as visiting scientists where they will participate in research and development of photovoltaic devices using printed electronics technology. The second-generation university (SGU) participants will take this technology back to their home institutions where new MS and undergraduate research programs are being developed. Parallel and collaborative research and development will take place at the Daughter Universities. The SGU participants will also travel to the National Centre for Nanostructured Materials in Pretoria for specialized characterization using AFM, TEM and SEM microscopes.

Cape Town will have three graduate students, 2 MS and 1 PhD, funded by the project who will develop research theses based on various technical aspects of the research and development project. The graduate students will be recruited from the SGU's and will also interact with the two faculty during their visits as well as with other project participants as they visit UCT.

The two post docs from Argonne and Oak Ridge National Laboratories will stay in Cape Town for 6 months each year on a rotating schedule to assist in the work on development of photovoltaic production technology. The Cincinnati PI will also visit UCT for an extended period in the first year to conduct site visits to the SGU's and to assist and participate in some aspects of the project. The two National Laboratory Scientists are also budgeted to visit UCT for short visits to discuss the project with the African participants.

Personnel and Activities at the Cincinnati Hub during the First 2 Years:

The Cincinnati Hub will coordinate research and development activities at the University of Cincinnati, the two National Laboratories, Eclipse Film Technologies and the other Cincinnati based industrial participants as well as NGO's involved in the project, particularly, Solar Light for Africa (SLA) of Atlanta Georgia and Village Life Outreach Program (VLO) of Cincinnati. The main personnel involved in the project for the first two years are the Cincinnati PI, a graduate student, and Dr. Ryan Breese from Eclipse Film Technologies who will spearhead the reel-to-reel photovoltaic manufacturing research and development effort. A lab will be set up at Eclipse, 10 miles from UC, for this development work that will be open to use by the NPA participants. Additionally, characterization and synthesis facilities of the PI at UC will be used by the participants.

The Cincinnati Hub will also coordinate efforts at Argonne and Oak Ridge National Laboratories particularly the two post doctoral students who will be housed at the National Labs and in Cape Town. These Post Docs will also visit UC to use the research faculties and to interact in the first two years with Eclipse Film Technologies.

4.3 Advisory Board

Nano-power Africa will have an advisory board composed of prominent scientists, administrators and, industrialists who have ties to the project and can offer insight into success in meeting the strategic goals outlined in Section 3. The board will have three main functions:

1) Assistance in selecting second-generation universities for the project,
2) Annual assessment of progress towards the strategic goals and,
3) Guidance in the functioning of the center.

NPA has commitments from most of the board membership. The PI's have spoken with all of the possible board members who are listed in Table 4.2 and a number have provided letters of acceptance that are included in Appendix B of this Strategic Plan.

Table 4.2 Advisory Board.

Cathy Moore*, Deputy Mission Director, USAID Southern Africa
Danie Visser*, Deputy Vice Chancellor, UCT
Sandra Degan, Director of Research and Graduate Studies, UC
Ian Anderson, Associate Laboratory Director, Oak Ridge National Lab
Gabrielle Long, Associate Director, Argonne National Lab
Russell Schwartz, Vice President, Sun Chemical Corporation
Wynn Sanders, Chief, US Air Force European Office of Aerospace R&D
Derek Hannekom*, Deputy Minister of Science and Technology SA
Carol Smith Hathaway, Executive Director, Solar Light for Africa
Max Walton, retired USAID officer Southern Africa

* or institutional representative

Cathy Moore is the Deputy Mission Director for USAID in Southern Africa. Cathy has broad experience in international relations and can contribute to the Board through her insight into the workings of USAID.

Danie Visser is the Deputy Vice Chancellor at UCT and has experience with the operations of the University and interactions with centers.

Sandra Degan is the Director of Research at the University of Cincinnati. She has had extensive experience with large projects involving collaboration between the University, National Labs and international organizations.

Ian Anderson is an experimental physicist with training in materials science and Associate Laboratory Director at Oak Ridge National Laboratory. He formerly worked at the Institut Laure-Langevine in Grenoble, France and was trained at the University of Cambridge and Birmingham University.

Gabrielle Long is a Materials Physicist and Associate Director of Argonne National Laboratories. Gabrielle was a Division leader at NIST in Gaithersburg MD and formerly a Professor at Northwestern University.

Russell Schwartz is Vice President of Sun Chemicals, a producer of pigments. Sun has pioneered the use of conducting inks in the production of photovoltaic devices.

Wynn Sanders is the Chief of the U.S. Air Force European Office of Aerospace R&D. He is the co-director of the African Materials Initiative which is in the process of funding printed electronics work that will contribute to the NPA project and will be used a cost share.

Derek Hannekom is the South African Deputy Minister of Science and Technology. Deputy Minister Hannekom is a well-known African expert on the development of entrepreneurial technology in sub-Saharan Africa. He was imprisoned during the Apartheid era for his opposition to the National Party and his work towards the national democratic transformation.

Carol Smith Hathaway is Director of Solar Light for Africa which is an NGO involved with the installation of solar panels in villages in Tanzania, Rwanda and Ethiopia among other sub-Saharan African countries. Carol visited the University of Cincinnati during the Board of Directors meeting and gave a presentation to the University community about her work in Africa. It is hoped that her insight into on the ground implementation of solar technology in Africa can be used to guide the design of solar panels in the project.

Max Walton is a retired USAID officer in South Africa. Max has familial ties to members of the research team at the University of Cape Town, though he now lives in Houston Texas. It is hoped that Max can draw on his experience to guide the relationship between UCT and USAID.

Due to budget constraints the Advisory Board will meet via video conference once per year to assess progress. There may be sufficient funding for some of the board members to visit the UCT, UC or other sites of the project on an individual basis even in the first two years. It is hoped that board meetings at rotating project sites could be covered in the budget in later years.

4.4 Work Areas and Task Timelines

To achieve the goals described in Section 3, a combination of different activities will be required. Often a particular activity will address issues and have an impact on different sectors, for example educational capacity and science capacity development will require similar interventions. Similarly, all activities related to the scientific research and development, which can be grouped together from an operational point of view, will yield results which contribute to goals in all the sectors.

From an operational perspective, it is therefore appropriate to specify tasks and objectives in four specific work areas, describing what is to be done and to reference these tasks to the previously defined strategic goals and milestones. The first of the work areas concerns setting up and *managing the project*. Without clearly defined tasks and objectives in this area, nothing else can be achieved. The other three areas, which can be mapped onto the five developmental sectors, are: *capacity building and education*; *research and development*; and *innovation and commercialization*, which are described in detail below.

Each Work Area has specific project related objectives that have to be achieved at certain stages in the life of the project. To do this, tasks have been specified for each quarter year reporting period. Each particular task can be assigned a set of quantifiable outputs, whether it is the number of samples measured or the number of papers submitted, that taken together, form an holistic picture of the progress. Each quantifiable output will be assigned a target value, as described below. Within broad guidelines, these targets will be revised on an annual basis so that they remain aligned to the current work plan and objectives. Consequently, only the measurable outputs and targets are described in detail for the first year of the project. For subsequent years, the new outputs and targets will be detailed in the annual submission by the project coordinators to the Advisory Board and HED. A summary of the quantifiable outputs and targets is given as a separate table for each of the four work areas.

4.4.1 Project Management

Table 4.3 shows the timeline for project management tasks. Arguably the most important project management tasks are those concerned with setting up of the administrative capacity at the two hubs in Cincinnati and Cape Town. Equally urgent is the establishment of a secure, robust and transparent internal financial management system, which bridges the vastly different financial management systems and legal frameworks of the different partner institutions and their countries. At the same time these procedures must not only have the capacity for efficient transfer of funds, in terms of time delay and the reduction of unnecessary service fees, but also must include reporting and oversight functions which allow rapid corrective action. All of these functions will need to be in operation within 12 weeks of the notification of the start of the project, and preferably before the site visits and planning meeting at which formal needs assessments are made for the initial African partner institutions. To complete the oversight function of the project, it is expected that all the provisionally nominated members of the Advisory Board will have confirmed their membership (or replacements appointed) by the same time, and a date set for the first Board meeting at the end of the first year of the project.

Table 4.2. Tasks List by Quarter Year: Project Management

	2010		2011				2012				2013				2014				2015	
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Set up USA Hub admin capacity	■																			
Set-up pipeline fund management	■																			
Set-up accounting and auditing protocol	■																			
Set up Africa Hub admin capacity	■																			
Set-up Africa fund management	■																			
Appoint advisory board	■																			
Site visits		■								■										
Planning meeting	■			■				■		■		■				■				■
Seek further external funding opportunities	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Seek external partners	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Set-up IPR sharing agreement		■																		
Set-up sub-Proposal and Evaluation		■																		
Full financial audit years 1-4																			■	
Full independent performance appraisal (technical audit)																			■	
Business model and Strategic plan for years 6 - 15																				■
Advisory Board Meeting				■				■				■				■				■
Secure Funding for Years 6 -10													■	■	■	■	■	■	■	■

Once all administrative systems, and the Board of Advisors are in place, an intellectual property sharing agreement, covering all project outcomes, can be negotiated and signed by the end of 2010. During the same period, systems will be set up for the other African partner institutions to apply competitively through the UCT hub for funds and resources required in the future years of the project. Ongoing tasks, subject to quarterly review will only commence formally in the second quarter after the initial set-up phase has been completed. These tasks will be focused on growing the project by exploring alternative funding and investment avenues, and also external partners in the sectors relevant to the goals of the project.

Table 4.4. Project Management: Quantifiable Outputs and Targets for the First Year

Task	Outputs	Targets and Dates
Set up Hub admin capacities	Approval of project and funds received Dates of Appointment of support staff, students and post-docs	Budget loaded Sept Support Staff Oct, Post-docs Oct-Nov
Set-up pipeline fund management	Invoicing & Reporting protocol from UCT to UC, payment to UCT	Agreed protocol & Invoice sent Sept, Funds transferred Sept
Set-up accounting and auditing protocol	Quarterly financial reports	Financial reports received by coordinators Dec, Mar, Jun, Sep
Set up Africa Hub admin capacity	Approval of project and funds received Dates of Appointment of support staff and post-doc	Funds received from UC and budget loaded Sept Support Staff Sept, Post-doc Oct
Set-up Africa fund management	Invoicing & Reporting protocol from African partners, payments	Agreed protocol Sept, bank details received Sept
Appoint advisory board	Letters of Appointment and Confirmation	Confirmation received from all members Nov
Site visits	Preliminary list of requirements for 2011, preliminary student faculty participation 2010/11	Visits before planning meeting, preliminary assessment of needs by end of visits
Planning meeting	Urgent interventions through UCT/UC purchasing and bridging finance, final needs assessment and participation for 2011,	Final assessment by Nov 10, Urgent interventions orders placed and bridging finance transferred Nov 17
Seek further external funding opportunities or partners	# of informal approaches, formal approaches, formal Expressions of interest, applications/ presentations made, negotiated contracts and value.	4 informal approaches in each sector, 8 formal approaches, 4 expressions of interest, 4 presentations, 1 negotiated contract.
Set-up IPR sharing agreement	Agreed IPR sharing agreement for project IP between all stakeholders	Signed agreement Dec 31
Set-up sub-Proposal and Evaluation	Application template, guidelines, evaluation panel	Final template Nov 30, evaluation panel Dec 30.

4.4.2 Capacity Building and Education

The initial set-up phase for capacity building and education is summarized in the table of quantifiable outputs for the first year. Even as these targets are being met, existing structures will be used to build capacity in the first two African partner institutions. These include major contributions to academic staff development achieved by enabling African faculty to undertake international level research as graduate students in Cincinnati and Cape Town. The normal criteria of acceptance on academic merit will apply, with the support from the project being given in the form of mentoring as well as financially. Throughout the first two years of the project, the numbers of these students will be held stable at one in the USA and 3 in South Africa, with regular replacement as these young scientists pass through the system. The registration of the first cohort will be timed to coincide with the start of the academic year in each host institution (October 2010 at UC, and February 2011 at UCT). Additional activities directed towards the career development of the senior students and junior faculty, is their participation in an existing student workshop convened by the partners at ANL and ORNL, as well as the holding of a summer school to be held initially in South Africa on selected themes with relevance to the goals and theme of Nano-power Africa.

Table 4.5. Task List by Quarter Year: Capacity Building and Education

	2010		2011				2012				2013				2014				2015	
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Set-up admin capacity at other African Institutions		■																		
Support of African partner undergraduate programs		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Support existing graduate program		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
New graduate program					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
African partner graduates or jnr faculty as UC grad students		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
African partner graduates or jnr faculty as UCT students			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Participation of Africans in ORNL/ANL scattering workshop			■				■				■				■				■	
Submission of proposals by other African partners			■				■				■				■				■	
Evaluation of African partner proposals				■				■				■								
African Participation International Conference					■				■				■				■			
African partner based research programs					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Set-up platform for online teaching and research resources					■	■														
Summer School										■				■				■		
Tie in with other HED projects and USAID activities					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Develop national network around other African partners							■	■	■	■	■	■	■	■	■	■	■	■	■	■
Extend to other regions or disciplines (Eng. Chem.)									■	■										
Business Development and Entrepreneurship training														■	■	■	■	■	■	■

Another immediate activity, commencing in October 2010 with the start of the academic year in the other African partner universities, is the financial support of students in their existing academic programs. At present, only Haramaya University has a graduate program in the relevant discipline, a coursework masters program in Physics initiated by Dr Goro Gonfa and colleagues. A significant fraction of students in this program will be encouraged to undertake short research projects on topics related to the Nano-Power Africa project.

Kigali Institute of Education, and most likely other potential partners in other African countries, will need to develop an appropriate graduate program. Planning of the first such program will formally commence at the beginning of the third year (July 2011), making full use of experience gained at the first institution, with the first students entering in October 2012. The specific targets required to meet this timeline are: a policy document with chosen area of study by September 2011; a synopsis and draft curriculum by the end of the year; and the submission of complete proposal to both the University and the Ministry of Education by the end of March 2012. In later years of the project, as capacity has been built and the technical outcomes of the Nano-Power Africa project progress towards product development and implementation, business development modules will be included in all the graduate programs. It is also intended that a summer school be dedicated to entrepreneurship and innovation. For this, expertise will be sourced from the business schools of the two lead universities, but also from the South African Venture Capital and business community and through collaboration with other HED projects, such as the UAA-UCLA project “Managing Ethiopia”.

Table 4.6. Capacity Building and Education: Quantifiable Outputs and Targets for the First Year

Task	Outputs	Targets and Dates
Set-up admin capacity at other African Institutions	Approval of project and funds received Dates of Appointment of support staff and post-docs	Budget loaded Sep 05 Support Staff Oct 02, Post-docs Oct 01
Support of African partner undergraduate programs	# of students registered, students supported, female students at each institution	20 students, 4 supported, 2 female
Support existing graduate program	# of students registered, students supported, female students at each institution	15 students, 3 supported, 1 female
African partner graduates or jnr faculty as UC or UCT graduate students	# registered at UC and UCT from each other institution	1 PhD at UC from each; 2 MSc and 1 PhD at UCT from each.
Participation of Africans in ORNL/ANL scattering workshop	# of students trained, individual and group performance, performance relative to U.S. students.	4 students, zero failures, average in 50th percentile.
Submission and evaluation of proposals by other African partners	Draft work plan and budget, informal feedback, final work plan & budget, formal feedback, budget allocation	Draft plans Feb 18, feedback Mar 04, final submission Mar31, feedback and budget allocation, May 17

In their initial role as junior partners, with the Universities of Cincinnati and Cape Town directing and controlling the research and development activities, the partner institutions are unlikely to become internationally competitive in either research or innovation. At some stage it is imperative that they take the lead for certain areas of activity, and that they take full responsibility and accountability for their specific activities. Scientists from African countries can only become acknowledged leaders in their field if they direct their own research, present their results (and themselves) at international conferences, and submit their work to peer review in respected international journals. The allocation of resources in subsequent years will be determined by a rigorous proposal and review process, in which the coordinators of the partner institutions define and justify their requirements. At the same time they, like the other principal investigators, will be encouraged to apply for third party research funding from their own government and international agencies. Internal review with constructive feedback of all proposals will continue to be freely offered. In the third year, this competitive process will be used to expand the network, and build a secondary hub structure, as shown in figure 4.5.

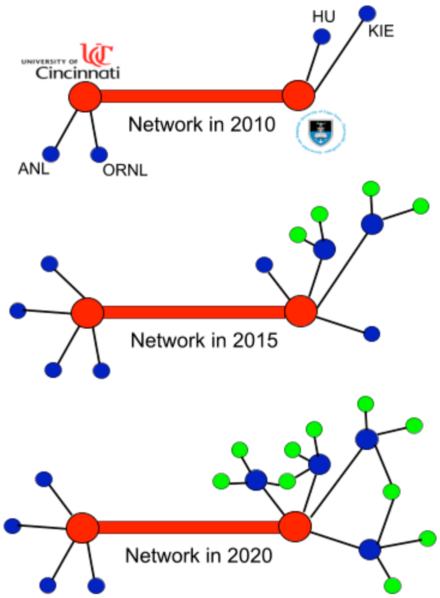


Figure 4.5. *Dendritic growth of the program in generations from the primary hubs to the second-generation to higher-level generation institutions.*

Growth of the network will be achieved by opening up the call for proposals, preceded by expressions of interest, to other African HE institutions, located in other regions (such as the ecowas countries), or with existing strengths in other related disciplines, such as engineering, chemistry, or business science. At the same time, the existing partners will be obliged to build collaborative links with other stakeholders in their country, effectively becoming national or regional hubs. As the project develops the choice of role for a particular institution – local node or regional hub – will be determined partly by the resources made available through the internal peer review system and the strategic interests of the institution, but mainly by the direct activities of the scientists themselves.

4.4.3 Research and Development

Unlike many HED projects, which are primarily targeted directly at influencing the societal or economic situation, such as addressing primary healthcare, Nano-Power Africa is science driven. In NPA a specific project, extending throughout the whole innovation chain, is used to leverage the development of research and innovation capacity serving five sectors identified in Section 3. Consequently, the research and development work area comprises a significant investment in terms of time, manpower, and other resources. It is also the area that has the most quantifiable outputs, in the form of experimental data. Table 4.6 shows the task list for Research and Development by quarter.

Table 4.6. Task List by Quarter Year: Research and Development

	2010		2011				2012				2013				2014				2015	
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Procure capital equipment											■	■	■		■	■	■		■	■
Plan instrument time/services									■	■	■	■	■	■	■	■	■	■	■	■
Research visit to UC or UCT by other African faculty		■			■				■				■				■			
Nanoparticle production		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Set-up sample system for SAXS/SANS and spectroscopy			■	■																
SAXS/SANS at major facility			■		■		■		■		■									
Data Analysis and interpretation			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Nanoparticle characterization			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Flame pyrolysis deposition			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Production of printed nanoparticle layers				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Layer characterization				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Production of heterojunction structures					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Heterojunction structure and interface characterization					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Refine models of charge transport					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Solar cell design, production and characterization									■	■	■	■	■	■	■	■	■	■	■	■
Submission of scientific papers on work to date		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Other than experimental data, quantifiable outputs include the number and quality of peer-reviewed journal publications, conference presentations, successful funding and measurement time proposals, patents filed and awarded, and artifacts such as instruments and laboratory scale proof-of-concept demonstrators. The contribution and leadership of the African partners in the activities generating these outputs is of particular importance to Nano-Power Africa and its capacity development imperatives. It is the synthesis of all these individual figures of merit that gives a meaningful snapshot of the scientific standing and ability of the researchers in the partner institutions. Table 4.7 shows the quantifiable outputs and targets for research and development in the first year.

The research aim of Nano-Power Africa is to combine the existing strengths of the whole research team in the synthesis and characterization of nanomaterials, with the experiences of the UCT team in innovation and commercialization of printed electronics, to develop an indigenous solar cell technology in Africa, for Africans, and by Africans. This will require a phased approach which moves the focus of activities forward, from the basic science end of the innovation chain, shown in Figure 4.6, ultimately leading in a series of commercializable products and the birth of new businesses on both continents.

Table 4.7. Research and Development: Quantifiable Outputs and Targets for the First Year

Task	Outputs	Targets and Dates
Procure capital equipment	Order placed, delivery, installation, training, test measurement	Orders placed UC Oct Delivery UC Nov Installation, training and testing completed all sites Dec 31
Plan instrument time/services	Instrument time applied for, applications by African partners, time awarded	2 successful applications for SAXS/SANS
Research visit by African faculty	# of scientists and length of stay, techniques trained, data obtained	1 scientist from each institution for at least one month, at least one new technique learned, useful data from 1 measurement series
Set-up sample system for SAXS/SANS and spectroscopy	Design of instrument, # of instruments constructed, test of performance	2 copies of system for aerosol powder measurement Mar 31 2 copies of system for liquid (ink) measurement Jun 30
SAXS/SANS at major facility	Data on particle size, morphology and clustering, # of African faculty and student participants, # African team/shift leaders, %contribution of African partners to experiment.	At least 6 African students and faculty, 2 shift leaders, 50% contribution to experiments
Material (sample) production	Amount of material produced, quality (purity, uniformity, etc), suitability for purpose	Ongoing data review every quarter
Material characterization	Data on structure, electronic and optical properties, # of students trained in each technique	Ongoing data review every quarter, 4 students trained in new techniques
Data Analysis and Interpretation	Correlation of results between techniques and samples.	Ongoing data review every quarter
Submission of scientific papers on work to date	# papers,# of African authors, # papers with African principal authors, # papers with African corresponding authors, impact factor	2 papers, 50% African authors, 1 African principal author, all impact factors >3, one impact factor > 6.

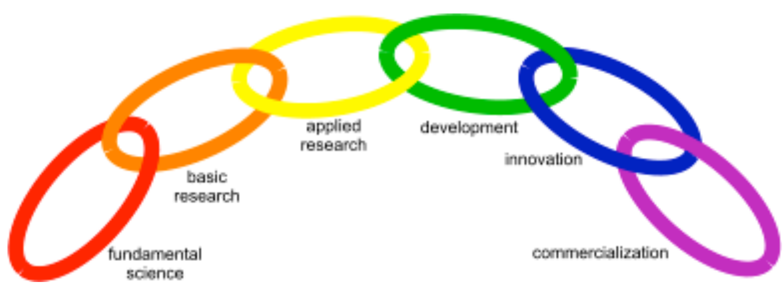


Figure 4.6. *The links in the complete Innovation Chain, extending from fundamental science to the commercial exploitation of products. The early focus of Nano-Power Africa is on the four central links, but does not neglect the two outermost links.*

Towards the middle of the innovation chain in Figure 4.6, at the junction between applied research and development, there are several competing technologies in the photovoltaic arena originating in Europe, the U.S. and recently South Africa, which are strong candidates for the development of robust, lightweight solar modules. The most advanced of these, which is now in the innovation stage (meaning the transition from prototype to product) is the dye sensitized solar cell, also known as the photochemical or Grätzel cell, shown in Figure 4.8.

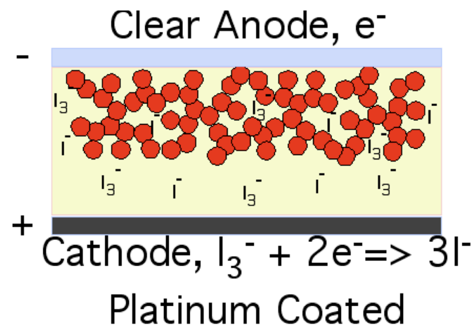


Figure 4.7 *Schematic of a Grätzel Cell. Red circles are titania aggregates coated with a dye. The yellow background is an iodide electrolyte gel. Platinum coated cathode is at the bottom and a clear plastic sheet coated with fluorine doped tin oxide anode is at the top.*

In the Grätzel cell, light is absorbed at a dye on the surface of a titania nanoparticle, causing a net negative charge to remain on the particle, and the combination of three iodide ions. The complex ion, I_3^-, then diffuses to one electrode, where it takes up negative charge and splits into three simple ions. Because the nanoparticles form a continuous network the negative charge is neutralized at the other electrode. When connected in a circuit, there is therefore an electric current from one electrode to the other.

An alternative approached, which mimics the operation of conventional thin film silicon solar cells, is based on the silicon nanoparticles used in the South African printed silicon technology. When light is absorbed at the junction between two different silicon nanoparticles (N and P type), extra charges (electrons and holes) are produced, which drift into separate nanoparticles by an intrinsic electric field. If there is a path of P-type silicon to one electrode, and of N-type silicon to the other, an electric current will be generated. A third option is a hybrid structure with a distributed junction consisting of a, usually N-type, semiconductor nanoparticle network embedded in P-type semiconducting polymer. In this system charge separation at the junction follows the same mechanism as the silicon cell, except that the free charges may also be produced in the polymer matrix, rather than in the particle.

At the level of basic and applied science, the investigative tools and skills that are required to produce and study all three material systems are identical. We are fortunate that in the composition of the core academic team, we have an extensive tool and skill base that covers all these aspects. In addition, the team members at the first two African partner institutions, Haramaya University and Kigali Institute of Education, completed their PhD dissertations at UCT in the characterization of nanomaterials and solar cell materials.

In the field of photovoltaics, we will apply the systematic scientific approach, shown in figure 4.4 to the problem of developing a working solar cell from what is effectively a handful of dust. Figure 4.4 is a simplified schematic flow chart of the complete research, development and innovation tasks, starting with the production of nanoparticles in box 1, at the lower left, and culminating in the spin-out of one or more companies in box 6 at the top right. With regard to the work areas, the first four tasks in this figure correspond directly to the research and development objectives given in the work plan above. These are indicated by the gray arrows, which specifically label the task related outcomes and show how these lead into other tasks. The yellow boxes indicate the composition of the research team involved in the activities leading to the expected outcomes.

Where the particular aspect of the research program is co-funded through matching funds from third parties, information describing the synergistic funding is also included.

Block 1, at the lower left of the flowchart describes production of the nanoscale materials at both centers, which should be underway by the end of the second quarter, after the establishment of the necessary administrative capacity. This task provides the fundamental materials for all basic research which is essential to capacity development, as well as supporting later innovation activities, and is therefore planned to continue throughout the project. In the first year of the project oxide nanoparticles will be produced in Cincinnati by flame pyrolysis, and elemental silicon nanoparticles will be produced using either mechanical milling at UCT, by thermal catalytic pyrolysis at the CSIR National Centre for Nanostructured Materials in the framework of an existing external collaboration.

The second block describes the comprehensive structural and composition characterization that is essential both to investigate the suitability of the nanoparticles for their eventual end-use application, and to provide the basic information to understand the physical phenomena involved which govern the processes occurring in their operation. The main technique to be applied will be small angle scattering, under the mentorship of the U.S. based partners who are world-leading authorities in this field. Measurement time at major SAXS and SANS facilities in the U.S. is therefore an essential element of the research program. It is also an activity that offers excellent opportunities to train African students in advanced research methods. For these experiments it will be necessary to design and construct specific sample handling systems by the end of the third quarter of the first year. The first of these is an aerosol system to enable the measurement of isolated nanoparticles and aggregates in a similar manner to the in-situ measurements of nanoparticles in flame pyrolysis developed by Beaucage. The second is a liquid phase handling system for the study of potentially unstable colloids, i.e. the ink for printed electronics..

Other structural analysis techniques which provide detailed local, rather than averaged global information, and which need to be correlated with the small angle scattering results, include: high resolution electron microscopy, to investigate the internal and surface structure of particles, scanning electron microscopy, and electron microscope tomography, which provides a 3-dimensional reconstruction of small clusters, as shown in Figure 4.8. These techniques are available at both hubs, but not at the other African sites. Scanning electron microscopy provides essential compositional information through the application of energy dispersive X-ray spectrometry, which will be the standard technique applied. More detailed compositional analysis will be achieved using Raman spectroscopy, Fourier transform infra-red spectroscopy, and X-ray photoelectron spectroscopy.

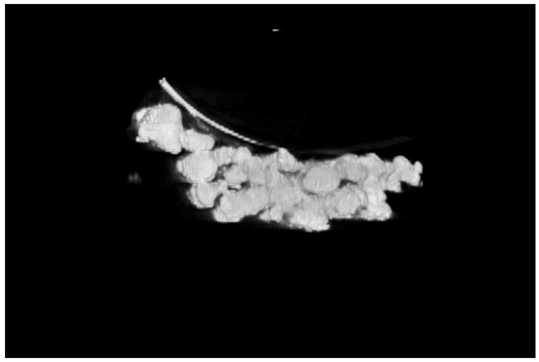


Figure 4.8. *3D tomographic reconstruction of a Silicon nanoparticle cluster by transmission electron microscopy. The large particle on the left is approximately 200nm across.*

Investigation of the electronic properties of the particles, and layers, will be conducted using temperature-dependent IV characterization, impedance spectroscopy and the field-dependent Hall effect. In addition, deposited layers will be characterized in transistor structures to access other semiconductor parameters, which are essential for understanding the electrical behavior of the materials when applied in solar cells. These studies will be performed at the two hubs, as well as in collaboration with PST Sensors and Omega Optics (See Appendix C).

Blocks 3 and 4 in the flow chart concern the deposition of nanoparticle coatings using one of two techniques. At Eclipse Film technologies, the flame pyrolysis technique will be adapted into a coating technique for polymer films, as shown in figure 4.9. This technique will be investigated for its application in the direct deposition of dense films and nanoparticle networks in the production of photochemical and hybrid cells, and for the production of nanoporous substrates for the second approach to layer deposition.

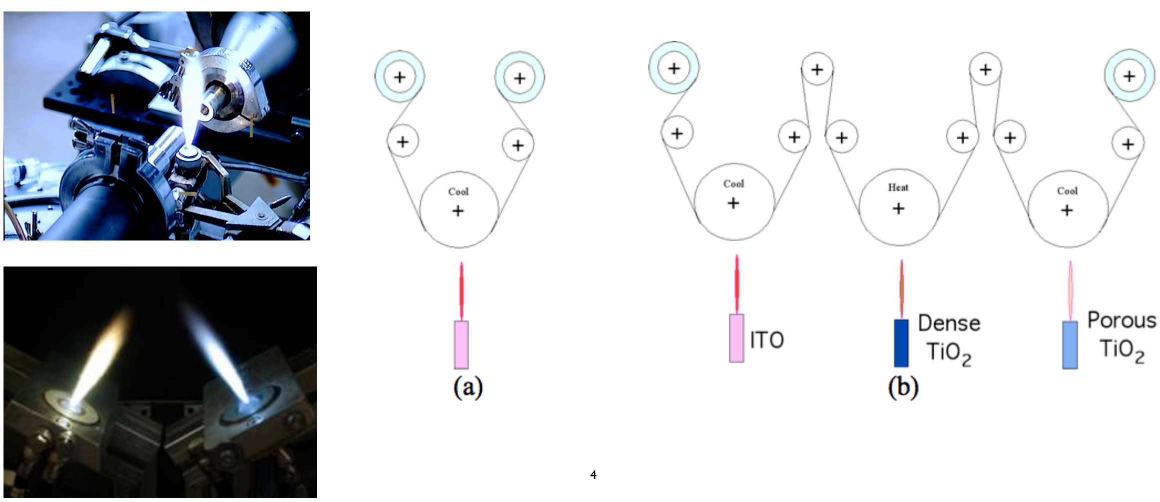


Figure 4.9. *Deposition of Nanostructured Coatings using flame pyrolysis: a) single layer coating used for the production of a nanoporous substrate, b) in-line deposition of multiple layers for the production of a Grätzel cell.*

The second approach to producing nanostructured layers is conventional screen printing, which has been applied to great effect in the printed silicon technology shown in figure 4.10.

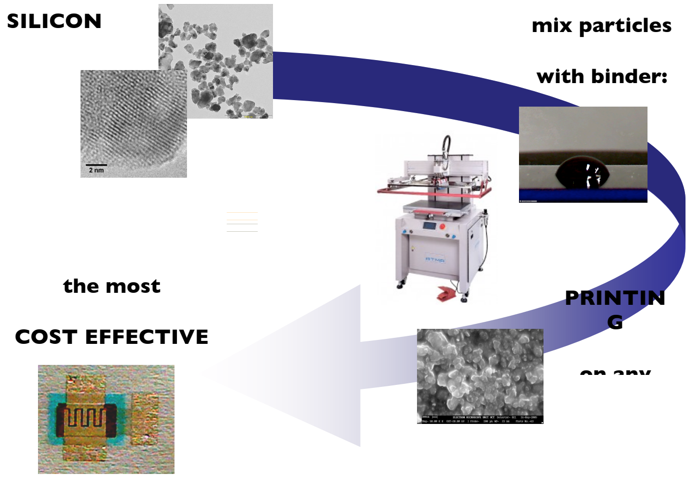


Figure 4.10. *An alternative approach to the production of nanostructured semiconductor films – printed silicon.*

In principle all the techniques previously mentioned will be applied to the study of the printed and flame deposited layers, providing valuable data which will feed into microscopic and mesoscopic models of charge transport through the layers. In turn, this will provide valuable understanding of the functioning of heterojunction devices, like solar cells, produced from these materials. The nanoscale topography of the layers and devices will be investigated using a Wyko NT1100 optical profiler, shown in Fig 4.11, which is (at the moment) a unique instrument on the African Continent. As well as being able to directly observe structural imperfections and anomalies, this instrument will provide height information at sub-nanometer resolution that can be correlated with the small angle scattering analysis.

Figure 4.11. *Wyko NT110 optical profiler for nanoparticle film characterization: A unique instrument on the African continent.*

The fifth block in the flow chart, Figure 4.4, represents the transition from research and development activities to the innovation and commercialization work area, and effectively covers aspects of both activities. With regard to research, this block refers to the production and testing of simple heterojunction devices, or single solar cells, as opposed to photovoltaic modules. At this stage, except for microscopy, all analysis techniques will be based on the electrical characteristics of the device. In addition to the basic electrical testing, described above, the photoresponse will be determined using industry standard solar cell testers, with an AM1.5 spectrum, similar to the one shown in figure 4.12.

Figure 4.12. *Spi-Cell tester, and industry standard AM1.5 solar cell tester at UCT*

4.4.4 Innovation and Commercialization

The development of an entrepreneurial culture associated with scientific and technical higher education is an important sector goal for the Nano-Power Africa project. Particular aspects have already been discussed under the task descriptions of the Capacity Building work area. The technology being developed in the Nano-Power Africa umbrella can be leveraged to serve the entrepreneurial and small business sector on both continents. As discussed above, the benefits of an inexpensive, locally produced and distributed, robust and lightweight solar technology to both sustainable development and quality of life in rural areas, are self-evident. The tasks in this work area have to address the question: how is the indigenous solar cell technology going to move from the laboratory to the end-user?

From a technical point of view, the most important task is a comprehensive assessment of the research data obtained for the different material systems and an evaluation of the electrical characteristics and performance for the different types of device structures. This information should then be combined with market information, such as the cost and availability of materials, and the transferability of the technical processes to a small business environment. The main output of this integrated technology assessment, to be conducted at the beginning of the third year, will be a thoroughly reasoned choice of the technology to be developed and implemented. The optimum choice will differ with locale, and we do not expect to produce identical products in Ethiopia, Rwanda and South Africa.

Concurrent tasks, the output of which will influence the technology assessment, include the identification and appointment of suitable business development partners, and an assessment of the formal and informal intellectual property required for the innovation and commercialization of the indigenous solar cell technology. This includes a rigorous up to date search to determine both what is protectable in terms of intellectual property, and how it should be protected, and a survey of existing intellectual property that could be used by other parties to block the development. At this stage, an accurate estimate of inward and cross-licensing costs will have to be made. A negative outcome, severely prejudice the choice of an otherwise technically favorable product, and it may be necessary to pursue the commercialization of a technically, slightly inferior product.

The above activities should be preceded by an extensive review of the current innovation system in each territory, which should include but not be restricted to present and planned IPR legislation, government and donor funding for start-up companies, corporate investment, local and international trends in venture and private equity funding, and any other conceivable enabler or barrier to innovation. Although it is expected, that much of this information will have been gathered informally since the start of the project, this process has to be formalized, and the information collated, in the two to three months preceding the technology and IPR assessments.

In collaboration with external partners, including end-use distributors and implementers such as Solar Light for Africa, there should be an extensive period of product specification and design throughout the third year. The outputs of this task will not only be the target efficiencies and milestones for the solar module, as it progresses from laboratory demonstrator to final production prototype, but also the specification of all the required peripheral devices, such as inverters and batteries. During this period, agreements will have to be made with third parties, such as the National Renewable Energy Laboratory or Spire Solar, for certified testing and validation of the performance of the devices.

The progression of the technical tasks related to the innovation and commercialization of indigenous solar cell technology, will follow the same structure as the basic research and development program. The only difference will be nature of the targets, which will be specifically linked to figures of merit describing the performance of the modules, formal intellectual property, and production capacity, rather than having an emphasis on knowledge generation and human capacity. During the initial specification phase, the design and construction of laboratory scale demonstration units will commence. This activity will be ongoing, as ultimately these studies are what drive the continued product development required to maintain a successful business. In an iterative development process, the outputs of this task will feed into the design and testing of prototype modules, first on a laboratory scale, then pilot scale, and finally full production scale. Table 4.9 lists the tasks associated with Innovation and Commercialization.

Table 4.9 Task List by Quarter Year: Innovation and Commercialization

	2010		2011				2012				2013				2014				2015	
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Review of national system of Innovation in partner countries																				
Seek business development partners																				
Technology Assessment																				
IPR Assessement																				
Solar Module and development targets specification																				
Solar Module design																				
Independent testing and validation agreements																				
Peripheral electronics specification and development																				
Solar module demonstrator production and testing																				
Lab-prototype production and testing																				
Pilot scale prototype production and testing																				
Full-Scale prototype production and testing																				
Product manufacture, testing and quality control																				
Production and marketing routes developed																				

4.5 Milestones According to Sector Goals

At any particular time, a specific combination of targets defines a quantitative milestone that can be used to map the development of capacity in each sector. The significant milestones in all five sectors are listed in chronological order in table 4.10, with the milestones for each sector highlighted in different colors. In keeping with the initial, basic science focus of the partnership, all early milestones are assigned to the education and science R&D capacity building sectors. As the project progresses, in the third and fourth years, significant entrepreneurial milestones arise. In the longer term, beyond the first five year period, as the indigenous solar cell technology reaches the local markets, there will be an increasing contribution to sustainable development and quality of life.

Table 4.10 Milestones for the first five years of the project according to sector goals

Dec 2010	First journal publication submitted with African authors First cohort of graduate students enter UC
Feb 2011	First cohort of MSc students enter HU First successful instrument time application First research visit by African faculty
Jun 2011	First cohort of graduate students enter UCT First female African PhD student registered First Africans in ORNL/ANL workshop First research Equipment installed at African institutions First experiments at major facility First flame deposited layers First research proposals by African partners
Sep 2011	Functional teaching labs at African partner institutions First journal paper published First journal paper with African principal author
Dec 2011	First Heterostructures produced First data from African partner research laboratories
Mar 2012	Online teaching resources published Curriculum for KIE graduate program submitted First successful instrument time application by African scientist
Jun 2012	First summer school completed Curriculum for KIE graduate program approved First African led experiment at a major U.S. or international facility
Sep 2012	First paper submitted with African corresponding author
Dec 2012	First African presentation at conference First independent research proposal to external funding agency by African scientist
Mar 2013	First cohort of MSc students enter KIE graduate program New African partners join the research network First solar cell structures produced
Jun 2013	First solar cells tested First research visit by new partners
Sept 2013	First MSc student graduates from UCT First cohort of MSc students graduate from KIE First research equipment installed at new partner institutions Review of national innovation systems
Dec 2013	First data from third African institution Business development partners appointed IPR assessment completed
Mar 2014	First research student registered at another African Institution Curriculum for new African graduate program submitted 0.1% efficiency from laboratory solar cell First patents filed Start of pilot scale development Design of solar module with input from NGOs
Jun 2014	First business modules in grad programs Curriculum for new African graduate program approved First independently funded African research project First business modules in grad programs Design of solar power system with input from NGOs
Sep 2014	First PhD student graduates from UCT 1% efficiency solar cell Spin-out or Joint Venture in SA or USA
Dec 2014	First invited presentation by African partner at a major international conference Pilot scale prototype 1% efficiency solar module
Mar 2015	First cohort of MSc students graduated from UCT PhD students registered in at least 2 other African Institutions New African partners join the research network 5% efficiency solar cell 1% efficiency pilot scale prototype
Jun 2015	First entrepreneur summer school submission of paper to Nature or Science First entrepreneur summer school field testing of pilot scale modules
Sep 2015	First PhD student graduates from UC All faculty in partnership have minimum qualification MSc First Science or Nature paper published with African authors Production and marketing routes defined First spin-out or joint venture in other African country 5% efficiency solar module pilot implementation of solar modules in rural areas

Education **Science R&D** **Entrepeurial** **Sustainability** **Quality of Life**

4.6 Training Goals of the Partnership

NPA will have as a major component training of scientists from Sub-Saharan Africa in approaches to developing their institutions of higher education and in dealing with systemic problems. The two hubs for the project, the University of Cincinnati and the University of Cape Town will both serve as training centers for these scientists. UCT is the premier university in Africa and serves as a center for the training of researchers from a wide range of African countries. Graduate students in the UCT group hold faculty positions at other African institutions, and NPA will investigate models for research capacity development in these institutions, using this research as a platform and led by this new generation of scientists. Researchers will frequently travel to the U.S. to participate in research activities at the University of Cincinnati as well as at Argonne and Oak Ridge National Laboratories. Students will be formally trained in skills that will enable research capacity development at their home institutions modeled on existing management and facilities at UCT and at UC. In addition to technical training, some specific topics of importance are given below:

How to obtain research funding: A course in writing effective proposals will be taught. Students/faculty will be required to write a proposal for project funding. Faculty will be assisted in development of proposals. Local and international sources of funding will be explored and the potential to fund research using entrepreneurial support from their own research efforts.

How to grow a scientific project: Students/faculty will be trained in effective methods of selection and management of graduate students. Methods to advertise research to the community and, the importance of publication to develop a track record of accomplishments in the field will be emphasized.

Monitor progress and project management plan: Methods to monitor progress in funded projects such as weekly group meetings, monitoring of effective progress towards graduate degrees, progress towards publications. Students and faculty involved in the center will be required to submit a management plan for their activities that will be over seen by the PI's in Cape Town or in Cincinnati.

How to protect intellectual property: Students/faculty will be trained in the importance of protecting intellectual property developed in their research efforts. Effective means to offset the expense of patent protection such as seeking outside support for patent prosecution will be developed.

How to deal with commercialization and industrial interactions: Students/faculty will become versed in what is expected in industrial interactions through interaction with the participating small businesses and corporations. Frequent meetings between the industrial participants and students/faculty will ensure the development of an understanding of the relationship between commercial interests and the fundamental research and education role of the university.

How to maintain equipment: Setting up a research lab will require hiring technicans who will be responsible for the maintenance of equipment and for training graduate students in the proper use of this equipment. A fee for use system might be setup to buildup service and repair funds to maintain the equipment. It is important to develop sufficient self-confidence in the use of new equipment so that the researcher is not afraid to do needed research because the equipment might break.

Roadblocks with suppliers: Equipment and other suppliers often won't reply to African researcher contacts making it difficult to obtain parts and even initial purchases of equipment. This is a major problem in Rwanda for example. One solution is to funnel purchases through

UCT in South Africa. The long-term solution is to build a functioning relationship with suppliers and the second-generation institutions. Methods to develop these relationships will be taught in the center.

How to reach self-sustainability: Development of a long-term plan with self-sustainability as a goal will be crucial to effective functioning of the second-generation institutions. Self-sustaining efforts will be based on local and national reputation and development of political support on the campus, in the nation as well as with international organizations and corporations. The entrepreneurial approach developed in NPA will be aimed at functional self-sufficiency of research/technical development efforts. The development of functional private enterprises based on the research of NPA second-generation institutions will be guided by the experience of the South African PI's as well as through the participating small business partners in the U.S. and in South Africa.

Computer access: At both of the initial second-generation institutions there are sever limitations in terms of computer access to library resources such as technical journals. The speed of local Internet connections is also an issue in Rwanda, Ethiopia as well as in Nigeria. NPA will circumvent some of these problems through the use of access to the UCT network for participating NPA students and faculty. Students and faculty in Rwanda, Ethiopia and Nigeria will be able to use Virtual Private Network (VPN) connections with the UCT network or with the computer network at the University of Cincinnati. This will also alleviate problems with filters on e-mails coming from Africa. For may sub-Saharan Africans it has been difficult to send e-mails due to screening of spam e-mails originating in countries such as Nigeria.

How to accredit programs: Students will be trained in procedures to accredit their teaching programs following international protocols and through African and national organizations. Affiliation with programs at the University of Cincinnati and the University of Cape Town will be used to enhance the appeal of the nascent graduate programs at the Kigali Institute of Education and at Haramaya University.

4.7 Infrastructure Goals of the Partnership

NPA will develop infrastructure at the host university, UCT, as well as at the second-generation universities in Rwanda and Ethiopia. Infrastructure development will take place in a staged approach and will be monitored by the hub institutions. Participants will be required to develop an infrastructure management plan that includes funding for technicians and for eventual replacement of the infrastructure investment through user fees where possible. Three types of facilities will be actively involved in NPA: 1) Hub facilities at UCT and travel grants for use of equipment at UCT and at Cincinnati. 2) Local facilities at the second-generation institutions. 3) User facilities available through participating national laboratories and travel grants to participating national laboratories at Argonne National Laboratory, Oak Ridge National Laboratory and at the National Center for Nanostructure Materials in Johannesburg.

Participating satellite campuses will submit proposals for equipment and support with a management plan, with cost recovery, plans for monitoring, with time the equipment should be self-sustainable. The infrastructure development plans will include development of an accounting system in the science departments to meet the accounting standards of UCT and the University of Cincinnati. The intent is to build a bureaucratic wall around the NPA funding. The management systems will be used as a model for the second-generation universities on how to protect program resources. Each institution will have two site visits per year with 4-5 people visiting to monitor the expenditures, management and accounting.

Building a center of excellence: NPA will enable the development of centers of excellence at the second-generation universities through development of a critical mass in research at the hub institutions that will be strong enough to extend out to the second-generation institutions.

4.8 Annual Workshop

Starting in the 3'rd year, Nano-Power Africa will provide an annual workshop that follows the annual meeting of the Board of Advisors. The workshop will cover the major areas of interest to the project with some local and some internationally recognized invited speakers. The workshop will be an opportunity to showcase the strength of the African Universities to outside visitors as well as an opportunity to exchange ideas and approaches to various aspects of the project ranging from scientific, technical to business and in rare cases cultural. The workshop will give an opportunity for students and faculty to showcase their work the previous year to the participants of the project and invited guests such as funding agencies and companies.

"*What the Maestro does is to provide the beat. It is just there as the percussion. To listen to just the percussion is not very pleasant. You need symphony. You take the percussion out of the symphony, you can't maintain the necessary rhythm…. You need two hands.*"

Trevor Manuel
Minister of Finance under Nelson Mandela, Thabo Mbeki and Kgalema Motlanthe,
Head of the National Planning Commission under Jacob Zuma,
and Chancellor of the Cape Peninsula University of Technology.

Section 5
Relationship to Stakeholders

Nano-power Africa focuses on a topic that impacts several sectors leading to a diverse community of stakeholders. During the planning stage of the project the partners have arranged meetings with a number of these stakeholders. In some cases these meetings have already lead to funding for aspects of the project. This section of the Strategic Plan outlines the relationships to the major stakeholders associated with the project.

5.1 USAID Mission in South Africa: The PI's and DOE participants met with Cathy Moore, Deputy Mission Director and Mathate Madibana on December 10, 2009 in Pretoria, RSA. The mission in South Africa is focused on AIDS/tuberculosis, housing, business development, government/democracy aid, victim support especially for rape, organized crime, criminal justice system and FET colleges (further education and training). There is a desire to be involved in higher education development but there are not sufficient resources.

The NPA project offers overlap with the business development effort since the entrepreneurial component of the project intends to develop self-sustained production of solar cells in sub-Saharan Africa based on indigenous research efforts tied to work in the U.S. Given interest at the USAID mission in advancing the higher education goals and overlap with the business development plans for South Africa it seems likely that this project and the USAID mission can develop a symbiotic relationship. Cathy Moore has verbally agreed to participate in the project as a member of the Advisory Board. She has also offered to visit UCT to discuss the project.

USAID is interested in clean energy technologies that offer the prospect for economic growth and reduced greenhouse gas emissions. USAID is especially interested in developing private enterprise solutions to clean energy technologies consistent with the goals of NPA. The development of clean energy can have a great impact on improved medical care for Africans since medical treatment is at times limited by lack of lighting, refrigeration (for vaccines, antibiotics and other medicines) as has been found in the Solar Light for Africa organization's efforts at supplying off-grid solar power in Uganda, Tanzania and Rwanda.

5.2 USAID Mission in Ethiopia: Dr. Girma Goro Gonfa from Haramaya University has met with Dr. Kevin Smith, Supervisory Program Officer for USAID in Ethiopia. Dr. Smith indicated that the USAID mission in Ethiopia is primarily focused on agriculture and primary education. The Mission Director, Thomas Staal has express interest in investments in sustainable development similar to the NPA entrepreneurial efforts and the partners of NPA believe that this link to the USAID Mission in Ethiopia could be strengthened as the project progresses.

5.3 USAID Mission in Rwanda: Dr. Evariste Minani met with Molly Brostrom who spearheads educational issues at the USAID Mission in Rwanda. Molly indicated that she was mainly interested in primary education but would be interested in supporting the NPA program if it were funded. Molly was also contacted by David Britton from the University of Cape Town by phone to discuss possibilities of interaction with the project.

5.4 Host Institution (UCT): The University of Cape Town, Figure 5.1, has as a general goal to be an Afropolitan University meaning to attract the global African diaspora, as well as develop an African, especially sub-Saharan, identity that brings together the traditional with the high-tech. The NPA project is fully in line with the strategic plans of UCT. The project seeks to use the resources and reputation of UCT to fortify other African institutions. The NPA program can help to organize research programs and to guide program and management development in Africa. UCT sees its role in Africa completely in line with these directives. During the partner's meeting in December the NPA organizers met with the Deputy Vice-Chancellor in charge of research, Prof. Danie Visser, and briefly with the Vice-Chancellor, Dr. Max Price. As a result of these meetings Prof. Visser has supported the development of a new University center focusing on nanotechnology that is directly linked to NPA. NPA furthers the university's goal of enhancing UCT's research profile and implementing the university's mission to be research-led.

(a)

(b)

Figure 5.1. a) University of Cape Town at the foot of Table Mountain. b) University of Cincinnati's Uptown Campus.

5.5 Host Institution (UC): The NPA partners have met with a number of administrators at the University of Cincinnati including Vice President Sandra Degen, who has agreed to serve on the Advisory Board. The Associate Vice-President for Research, Deborah Galloway has extensive experience with large USAID projects in the past at other institutions and has offered to enhance the effectiveness of the NPA project especially in terms of administrative education and training. Debbie previously worked at Syracuse University where she over saw the financial aspects of USAID projects involving education outreach in Africa and South America. The partners also met with Prof. Makram Suidan, Head of the School of Energy, Environmental and Biological Systems in the College of Engineering to discuss interactions with the NPA project with the new Energy Engineering Center and program. The College of Engineering is firmly behind the project and has offered logistical support such as office and lab space for the project.

During the project meeting at the University of Cincinnati, the partners met with two groups involved in Africa from the University, the NGO, Village Life Outreach Project and an undergraduate organization, Engineer's Without Borders. Both organizations expressed interest in working with NPA. Village Life's designated teams for life, health and education have created exciting projects such as water purification systems for access to clean water, distribution of mosquito nets to prevent malaria, and a school lunch program to combat severe malnutrition in school-age children. By illuminating and joining the struggle against poverty, disease and malnutrition in Africa, VLO hopes to also strengthen Cincinnati communities by exemplifying the ideas of humanitarianism, service and social responsibility. VLO has been consulted concerning the NPA project and has offered advise towards the project. The NPA project is consistent with the goals for the University, College of Engineering and School of Energy, Environmental and Biological Systems.

5.6 Second-generation Hub (Haramaya University, Ethiopia): Haramaya University (formerly known as Alemaya University), Figure 5.2, is one of the oldest universities in Ethiopia. It is located in Alemaya, a town in the Misraq Hararghe Zone, about 20 kilometers from the city of Harar and 40 kilometers from Dire Dawa. The university was founded with the help of Oklahoma State University, accepting its first students in 1954, and the new campus was opened in January 1958 by Emperor Haile Selassie. Haramaya University was promoted from a college within Addis Ababa University on May 27, 1985 to an independent university. For many years the university had been limited to only an agricultural curriculum, but in 1996 the university was given permission to open other faculties and departments.

In 1996 a program in physics to train teachers was begun. A new MS in Physics program has been started with 50 scholarships. This program will be involved with the NPA project. Some of the top students from this MS program will enroll in the PhD program at UCT and at UC and become involved in the development of photovoltaic devices. The technology will be developed in parallel at Haramaya University through Prof. Girma Goro Gonfa. The goal in the NPA project for Haramaya is to setup a research capacity and post graduate curriculum tied to an entrepreneurial program to produce photovoltaic devices for local use.

(a)

(b)

Figure 5.2. a) Haramaya University, Haramaya, Ethiopia. b) Kigali Institute of Education, Kigali, Rwanda.

5.7 Second-generation Hub (Kigali Institute for Education, Rwanda): Kigali is not as advanced as Haramaya University. The Kigali Institute of Education (KIE) is a young public institution of higher learning in Rwanda, which was founded in 1999. The establishment and operation of KIE was made possible by combined efforts of the Rwandan government as major stakeholder, and assistance from various donors including the World Bank, African Development Bank, Swiss Cooperation, Belgian Cooperation, DFID, USAID, German Cooperation, the French Cooperation and the Netherlands. In its ten years of existence, KIE has made significant strides. It has evolved into a dual-mode institution offering distance and pre-service programs in various disciplinary areas ranging from diploma to Honours degree. At Master Level, the MSc/MRes degrees in Social and Educational Research Methods have been offered since 2007. KIE, in partnership with UNISA, offers programs that range from certificate to PhD. KIE is an internationally known centre of excellence producing professionally qualified teachers and other professionals in high quality research environment that promotes community services.

Arrangement with Kigali will be similar to an existing arrangement between UCT and the African Institute for Mathematical Sciences in Muizenburg, RSA that supplies 7 students/year for the masters program in Physics at UCT. The Faculty at Kigali Institute will be trained at UCT for higher degrees to enhance the profile of the Lecturers and Professors at KIE. There will also be an opportunity for staff training to enhance the degrees of the Kigali faculty.

5.8 Solar Light for Africa: During the partners meeting in Cincinnati, NPA invited Carol Hathaway and Emily Ridgway from Solar Light for Africa (SLA) to visit the UC campus. There are a number of areas of likely interaction and symbiosis between *Solar Light for Africa (SLA)* and the *Nano-power Africa (NPA)* Project. These include visits by the participants in the NPA program to SLA sites to assess the need and application of technology being developed in the African Universities. SLA could also provide a potential link between SLA's volunteer work force and NPA's educational programs by encouraging SLA's young volunteers to pursue technical degrees associated with *Nano-power Africa*.

The NPA project could possibly provide a source for indigenously produced solar panels which would solve some issues concerning local maintenance, shipping from North America or China and customs that SLA must currently deal with. This could be of great importance in countries such as Ethiopia where these problems have, for the most part, precluded SLA's work. Other advantages to SLA are contacts in new areas of Africa such as Rwanda and South Africa, as well as the potential for enhancement of SLA's efforts by allowing local investment of donated funds towards solar panels and other components needed in our work.

Carol Smith Hathaway will be a member of the Advisory Board for NPA.

5.9 South African National Research and Development Strategy: In December of 2009 the NPA team met with Derek Hanekom, the Deputy Minister of Science & Technology for South Africa and with J. (J. J.) Molapisi, the Director of Emerging Research Areas and Head of the Nanotechnology Initiative, to discuss the relationship between the proposed NPA project and the long term scientific and higher education goals of South Africa. The reception to the NPA project was extremely encouraging. The NPA goals parallel the goals of the South African Administration in leveraging expertise in South Africa to enhance economic development. The project also fits in with the South African energy equation for clean, renewable energy and in plans to develop off-grid power in an affordable way. The Deputy Minister expressed interest in fleshing out the potential for interaction and funding with the Director of Emerging Research Areas, J. J. Molapisi.

Figure 5.3. *Meeting between Derek Hanekom, Deputy Minister of Science & Technology (center right), Joseph J. (J.J.) Molapisi, Director : Emerging Research Areas (far right), and the NPA team in Johannesburg RSA December 10, 2009.*

5.10 National Centre for Nanostructured Materials (NCNSM): The NCNSM is a Center within the Council for Scientific and Industrial Research (CSIR). http://www.csir.co.za/nano/ The Council for Scientific and Industrial Research (CSIR) in South Africa is one of the leading scientific and technology research, development and implementation organizations in Africa. It undertakes directed research and development for socio-economic growth. The national center is mandated to support university led research in the nanosciences and to provide access to facilities. In December the NPA team met and discussed interactions with Manfred Scriba, a senior researcher and project leader of the silicon nanoparticle synthesis research group which focuses on the synthesis of doped silicon nanoparticles and the design and development of a multipurpose chemical vapor deposition system. Scriba has close ties to Britton and Härting since he is a PhD graduate of their group at UCT. Close interactions with NCNSM are planned for the project.

5.11 South African Nanotechnology Initiative (SANI): http://www.sani.org.za SANI is an organization in parallel to the goals of NPA project formed to establish critical mass in nanotechnology R&D in South Africa. SANI focuses on enhancing industry involvement in nanotechnology; improving university links with industry; developing international networks; encouraging R&D spending in nanotechnology; and developing nanotechnology projects that generate benefits for South Africa. The NPA project is directly in line with the goals of SANI and we expect strong interaction with this organization.

Figure 5.4. *David Britton (right) at the SANI meeting from the SANI web page.*

Figure 5.5. *Manfred Scriba at a SANI workshop.*

5.12 US National Science Foundation: Beaucage and Britton have a pending proposal with the U.S. NSF that is symbiotic to the HED project. The NSF proposal is pending in the Materials World Network Program under Dr. Daniele Finotello, Program Director, Office of Special Programs Division of Materials Research, National Science Foundation. Beaucage and Britton discussed the NPA project with Finotello during Britton's visit to the U.S. at the end of February. The NSF proposal focuses on fundamental scientific challenges in nanoparticle formation and growth in flames as well as their adaption to solar cells and printed electronics. We plan to submit other proposals to NSF dealing with scientific aspects of the proposed work. The advantage of the Materials World Network program is that it supports both U.S. and foreign researchers in a collaborative project with South Africa as a target country for the program. The project goals are inline with several goals and directives of the National Science Foundation, particularly in the development of young scientists exposure to the international research environment. The NSF program will include support of travel and participation of undergraduate students and high school teachers in the program. These students and teachers may become involved in installation of solar panel systems with SLA for instance, or may work at UCT or the other campuses involved in the NPA program.

5.13 US Department of Energy (DOE): The DOE is heavily involved in NPA. Representatives of Argonne National Laboratory and Oak Ridge National Laboratory have participated in the planning meetings for the project and two DOE representatives will participate in the Advisory Board, Gabrielle Long, Associate Director, Argonne National Laboratory and, Ian Anderson, Associate Director, Oak Ridge National Laboratory. While the Department of Energy does not have a primary role in international relations, the NPA program goals are consistent with DOE initiatives for development of renewable resources in the U.S. and abroad. Interaction with NPA by the DOE Labs is seen as an educational outreach program. DOE is also interested in external users for their user facilities such as the neutron and X-ray scattering facilities and the nanomaterials labs at Oak Ridge and Argonne. Direct funding from DOE may also be possible for this project from the Basic Energy Sciences Program. This funding would be directed towards scientific aspects of the project similar to the requested NSF funding. DOE funds could be used to support South African and other African researchers directly.

5.14 US Air Force: The Air Force Windows on Science and Windows on the World programs fund interactions between Air Force scientists and African scientists that could be part of the NPA project. Members of the NPA team met with Air Force scientists at the Air Force Materials Directorate, Air Force Research Lab, Dayton Ohio. Another program of interest is the Air Force Office of Scientific Research (AFOSR) African Materials Initiative that focuses on materials, energy, and nanotechnology. The NPA team met with Deanna Won who is one of two Program Managers for the African Materials Initiative and a white paper was submitted to Deanna. The other program manager, Chief Wynn Sanders, of the European Office of Aerospace R & D will visit Cape Town in April to discuss funding the scientific and development aspects of the project with the Cape Town team. Wynn has verbally agreed to be a member of the Advisory Board for the NPA project. There is extensive synergistic overlap between the interests of the U.S. Air Force and the NPA project and there are a number of areas of potential and likely interaction including exchange of personnel with the Wright Materials Directorate (30 miles from Cincinnati) and direct funding through the African Materials Initiative.

5.15 Eclipse Film Technology: Eclipse Film Technology is a small business in Cincinnati that specialized in processing of flexible polymer film. Eclipse is interested in interacting with the project in the development of reel-to-reel plastic film printed electronics and solar cells. NPA will setup a lab in collaboration with Eclipse for the development of reel-to-reel technologies for solar cell manufacturing in sub-Saharan Africa. African students and scientist visiting the University of Cincinnati will work at Eclipse in the process development work. The technology developed in Cincinnati will be adopted in Africa as part of the technical development for solar cell production. Ryan Breese, the president of Eclipse, was a graduate student of Beaucage with a PhD from the University of Cincinnati.

5.16 PST Sensors: David Britton and Margit Härting have formed a small company focusing on printed electronics that will interact with the proposed work. PST Sensors Ltd. The startup intends to manufacture thermistors using printed electronics technology developed in their lab at the University of Cape Town. PST will serve as a potential market for technology developed in the NPA project.

5.17 Sun Chemical Corporation: Sun Chemical has research and production facilities in Cincinnati. Sun manufactures pigments for automotive and plastics industries. Sun has developed a product line in printed electronics inks that are used in the manufacture of solar cells. This technology is closely related to inorganic pigments in polymers and other organic bases. Sun has expressed interest in interacting with the NPA project but details of the interaction have yet to be worked out. Sun has verbally agreed to supply $100,000 per year for 5 years to the project in direct funding. Additional in-kind support has also been promised.

5.18 Collins Ink Corporation: Collins Ink Corporation is a medium size business in Cincinnati that manufactures inks and has recently developed a product line of printable electronic inks for ink jet printing. There is strong overlap between the NPA project and the commercial interests of Collins. The research scientist in charge of printable inks, Suresh Murugesan, is a PhD graduate of Beaucage's group. A close interaction has begun with Collins associated with NPA. This interaction involves the development of magnetic inks using flame made particles.

5.19 Omega Optics Corporation: Omega Optics is a start-up in Austin TX. Primarily they are interested in using printed silicon in microwave antennas, but they are also interested in collaborating on solar cell research. Omega optics will provide in-kind matching funds for NPA.

5.20 Procter & Gamble Corporation: Beaucage has had extensive interactions with Procter & Gamble over the past 20 years. P&G is interested in printed electronics for packaging, so the NPA project runs parallel to these corporate goals. P&G is also interested in enhancing their company as a global citizen and improving interactions with developing countries. For example they have recently developed a water purification filtration system that will be used in rural India and has been supplied to Haiti.

5.21 ExxonMobil Corporation: Beaucage has also developed ties with ExxonMobil Corporation in their Annandale, NJ central research laboratory. ExxonMobil is interested in alternative energy technologies as well as understanding the physical and electrical properties of nanoaggregates using scattering techniques. ExxonMobil has already funded work in Beaucage's group that seeks to quantify the structural nature of complex branched structures using ExxonMobil's small-angle neutron scattering beam line at NIST in Gaithersburg, MD.

In the world we would like to build, South Africa could play an outstanding role, and a role of leadership in that effort. This country is without question a preeminent repository of the wealth and the knowledge and the skill of the continent. Here are the greater part of Africa's research scientists and steel production, most of its reservoirs of coal and of electric power. Many South Africans have made major contributions to African technical development and world science; the names of some are known wherever men seek to eliminate the ravages of tropical disease and of pestilence. In your faculties and councils, here in this very audience, are hundreds and thousands of men and women who could transform the lives of millions for all time to come.

Robert F. Kennedy
June 6, 1966
University of Cape Town

Section 6
Current Capacity of Participating Institutions as Agents of Change

NPA is composed of two founding institutions, the University of Cincinnati and the University of Cape Town. The project grew out of a research collaboration initiated by Prof. Britton and his student Emanuel Jonah to understand the structure property relationships for complex ramified nanomaterials that are used in printed electronics. Prof. David Britton and Prof. Margit Härting of the Physics Department at the University of Cape Town are collaborators in this work on printed electronics. Profs. Britton and Härting have a network of PhD and MS graduates who teach in Universities and other institutions in sub-Saharan Africa. Prof. Gregory Beaucage of the Department of Chemical and Materials Engineering at the University of Cincinnati is an expert in the characterization of nanomaterials using small-angle scattering and has nanoparticle production capabilities that can be used to produce nanomaterial layered devices for photovoltaic devices. Beaucage also has an extensive network of contacts in industry especially in the Cincinnati area as well as strong contacts at the U.S. national labs especially at DOE labs. The team offers unique and complementary strengths in organizing the development of higher education in sub-Saharan Africa aimed at scientific and technical sectors. The team also is capable of developing a new model for African science education based on an entrepreneurial model since Härting and Britton have developed a startup company using their printed silicon technology and because Beaucage has several graduates and collaborators who have started entrepreneurial spinoff companies in the Cincinnati area that will be involved in this project. Beaucage currently manages a research program of about $300,000 per year and Britton and Härting currently manage research programs of about the same order of magnitude in Cape Town.

6.1 University of Cape Town: Through the stewardship of David Britton and Margit Härting the University of Cape Town will serve as the hub around which a center of excellence in the development of a new model for higher education in Africa will emerge. UCT is an impact institution that uniquely displays a critical mass of scientific know-how and entrepreneurial spirit that can extend to other institutions in sub-Saharan Africa. UCT has had experience in managing large USAID projects. For example, the Periperi U project funded by USAID seeks to develop disaster mitigation through outreach to other African Universities. (http://www.uct.ac.za/dailynews/archives/?id=6829). Funded by USAID's Office of Foreign Disaster Assistance, Periperi U supports institutional development related to disaster risk reduction capacity development, multi-disciplinary graduate programs, and the provision of professional short courses across Anglophone, Francophone and Lusophone universities. It trains up to 600 students and practitioners in ten countries.

Since 2003, UCT has maintained its position as the highest ranked South African and African university in the Academic Ranking of World Universities (ARWU) conducted annually by the Institute of Higher Education at Shanghai Jiao Tong University. Since 2007 UCT has been the only African university to make it into the top 200 of the Times Higher Education Supplement (THES) World University Rankings conducted each year by the London-based newspaper The Times Higher Education Supplement and study-abroad specialists Quacquarelli Symonds. UCT is one of only four universities from the developing world in the list of top 200 universities, and is currently ranked 146. In 2008 UCT enrolled a total of 6485 (out of a total of 22608) graduate students of which 33% were designated black South African. The remaining 4000 graduate students were predominantly international, with the majority originating from other countries in Africa. The use of such a center allows a small investment in this partnership to have a great impact across a wide spectrum of locations in Africa. As the junior scientists, currently based at the center, return to their home institutions in countries such as Rwanda, Ethiopia and Nigeria, they will take with them not only research experience and expertise, but also valuable networks, and they will in turn serve as mentors and role models to the next generation of students. Furthermore, taking advantage of this center will allow resources and work to be distributed in the most efficient fashion allowing centralization of the essential technical aspects of the project as well as direct access to dispersion of the technology and field-testing at universities in other countries.

6.2 University of Cincinnati: The University of Cincinnati has developed a number of international programs over the past few years. The most active project in Africa involves the Village Life Outreach Project that is associated with UC (www.villagelifeoutreach.org). The organization has received some USAID support. Village Life's work focuses on three remote and impoverished villages in the Tarime district of Tanzania where they have developed water filtration systems in collaboration with the UC chapter of Engineers Without Borders and improved health care through association with the UC Medical School. Village Life is building a health care center through collaboration with the School of Design and Architecture and the College of Engineering. Village Life also includes a nutrition program, mosquito net program, education sponsorship for boarding school tuition and a pen-pal program involving local high schools. UC also has an active affiliate of Engineers Without Borders that has worked with villages in Kenya for a number of years in developing clean drinking water systems. This group has also expressed interest in working with NPA. The Associate Vice-President for Research, Deborah Galloway has extensive experience with large USAID projects in the past at other institutions and has offered to enhance the effectiveness of the NPA project especially in terms of administrative education and training. Debbie previously worked at Syracuse University where she over saw the financial aspects of USAID projects involving education outreach in Africa and South America.

6.3 Haramaya University (Ethiopia): Girma Goro Gonfa at Haramaya University has met with the President of HU and with his immediate supervisors to discuss the implementation of NPA in Ethiopia. The University is enthusiastic about the chance to participate in the program an will provide all needed resources for its success. Gonfa started a new MSc in Physics program this year with 50 scholarships. This program will be involved with the NPA project, and the ongoing goal now is to setup a research capacity and develop a full postgraduate curriculum. Some of the top students from this MS program will enroll in the PhD program at UCT and at UC and become involved in the development of photovoltaic devices. The technology will be developed in parallel at Haramaya University through the activities of Prof. Girma Goro Gonfa.

Figure 6.1. *Science students at Haramaya University in Ethiopia. Center is Girma Goro Gonfa who is a partner in NPA.*

Currently at HU Physics Department there are only 3 PhD holder Ethiopians and two expatriates. In total only five academic staff are ready to supervise and teach post grad programs. Under normal conditions this figure is very small. The shortage of academic staff is not peculiar to HU, it is a common tragedy for all tertiary institutes in the country. At the national level, there are about 31 public (government owned) universities that are supposed to train students among others, in physics. When we look at the number of PhD (physics) holders in the country, there are only about 20, which shows how desperate the nation is for trained manpower. MSc or BSc holders staff most of these higher institutions. Therefore the human capacity building component of this project is highly benefical to HU in particular and the nation in general. The end result of the project will empower local institutes to produces cheap and robust solar cells. For a country like Ethiopia, where more than 75% of the 80M population is settled in rural areas, this technology is ideal. It is in line with the government's rural electrification policy. NPA is a great opportunity for Haramaya University to be a national and regional hub to train manpower and disseminate technology. Haramaya University will become a resourceful institution to share its part in alleviating the nation's shortage of trained manpower at the MSc and PhD levels.

6.4 Kigali Institute of Education: Evariste Mirani at KIE has met with the HOD for the Institute as well as to the Rector about the project and they were all impressed by the project. He has worked with the Dean of the Science Faculty, Prof. Iyamuremye Daniel, in developing a plan of interaction with NPA. KIE is a public institution of higher learning in Rwanda and was founded in 1999. Among other missions, KIE collaborates with other higher learning and research institution in the area of academic and research with the aim to reach national as well as international standards. KIE has developed curricula and offers high-level educational courses, which in the end will enhance economic and socio-cultural development of the country. In its eleven years of existence KIE has offered programs in various disciplinary area ranging from diploma to honors and it is in preparation of some masters programs.

KIE has only a few nationals who have either MS or PhD and is mainly relying on expatriates. NPA can help in building the capacity of nationals by allowing them to get MS and PhD degrees. The aim of NPA is to produce a cheap and robust solar cell which is very needed in rural places where the access to electricity in almost impossible. This will be a solution to many problems of Rwandese but at the same time it will make the distance training program more efficient and e-learning possible. There are other benefits from this project ranging from access to library and journals to becoming a hub for other sister institutions in central Africa. NPA is of tremendous importance to KIE and the whole of Rwanda in general.

Figure 6.2. *Science students at the Kigali Institute of Education.*

Kigali offers several unique opportunities as a launch pad for the NPA project. First, there has been a substantial investment, $7.66 million in Rwanda to make the entire city of Kigali a wireless broadband hot spot. This includes the Kigali Institute of Education. This broadband access should enable Internet-based teaching programs, allowing easy connections between the U.S., Cape Town and Kigali. Rwanda is also investing $40 million in the Kigali Metropolitan Network (KMN) that is a fiber optic network in the city.

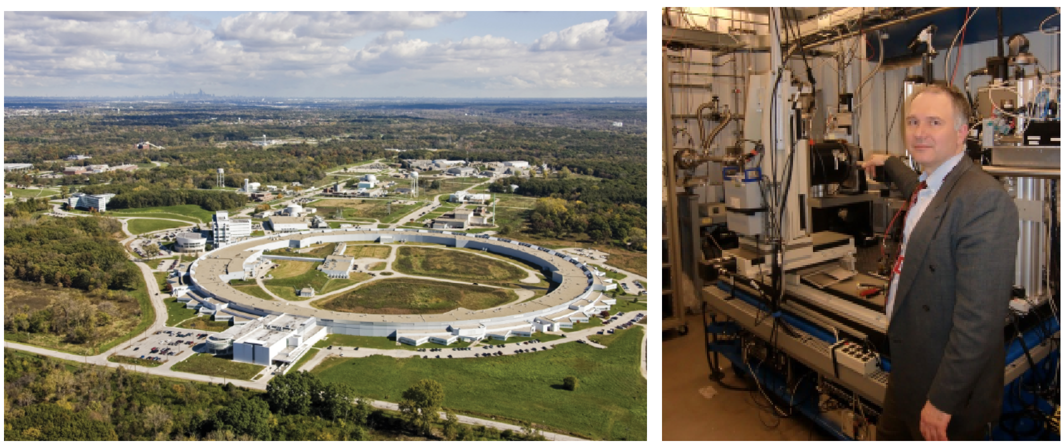
The One Laptop per Child project, aimed at providing a laptop to every pupil in primary school is active in Rwanda. The One Laptop per Child NGO is delivering 100,000 XO laptop computers at a cost of $181 per laptop to the Rwandan government. One problem with this project is that for most of Rwanda there is no access to grid power so recharging these laptops is already a major issue. NPA could have a broad market in Rwanda for indigenously produced inexpensive photovoltaic devices to charge these laptops.

6.5 Oak Ridge National Laboratory: Oak Ridge National Laboratory offers a wide range of instrumental support for participants in the NPA project. The Center for Nanophase Materials Science has extensive facilities for electron and atomic force microscopy, spectroscopy, diffraction and scattering that the NPA students and faculty will utilize. The Spellation Neutron Source (SNS) and the High Flux Isotope Reactor (HFIR) offer unique tools to characterize nanomaterials in printed electronics and other devices. Through these characterization methods an understanding of the relationship between tuned nanostructure and electrical properties in photovoltaic devices will be developed through NPA. Oak Ridge also has world class scientific staff who will interact with the students an faculty in the project leading to collaborations and exchange of ideas. The CNMS offers a unique collaborative arrangement where researchers can request chemists at Oak Ridge to synthesis custom materials that are then used in research projects. Oak Ridge conducts a summer school in scattering techniques in collaboration with Argonne National Laboratory that will be incorporated into the NPA program. NPA will have a post-doc based at ORNL who will coordinate interactions with Oak Ridge Researchers.

Figure 6.3. *Emmanuel Jonah (University of Cape Town), Girma Goro Gonfa (Haramaya University), Ram Ramachandran (University of Cincinnati) and Greg Smith (Oak Ridge National Laboratory) touring the Spellation Neutron Source at Oak Ridge National Laboratory.*

6.6 Argonne National Laboratory: Argonne National Laboratory, Figure 6.4, offers excellent opportunities for NPA students and faculty to interaction with world-class scientists and extensive and unique scientific instrumentation such as the Advanced Photon Source (APS). The APS is a synchrotron that produces x-rays of exceedingly high brightness, collimation and narrow wavelength distribution. The relationship between a synchrotron x-ray and a lab source x-ray beam is similar to the difference between a flashlight and a laser. High-flux x-rays enable real time measurements on dynamic systems such as printed electronic devices during operation and nanoparticles during growth in a flame. From this information scientists can design new processes and devices that can improve performance and lower costs of production. No synchrotron x-ray source exists in Africa so it is necessary to travel to the U.S. or Europe to find this type of research facility.

Argonne National Laboratory also has a Center for Nanoscale Materials (CNM) that focuses on electronic devices produced using nanoscale structures. The NPA project will take advantage of the CNM through interactions with researchers and use of some of the unique facilities for measuring magnetic and electronic behavior of aggregated nanomaterials. NPA will have a post-doc based at Argonne who will coordinate interactions with Argonne researchers.



(a) (b)

Figure 6.4. *a) The Advanced Photon Source (APS) at Argonne National Laboratory. APS is the largest scientific user facility in the world. b) Board Member Jan Ilavsky at the Advanced Photon Source.*

6.7 Eclipse Film Technology: Eclipse Film Technology is a small business in Cincinnati that manufactures flexible plastic films for a variety of end uses. EFT has expertise in reel-to-reel processing and lamination of a wide range of polymers. This reel-to-reel technology is at the heart of mass production of low-cost solar cells. Eclipse will work with NPA to develop new processing technologies for the production of solar cells in sub-Saharan Africa by dedicating space and expertise to the incorporation of printed electronics and pyrolytic synthesis with existing technology. A lab-scale reel-to-reel film-processing instrument will be purchased and a research lab setup at Eclipse in the NPA project. This will serve as a development arm where African researchers will work with Eclipse in implementing technology developed in the labs in Africa and in the U.S. A letter of commitment from Ryan Breese of EFT is included in Appendix C.

6.8 Solar Light for Africa: SLA is an NGO operating primarily in Tanzania, Uganda and Rwanda. SLA installs solar panels in African villages to provide off-grid power for medical, household and business use. SLA could play a significant role in this project serving as a link to deliver the technology to villages and also to gain feedback into the feasibility of the various technologies. Carol Smith Hathaway, Executive Director of SLA, has agreed to serve on the board of directors of the NPA project. We also plan to tie the African universities with SLA activities through volunteers helping with installations and on the ground support, especially in Ethiopia, Rwanda, Nigeria and in South African townships. The young people involved in SLA may become involved in solar technology development in NPA either in the U.S. or in Africa. NPA will support activities that directly link to the project such as supporting students involved in the research/development and their travel expenses as well as expenses related to serving on the board of directors of NPA. SLA has found that solar power is a transformative technology, so they have great hopes for the spread of solar energy technology throughout Africa where grid power is not available or as a backup to or alternative for grid power. Cooperation between SLA and NPA could be an important component to further encourage the spread of solar technology in Africa.

(a) (b)

Figure 6.5. *a) Carol Hathaway SLA presenting at University of Cincinnati. b) SLA solar panel installation at a rural hospital in Tanzania*

6.9 Air Force Research Laboratory: The University of Cincinnati is 30 miles from the main research laboratory for the U.S. Air Force. The AFRL supervises \$2.4 billion/yr in research funds. These funds are allocated to Directorates that focus on specific research sectors. The Wright Materials and Manufacturing Directorate located in Dayton Ohio (30 miles from Cincinnati) focuses on development of materials for Air Force applications. Beaucage has extensive contacts with the Materials Directorate and NPA has been in contact with AFRL concerning exchange of scientists, collaboration and other interactions that may be funded by the Air Force. The Air Force has a program targeting the development of science and technology in Africa through which NPA has applied for support.

6.10 Procter & Gamble: Procter & Gamble is headquartered in Cincinnati and has an extensive research and development effort at a number of labs in the Cincinnati area. The main area of overlap with the NPA project is in P&G's interest in low cost disposable power sources for packaging and the use of printed electronics to enhance consumer products and packaging. P&G is also interested in understanding aggregated materials such as those found in plastics reinforcement and in colloids. NPA is in discussion with P&G concerning support for the project through joint research projects. P&G is interested in directly supporting the project with approximately \$20,000 per year as well as through in-kind support.

6.11 Sun Chemical: Sun Chemical is the world's largest producer of pigments and printing inks. Sun has a R&D and production facilities in Cincinnati. Sun produces conducting inks that are used in the production of photovoltaic devices and they are interested in collaborating with NPA researchers in the development of new inorganic dispersions that can be used to produce printed electronic devices. NPA met with Russell Schwartz, Vice President of Sun Chemical, and Researchers and Division Leaders concerning this interaction during the Cincinnati site visit as well as in teleconferences since the Cincinnati meeting. Sun has verbally agreed to support the NPA project through directly payment to UCT of approximately \$100,000 per year as well as in-kind support that is not yet specified. NPA can utilize Sun's expertise and materials in the development of new photovoltaic devices for use in Africa.

6.12 Collins Ink: NPA also had meetings with a moderate sized company in Cincinnati that produces inkjet inks for a variety of applications. Ink jets are now used to produce rapid prototype objects and for printed electronics. Collins is interested in developing magnetic inks for display devices and other applications using flame made technologies being developed in the NPA project. They will participate in the NPA project through in-kind support of materials and supplies as well as contributing personnel time and training for visiting African students and faculty.

We know it is a matter of fact that we have it in ourselves as Africans to change all this. We must, in action, assert our will to do so. We must, in action, say that there is no obstacle big enough to stop us from bringing about a new African renaissance.

Nelson Mandela
Oau Meeting of Heads of State and Government
Tunis, 1994

Section 7
Development of Complementary Funding and Long-Term Funding for the Project

During the planning stages of the Nano-power Africa project the PI's have had success at raising a number of diverse funding sources for various aspects of the project. The funding successes are briefly mentioned in **Section 6, Current Capacity**. The PI's plan to spend a significant amount of time expanding the funding base through outreach to traditional and non-traditional funding sources. It is hoped that the entrepreneurial approach will lead, in a number of years, to self-sustaining research efforts at the second-generation universities. Expanding the funding source will help bridge the gap until self-sufficiency can be reached and will serve as examples of the necessary methods to maintain a scientific research effort. In this section some of the possible future funding sources for NPA are briefly mentioned.

7.1 National Science Foundation: The National Science Foundation offers a number of programs that can compliment and enhance the NPA project. The PI's of NPA plan to develop a proposal for an Integrative Graduate Education and Research Traineeship program that will fund graduate students interested in the application of their scientific and technical skills to international development projects. The IGERT project that the PI's have planned will include a significant international component including travel to and residence in sub-Saharan Africa. U.S. students involved in this program will work at the second-generation universities for part of their graduate degree programs and will focus their graduate training of science and technology issues of importance to resolving social issues through entrepreneurial approaches that are viable in sub-Saharan Africa. It is expected that this project will be funded at $1.5 million over 3 to 5 years.

The NPA project also expects to submit proposals to NSF to expand fundamental research into the production of nanoparticulate titania coated with inorganic pigments in a simple flame process amenable to the production of photovoltaic devices. Typically a research project of this type is funded for $750,000 for 3 years.

7.2 ExxonMobil Corporation: Beaucage has research contacts with ExxonMobil's Annandale, NJ central research lab. ExxonMobil has expressed interest in several aspects of the NPA project and the PI's are pursuing direct funding of some aspects of the project involving the quantification of nanostructure using unique analytic methods developed by Beaucage and the new printed electronic materials developed by Britton and Härting. We expect request a long term (5 year) collaboration with ExxonMobil with about $100,000/year in funding.

7.3 Soros Foundation Open Society Fellowship: Many of the goals and ideas in the NPA project are parallel to the intents and interests of the Soros Foundation. NPA plans to apply for small amounts support from the Soros Foundation through Fellowships for the African Faculty.

7.4 State of Ohio Third Frontier Photovoltaic Program: The collaboration with Eclipse Film Technologies in the development of reel-to-reel manufacturing processes for the production of photovoltaic devices is a model project for support by the Ohio Third Frontier Program. We will submit a proposal to the State of Ohio in September, 2010 that will support rapid development of the technologies being developed in the NPA project, particularly, coupling flame synthesis of nanoparticles with reel-to-reel manufacturing techniques and the use of printed silicon electronics in a reel-to-reel polymer film application. The development of businesses in Ohio can be a symbiotic process to the development of an entrepreneurial model for African universities.

7.5 Procter & Gamble: Procter & Gamble is headquartered in Cincinnati and has major research and production facilities in the Cincinnati region. P&G is interested in the application of printed electronics and low cost photovoltaics in packing for consumer products. NPA is in discussion with P&G concerning possible support for work on these applications that would run parallel with the main goals of NPA. P&G is also interested in characterization of nanostructured materials using scattering techniques pioneered by Beaucage. A contract is being written concerning work on characterization of disordered materials in parallel with the NPA goals.

7.6 U.S. Army Watertown Laboratory: The NPA project plans to apply for support from the Army Materials Technology Laboratory in Watertown MA. NPA plans to propose a research project coupling printed electronics using the Cape Town printed electronics with the production of "smart clothing" that contains embedded electronics. The army is also interested in coupling photovoltaic devices in clothing to power and recharge portable electronic devices. These applications have strong symbiosis with the development of cheap photovoltaics in sub-Saharan Africa.

7.7 DOE/BES: With the strong involvement of the DOE labs in the NPA project application for funding from the Department of Energies Basic Energy Sciences program is a logical path. BES can fund basic scientific research that uses national facilities to answer fundamental scientific questions. In the case of NPA we are interested in the fundamental relationship between nanostructure and electrical performance. The nanostructure will be quantified using new tools developed by Beaucage and the synchrotron and neutron scattering facilities as well as the two nanomaterials centers at Argonne and Oak Ridge National Laboratories. Funding from a DOE/BES project of this type is expected to be on the order of $200,000 per year for 5 years.

7.8 World Bank: During the HED meeting in Washington DC the NPA PI's had a chance to discuss possible funding with Joshua Mandell, Science and Technology Program Officer from the World Bank. Joshua mentioned that the World Bank in collaboration with other organizations is planning a call for proposals that could parallel some of the topics covered in the NPA project. NPA plans to pursue funding from the World Bank possibly through these new programs.

All do not develop in the same manner and at the same pace. Nations, like men, often march to the beat of different drummers, and the precise solutions of the United States can neither be dictated nor transplanted to others, and that is not our intention.

Robert F. Kennedy
June 6, 1966
University of Cape Town

Section 8
Monitoring Performance

Monitoring and quantifying the performance of the Nano-power Africa project is one of the most challenging aspects of the project. The assessment for NPA will be multi-fold. At the highest level the project will be assessed annually at the Board of Advisors meeting. The Board will provide a written assessment and directions for change after consideration and discussion of the progress made towards the Strategic Goals listed in Section 3 and assessment of the adherence to the proposed work plan in Section 4. The assessment will be on an individual institutional level as well as on the project as a whole. The Advisory Board assessment will be shared with HED on an annual basis.

The Board of Directors will prepare a quarterly report on progress for presentation to HED. This report will include an assessment of all of the project participants. These assessments will be considered before further funding is allocated within the project.

8.1 Human Capacity Building and Retention: The Cape Town hub will be in charge of monitoring human capacity building and retention for the majority of the program participants who are funded through a sub-contract to UCT. Simple metrics of capacity building are degrees granted, publications, number of students and progress of each student towards a degree. Retention pertains both to retention with in the program and retention of the graduates in sub-Saharan Africa.

The Cincinnati hub will be responsible for the quarterly assessment of the three post-doctoral students who will reside at the National Labs and at Cape Town, and the graduate students funded through the University of Cincinnati.

Assessment of the entrepreneurial aspects of human capacity development will be judged by the creation of new startup companies and creation of jobs in African communities. This can only be fully judged in the latter stages of the project, after 5 to 10 years. Progress towards business development can be measured through the milestones listed in Section 4.

8.2 Institutional Capacity Strengthening: Institutional capacity strengthening can be measured by the purchase and maintenance of equipment and infrastructural improvement,

improvement in the functioning of the administrative structure and, improvement in the number and qualify of faculty. The development of an accounting structure to maintain and purchase replacement equipment is achieved through a fee per use system that is flexible enough to allow for training of students and development of new instrument users. Primarily the two initial second-generation institutions will be assessed for institutional capacity strengthening though strengthening at Cape Town will also be considered.

8.3 Contribution to Host Country National Development Goals: Contributions to the national development goals of South Africa, Rwanda and Ethiopia will be assessed by discussions with the respective Ministries of Science. We have a working relationship with Derek Hanekom, the Deputy Minister of Science & Technology in South Africa and we have contacted the Ministries in Ethiopia and Rwanda. Hanekom will server on the Board of Advisors for NPA so he will have direct input into the program. In all three of these countries the national development goals are parallel to the goals of NPA. For instance, all three countries are interested in development of alternative energy sources for off-grid power as well as in strengthening their higher education infrastructure.

8.4 Cost Effectiveness of Partnership Activities and Program: The efficiency effectiveness of the NPA project compared to similar higher education initiatives will be assessed in terms of some quantifiable parameters such as number of papers per invested dollar and number of PhD and MS graduates per invested dollar. The project will also be qualitatively assessed by consultation with peers. The Board of Advisors contains several business executives who will assess the financial effectiveness of the NPA project. Self-sufficiency of the second-generation programs will be the ultimate measure of the cost effectiveness of the partnership activities.

8.5 Assessment of Medium and Long-Term Impact: The NPA project will have several points for clear assessment of medium and long-term impact. Long term impact will be measured by the enhancement of the second-generation institutions through their world rankings, number of PhD's in the faculty, strength of their MS and PhD programs in terms of the number of graduates per year and number of funded research projects. The success of several spin-off companies, especially from the second-generation institutions will also be a long-term impact for the project. The translation of the NPA project to third generation universities, using the second-generation institutions as hubs, would also be an indicator of long-term impact.

In the medium term we expect to see entrepreneurial projects into the commercialization phase by the end of year 5. We also expect to see the first PhD graduates in faculty jobs at African universities and significant enrollment of MS and BS students who hold faculty jobs at other African universities. Significant progress towards scientific understanding of the mechanism for improved conductivity and other properties associated with solar cells should be evidence by a number of papers in this are by 5 years or project operation.

If you need something you can't rely on someone else to provide it.
That is my slogan.

Patience Bogatsu
South Africa's First Black and First Female Game Guide
Discussing the Black Economic Empowerment Program
Madikwe Game Reserve
2008

Section 9
Two-Year Budget

9.1 Budget and Justification

The budget is divided into two parts for the two hubs involved in the project, Cincinnati and Cape Town. The University of Cincinnati will monitor and hold responsibility for the overall budget. Cape Town will be allocated a sub-contract on the order of $230,000/year. The Cape Town budget will be managed by the two Cape Town PI's, Prof. David T. Britton and Prof. Margit Härting, who will be locally overseen by the Sponsored Research Office at the University of Cape Town. Quarterly financial and progress reports from Cape Town will be incorporated into the quarterly reports for the project that will be provided by the University of Cincinnati to HED. Since there is some difficulty in arranging for travel in the U.S., especially for faculty and students at the second-generation universities in Rwanda and Ethiopia, domestic travel allowance for U.S. travel by the second-generation university participants is included in the Cincinnati part of the budget.

SALARIES/PERSONNEL:

Personnel	Location	Time/year (Months)	Budget	Amount/year $
PI/Beaucage	Cincinnati/UCT	3.23	Cincinnati	42,265
PI/Britton	UCT	3.38	UCT	30,000
PI/Härting	UCT	3.38	UCT	30,000
Post Doc 1	ORNL	6	Cincinnati	21,250
Post Doc 1	UCT	6	Cincinnati	21,250
Post Doc 2	UCT	6	Cincinnati	21,250
Post Doc 2	Argonne	6	Cincinnati	21,250
Secretary	UCT	12	UCT	18,000
PhD 1	Cincinnati	12	Cincinnati	24,000
PhD 2	UCT	12	UCT	20,000
MS 1	UCT	12	UCT	15,000
MS 2	UCT	12	UCT	15,000
Visiting Scientist	UCT	1	UCT	5,800
S. G. Scientist 1	UCT/HU	6	UCT	10,000
S. G. Scientist 2	UCT/KIE	6	UCT	10,000
3 Undergraduates	Haramaya	9	UCT	3,000
3 Undergraduates	KIE	(Second year)	UCT	3,000
Matching Funds				
Smith	ORNL	1	ORNL	30,000
Ilavsky	Argonne	1	Argonne	30,000
Breese	Eclipse	1	Eclipse	40,000
Technician	Eclipse	2	Eclipse	40,000

The proposed budget includes 3.23 months recess effort per year by the Cincinnati PI ($42,265) and 3.38 months academic effort ($30,000, R220,000) for each of the UCT PI's ($60,000, R440,000).

Two post-doctoral students are budgeted for Cincinnati at a total annual cost of $42,500. The post-doctoral students that will be shared between Argonne National Lab, Oak Ridge National Lab, and the University of Cape Town are included in the Cincinnati budget since the overhead rates are lower than for the National Labs and since it is easier to recruit post-docs through Cincinnati. The post-docs will spend about 6 months at the national labs and 6 months in Cape Town each year.

The Cincinnati budget includes one PhD student who will be a US citizen who will interface with Ryan Breese at Eclipse Film Technologies ($25,000/year) studying scale-up of solar cell production.

The cost share for the first year includes Dr. Beaucage's academic salary of $32,202 at 50% effort during Winter and Spring quarters of 2010-2011 while the PI is on sabbatical leave.

The Cape Town subcontract includes the PI salaries mentioned above. A secretary at UCT is budgeted at $18,000 (R132,000). A second PhD student is budgeted at $20,000 (R147,000). This student will be from the BS/MS programs at the two second-generation universities. Similarly two MS students recruited from the second-generation universities are budgeted at $30,000 (R220,000).

Visiting scientist support at $5,800 in the Cape Town Budget covers a stipend for two scientist for 1 month each at $18/hour.

Two faculties at the second-generation universities are budgeted for $10,000 that amounts to about 50% of their academic time or 4 months effort for the project.

The budget also includes participant costs for undergraduate students at Haramaya University ($3,000 R22,000) and in the second year the same amount at the Kigali Institute of Education.

In addition to these salaries time has been committed to the project by Argonne National Laboratories, Oak Ridge National Laboratories and Eclipse Film Technologies as noted in the Cost Share section below.

FRINGE

For the UC budget, fringe benefits are a direct-charge as a percentage of salaries and wages at rates established by the university, and reviewed annually by DHHS, for salary expenses. Fringe Benefits amount to about $37,000 per year for the Cincinnati part of the budget incrementing with the salaries for year 2.

TRAVEL

A significant budget for travel is included in both the Cincinnati and Cape Town Budgets.

Airfare between US and Cape Town on a US carrier: $2,500

The following are per diem rates (2010) at the locations involved in this proposal.

Location	**Hotel**	**M & I**
Cape Town	$371	$114
Johannesburg	$244	$104
Cincinnati	$115	$56
Kigali, Rwanda	$203	$72
Addis Ababa, Ethiopia	$275	$103
Other Parts of Ethiopia	$50	$37
Oak Ridge, TN	$90	$46
Argonne, IL	$100	$61

Some costs can be reduced using campus housing at UCT and less expensive facilities when they are available.

Second-Generation University Professors (2): The logistics of travel in the US for the second-generation participants is complicated by their inability to obtain credit cards, so the Cincinnati budget will pay for the second-generation university visits to the U.S. The second-generation university professors will travel to the U.S. once per year at about $2,000 per flight (Cape Town Budget). Per diem in Cincinnati/Oak Ridge/Argonne for a 2 week stay using $150/day will be required ($2,100 each). Rental Car in Cincinnati with gas $700. USAID HAC Health insurance $50 per participant.
Cincinnati Budget: Cincinnati/Oak Ridge/Argonne Per Diem $5,000 (Domestic)
UCT Budget: $4,000 (International)

The two Second-Generation Professors will visit Cape Town for one month. This will cost $1,200 airfare each, housing and per diem $3,000 each.
UCT Budget: $8,400 (International)

MS and PhD students in Cape Town: Airfare and per diem for the three graduate students from Haramaya and Kigali to travel to UCT will cost $1,200 each. ***UCT Budget: $3,600 (International)***

2 Post Docs: The Cincinnati budget will also pay for flights of U.S. based participants and per diem and housing. The two post-docs are considered U.S. participants and the U.S. members of the Advisory Board are U.S. participants. The two post-doctoral students will reside in Cape Town for 1/2 of the year requiring 2 round trip tickets to Cape Town from Chicago, Oak Ridge or Cincinnati per year at $2,500 per flight. The post docs will reside at U.S. National Labs during the remainder of the time with travel between the facilities and Cincinnati costing approximately $1,700 in per diem per trip for 2 trips per year of 10 days with $500 for airfare. Medical inoculations $700 each first year only.
Cincinnati Budget: Flights $6,400 first year, $5,000 second year (International), $9,000 (Domestic)

3 PI's: The three PI's will travel to Cape Town and Cincinnati once per year each. These trips will require about 5 days for each trip at $170 per day in per diem for Cincinnati and about $300 per day in Cape Town.
Cincinnati Budget: Flight $2,500, Per Diem $1,500 (International)
UCT Budget: Flights $5,000, Per Diem $1,700 (International)

The UCT PI's will need to travel to the National Centre for Nanostructured Materials (NCNSM) in Pretoria as well as to meet with USAID Mission. Airfare is about $250 and per diem is $300 so for an average 2 day trip $750. The project plans 4 of these trips per year.
UCT Budget: $3,000 (Domestic within South Africa).

National Laboratory Participants: The two National Laboratory participants will travel to Cape Town once per year for about 5 days.
Cincinnati Budget: Flights $5,000, Per Diem $3,000 (International)

Beaucage Sabbatical in First Year Only: In the first year of the project Prof. Beaucage will travel to Cape Town, Kigali and Haramaya for an extended visit during his sabbatical leave. Beaucage plans to setup operations in Cincinnati in the early stage while operations are setup on Cape Town, Kigali and Haramaya. After 3 months of project operation he will travel to Africa to assist with the initial stages of the project. He will reside in Cape Town for about 10 weeks and use this as a base for visits to Kigali and Haramaya. The expenses for the sabbatical are $25,000. This will be used to travel to Cape Town for 10 weeks as well as to travel to Kigali and Haramaya during this time period (about $2,500 each) in the initial stages of the project setup.
Cincinnati Budget: Airfare/Housing/Car in Cape Town $10,000, per diem and expenses $10,000. Trips to Kigali, Rwanda and Addis Ababa, Ethiopia $2,500 each including about $1,200 airfare each. Total $25,000 first year only (International).

UC Graduate Student: The UC graduate student will need one trip to Africa for 5 days to communicate the progress of the project. *Cincinnati Budget: $4,000 (International)*

The UC PI and graduate student will make 1 trip per year to Oak Ridge or Argonne National Labs to interact with program participants. $3,000 per trip. *Cincinnati Budget $3,000 (Domestic)*

MATERIALS AND SUPPLIES

The Cincinnati budget includes about $5,220 per year allocated to materials and supplies. These costs include the cost to setup a reel-to-reel processing lab for exploration of production methods amenable to African production of solar panel sheets. The facility will be setup at Eclipse Film Technologies in Cincinnati since parallel equipment and expertise in safety exist at the facility. The HED facility will be separated from the Eclipse facilities with a separate keyed entrance. The space will be donated by Eclipse to the University of Cincinnati. Setting-up and operating the facility will cost approximately $20,000 per year from Materials and Supplies most of which will come from cost share from Eclipse and a pending proposal to the Ohio Third Frontier Program. The remaining Materials and Supplies will be used to operate the project in Oak Ridge, Argonne National Laboratories and Cincinnati. Separate accounts will be set up at Oak Ridge and Argonne so that the post-docs and graduate students can use and order materials as they need them while they work at these labs. Some of these funds will be used to improve Internet access at the institutions for Internet based education programs that are part of this project.

The Cape Town Budget includes $20,000 for Materials and Supplies to support research and development at UCT and the Second Generation Universities.

EQUIPMENT

The UC budget includes $25,000 for equipment purchase that includes funds to purchase a polymer film reel-to-reel processing machine to be housed at Eclipse Film Technologies that will be used to prototype the production of thin film flexible solar cells. The total cost of this machine is $150,000 which will be supplied by Eclipse and possibly by a third company, LyondellBasell Corporation with a user agreement between the parties for the small amount of time that LyondellBasell is interested in using this equipment. A processing lab will be developed around this machine for the training of African scientists in solar cell production. Research in the development of new methods for the production of solar cells in

Africa will be conducted with this instrument. The instrument will be housed at Eclipse Film Technologies where expertise in polymer film processing and safety exists. The instrument is a bench scale film-processing machine produced in Germany by Collin. Some capital funds may also be used to improve existing x-ray scattering cameras at UC that will be used to characterize nano-structure in printed electronic layers and in flame made nanomaterials used in the production of solar cells.

ANALYTIC SERVICES

The Cincinnati budget also includes $2,000 per year for analytic services, which will be used for services such as use of TEM and SEM microscopes in the UC Characterization Center, mass spectrometers and other spectrometers in the Chemistry Department as well as the Engineering and Physics Machine Shops through university approved service centers. Rates at approved service centers are approved by the university council for service centers in accordance with federal regulations.

The UCT budget includes $10,000 for analytic services that include mostly the use of electron microscopes at UCT and at the National Centre for Nanostructured Materials (NCNSM) in Pretoria.

TUITION

Tuition is included in the UC budget for the graduate student at $3,090 for the first year and increasing at 3% annually as mandated by the University. Tuition is charged at a reduced rate that represents a savings of about $4,000 per year. This contribution of the University of Cincinnati is included as cost-share. UC requires an increase in tuition of 3% per year.

PUBLICATION CHARGES

The UC budget includes about $200 per year for publication and reprint charges.

INDIRECT COSTS

The University of Cincinnati indirect costs are charged at 26.0% of Modified Total Direct Costs (MTDC) per DHHS rate agreement dated 06/11/10, excluding equipment, and tuition. Indirect costs are taken on the first $25,000 of the subcontract to the University of Cape Town.

The University of Cape Town requires 13% cost recovery on recurrent non-capital expenditures and 17% cost recovery on additional salaries.

Table 9.1 Overall 2-Year Budget

Sponsoring Agency : Higher Education for Development/USAID
Principal Investigator : Gregory Beaucage
Period : 06/01/10 thru 06/01/15
Titled : Nano-Power for Africa

A. Salaries	App't Type	% Effort	PM	Salary	Year 1	Year 2	Year 3	Year 4	Year 5	CUMULATIVE
Senior Personnel										
PI Gregory Beaucage	ACAD	39.58%	2.92	$ 96,606		-		-	-	-
PI	Sumr	100.00%	3.23	$ 42,265	42,265	42,265		-	-	84,530
Co	ACAD	0.00%	0.00	$ -	-	-	-	-	-	-
	SUMR	0.00%	0.00	$ -	-	-	-	-	-	-
Co	ACAD	0.00%	0.00	$ -	-	-	-	-	-	-
	SUMR	0.00%	0.00	$ -	-	-	-	-	-	-
Co	CAL	0.00%	0.00	$ -	-	-	-	-	-	-
Co	CAL	0.00%	0.00	$ -	-	-	-	-	-	-
Senior Personnel Subtotal :					42,265	42,265	-	-	-	84,530

B. Other Personnel	Name	% Effort	PM	Salary	Year 1	Year 2	Year 3	Year 4	Year 5	CUMULATIVE
Exempt Staff (Monthly)										
Administrative Assistant		0.00%	0.00	$ -	-	-		-	-	-
		0.00%	0.00	$ -	-	-	-	-	-	-
		0.00%	0.00	$ -	-	-	-	-	-	-
Total Exempt Staff					-	-	-	-	-	-
Post Doctoral Support					85,000	85,000		-	-	170,000
Graduate Students					24,000	24,000		-	-	48,000
Undergrad Students					-	-	-	-	-	-
Part-time Faculty/Staff					-	-	-	-	-	-
Non-Exempt Staff (Bi-Weekly)					-	-	-	-	-	-
Salaries Subtotal :					151,265	151,265	-	-	-	302,530

C. Fringe Benefits	Year 1	Year 2	Year 3	Year 4	Year 5	Year 1	Year 2	Year 3	Year 4	Year 5	CUMULATIVE
Faculty	32.50%	33.00%	33.50%	34.00%	34.50%	13,736	13,947	-	-	-	27,683
Exempt Staff	37.00%	37.50%	38.00%	38.50%	39.00%	-	-	-	-	-	-
Post Doctoral	25.00%	25.50%	26.00%	26.50%	27.00%	21,250	21,675	-	-	-	42,925
Graduate Students	8.00%	8.00%	8.00%	8.00%	8.00%	1,920	1,978		-	-	3,898
Undergrad Students	8.00%	8.00%	8.00%	8.00%	8.00%	-	-	-	-	-	-
P-T Faculty/Staff	25.00%	25.50%	26.00%	26.50%	27.00%	-	-	-	-	-	-
Non-Exempt Staff	45.50%	46.00%	46.50%	47.00%	47.50%	-	-	-	-	-	-
Fringe Benefits Subtotal :						36,906	37,600	-	-	-	74,506
Total Salaries and Fringe Benefits :						**188,171**	**188,865**	**-**	**-**	**-**	**377,036**

	Year 1	Year 2	Year 3	Year 4	Year 5	CUMULATIVE
D. Equipment						
Polymer Film Lab Instrument and Improvements (UC)	25,000	-	-	-	-	25,000
Scattering Camera (UC)	-	-	-	-	-	-
Total Equipment :	**25,000**	**-**	**-**	**-**	**-**	**25,000**
E. Travel						
Domestic (list)	17,000	17,000		-	-	34,000
International (list)	43,400	21,000				64,400
Total Travel :	**60,400**	**38,000**	**-**	**-**	**-**	**98,400**
G. Supplies and Other Direct Costs						
Materials & Supplies (Includes Prototype Fabrication Lab at Eclipse)	5,220	5,220		-	-	10,440
Publication Costs	200	200		-	-	400
Consultant Services	-	-	-	-	-	-
Computer Services	-	-	-	-	-	-
UC Tuition rates (Not Subject to Indirect)	3,090	3,183		-	-	6,273
Long Distance (Not Subject to Indirect)	-	-	-	-	-	-
Other (Analytical Services/Instrument Use)	2,000	2,000		-	-	4,000
Subcontracts 1) University of Cape Town	**220,740**	**223,740**				**444,480**
2)	-	-	-	-	-	-
3)	-	-	-	-	-	-
4)	-	-	-	-	-	-
Total Supplies and Other Direct Costs :	231,250	234,343	-	-	-	465,593
TOTAL DIRECT COSTS:	**504,821**	**461,208**	**0**	**0**	**0**	**966,029**
Facilities and Administrative Cost Base:	280,991	234,285	-	-	-	515,276

Facilities and Administrative Costs Calculation:						Year 1	Year 2	Year 3	Year 4	Year 5	CUMULATIVE
F&A Cost (on MTDC):	26.00%	26.00%	26.00%	26.00%	26.00%	66,558	60,914	0	0	0	127,472
Sub-Contract <$25,000 1):	26.00%	26.00%	26.00%	26.00%	26.00%	6,500	0	0	0	0	6,500
Sub-Contract <$25,000 2):	26.00%	26.00%	26.00%	26.00%	26.00%	0	0	0	0	0	0
Sub-Contract <$25,000 3):	26.00%	26.00%	26.00%	26.00%	26.00%	0	0	0	0	0	0
Sub-Contract <$25,000 4):	26.00%	26.00%	26.00%	26.00%	26.00%	0	0	0	0	0	0
Total F&A Cost :						**73,058**	**60,914**	**-**	**-**	**-**	**133,972**
Total Cost						**577,879**	**522,122**	**0**	**0**	**0**	**1,100,000**

Facilities and Administrative Data

Purpose of Grant / Contract :	R	(R = Research, I = Instruction, P = Public Service, S = Special Rate on Total Costs)
Campus Status :	O	(C = On Campus, O = Off Campus)
Special F&A Rate :	10.00%	

Table 9.2 Required Cost Sharing 25% of Total Budget (Including Cost Share)

Needed Funds Based on Budget:	**192,626.29**	**174,040.53**				**366,666.83**
Total of Contributions (Committed and Pending)	**961,076.14**	**940,771.46**				**1,801,847.60**
Percent of Total Budget Including Matching:	**62.4**	**64.3**				**62.1**
Interest on UCT Project Funds (1.9 %)	4,194.06	4,251.06	-	-	-	8,445.12
UCT Internationl Fee Waiver	45,000.00	45,000.00				90,000.00
UCT NanoScience Innovation Center	200,000.00	200,000.00				400,000.00
NRF Research Funds (Britton and Härting)	40,000.00	40,000.00				80,000.00
Omega Optics Company	75,000.00	75,000.00				150,000.00
Gregory Smith ORNL	40,340.00	41,550.20				81,890.20
Jan Ilavsky APS/ANL	40,000.00	41,200.00				81,200.00
Sun Chemical Russell Schwartz	100,000.00	100,000.00				200,000.00
Eclipse Film Technology, Ryan Breese	277,500.00	285,825.00				563,325.00
Collins Ink, Suresh Murugesan	20,000.00	20,000.00				40,000.00
Graduate Tuition at UC	36,840.00	37,945.20				74,785.20
Beaucage Sabbatical Leave 2010 (50%)	32,202.08					32,202.08
AFOSR Proposal	50,000.00	50,000.00				100,000.00

Table 9.3 Cape Town Budget

Sponsoring Agency : Higher Education for Development/USAID
Principal Investigator : David Britton/Margit Härting UCT
Period : 06/01/10 thru 06/01/15
Titled : Nano-Power for Africa (CAPE TOWN PARTIAL BUDGET)

	App't Type	% Effort	PM	Salary	Year 1	Year 2	Year 3	Year 4	Year 5	CUMULATIVE
A. Salaries										
Senior Personnel	App't Type	% Effort	PM	Salary						
PI David T. Britton (1)	ACAD	100.00%	7.38		30,000	30,000		-	-	60,000
PI	SUMR	0.00%	0.00			-	-	-	-	-
Co Margit Härting (2)	ACAD	100.00%	7.38	$ -	30,000	30,000		-	-	60,000
Co	SUMR	0.00%	0.00	$ -	-	-	-	-	-	-
Co Girma Goro Gonfa (3)	ACAD	0.00%	0.00	$ -	10,000	10,000		-	-	20,000
	SUMR	0.00%	0.00	$ -		-	-	-	-	-
Co Evariste Minani (4)	ACAD	0.00%	0.00	$ -	10,000	10,000		-	-	20,000
Co		0.00%	0.00	$ -	-	-	-	-	-	-
Senior Personnel Subtotal :					80,000	80,000	-	-	-	160,000
B. Other Personnel										
Exempt Staff (Monthly)	Name									
Secretary UCT		0.00%	0.00	$ -	18,000	18,000		-	-	36,000
Technicain UCT					-	-		-	-	-
Secretary Haramaya University					-	-		-	-	-
Technician Haramaya University						-	-	-	-	-
Secretary Kigali Institute of Technology					-	-		-	-	-
Technician Kigali Institute of Technology		0.00%	0.00	$ -	-	-	-	-	-	-
		0.00%	0.00	$ -		-	-	-	-	-
Total Exempt Staff					18,000	18,000	-	-	-	36,000
Post Doctoral Support (0)								-	-	-
Visiting Scientist Stipend (2)					5,800	5,800		-	-	11,600
Graduate Students UCT MSc (2)					30,000	30,000		-	-	60,000
Graduate Students UCT PhD (1)					20,000	20,000		-	-	40,000
Student Support Haramaya University (3)					3,000	3,000		-	-	6,000
Student Support Kigali Institute of Education (3)						3,000		-	-	3,000
Salaries Subtotal :					151,000	154,000	-	-	-	305,000
C. Fringe Benefits										
Faculty										-
Exempt Staff										-
Post Doctoral										-
Graduate Students						-	-	-	-	-
Undergrad Students										-
P-T Faculty/Staff										-
Non-Exempt Staff										-
Fringe Benefits Subtotal :					-	-	-	-	-	-
Total Salaries and Fringe Benefits :					**151,000**	**154,000**	**-**	**-**	**-**	**305,000**
D. Equipment										
Haramaya University Teaching Equipment (11)								-	-	-
Haramaya University Research Equipment (12							-	-	-	-
Kigali Institute of Education Teaching Equipment (13)								-	-	-
Kigali Institute of Education Research Equipment (14)							-	-	-	-
UCT Research equipment (15)								-	-	-
Total Equipment :					**-**	**-**	**-**	**-**	**-**	**-**
E. Travel										
Domestic	(list)				3,000	3,000		-	-	6,000
International	(list)				22,700	22,700				45,400
Total Travel :					**25,700**	**25,700**	**-**	**-**	**-**	**51,400**
G. Supplies and Other Direct Costs										
Materials & Supplies (15)					20,000	20,000		-	-	40,000
Publication Costs						-	-	-	-	-
Consultant Services					-	-	-	-	-	-
Computer Services					-	-	-	-	-	-
UC Tuition rates (Not Subject to Indirect)						-	-	-	-	-
Long Distance (Not Subject to Indirect)					-	-	-	-	-	-
Other (Analytical Services/Instrument Use) (16)					10,000	10,000		-	-	20,000
Subcontracts **1)**	University of Cape Town					-	-	-	-	-
2)	Haramaya University				-	-	-	-	-	-
3)	Kigali Institute of Education				-	-	-	-	-	-
4)					-	-	-	-	-	-
Total Supplies and Other Direct Costs :					30,000	30,000	-	-	-	60,000
TOTAL DIRECT COSTS:					**206,700**	**209,700**	**0**	**0**	**0**	**416,400**
Facilities and Administrative Cost Base:					206,700	209,700	-	-	-	416,400

C. Fringe Benefits (rates)

	Year 1	Year 2	Year 3	Year 4	Year 5
Faculty	32.50%	33.00%	33.50%	34.00%	34.50%
Exempt Staff	37.00%	37.50%	38.00%	38.50%	39.00%
Post Doctoral	25.00%	25.50%	26.00%	26.50%	27.00%
Graduate Students	8.00%	8.00%	8.00%	8.00%	8.00%
Undergrad Students	8.00%	8.00%	8.00%	8.00%	8.00%
P-T Faculty/Staff	25.00%	25.50%	26.00%	26.50%	27.00%
Non-Exempt Staff	45.50%	46.00%	46.50%	47.00%	47.50%

Facilities and Administrative Costs Calculation:

	Rate Yr 1	Rate Yr 2	Rate Yr 3	Rate Yr 4	Rate Yr 5	Year 1	Year 2	Year 3	Year 4	Year 5	CUMULATIVE
UCT 13% Cost Recovery on Recurrent Non-Capital ($30,000)						3,900	3,900		0	0	7,800
UCT 17% Cost Recovery on Additional Salaries ($78,000)						10,140	10,140		0	0	20,280
Sub-Contract <$25,000 2):	0.00%	0.00%	0.00%	0.00%	0.00%	0	0	0	0	0	0
Sub-Contract <$25,000 3):	0.00%	0.00%	0.00%	0.00%	0.00%	0	0	0	0	0	0
Sub-Contract <$25,000 4):	0.00%	0.00%	0.00%	0.00%	0.00%	0	0	0	0	0	0
Total F&A Cost :						**14,040**	**14,040**	**-**	**-**	**-**	**28,080**
Total Cost						**220,740**	**223,740**	**0**	**0**	**0**	**444,480**

Facilities and Administrative Data

Purpose of Grant / Contract : R (R = Research, I = Instruction, P = Public Service, S = Special Rate on Total Costs) 697456
Campus Status : O (C = On Campus, O = Off Campus)
Special F&A Rate : 10.00%

Appendices

Appendix A: Two page Curricula Vitae for Project Partners.

Curricula Vitae are provided for:

Prof. Gregory Beaucage, University of Cincinnati
Prof. David Britton, University of Cape Town
Prof. Margit Härting, University of Cape Town
Dr. Girma Goro Gonfa, Haramaya University, Ethiopia
Dr. Schadrack Nsengiyumva, Kigali Institute of Education, Rwanda
Dr. Everiste Minani, Kigali Institute of Education, Rwanda
Dr. Ryan Breese. Eclipse Film Technology, Cincinnati OH
Dr. Jan Ilavsky, Argonne National Laboratory, Argonne IL
Dr. Greg Smith, Oak Ridge National Laboratory, Oak Ridge, TN

Gregory Beaucage, Professor
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http://www.eng.uc.edu/~gbeaucag/BeaucageResearchGroup.html

1980 University of Rhode Island, Kingston, RI 02881 ***B.S. Zoology***; Highest Distinction. (National Merit Scholar Finalist, Elected to Phi Beta Kappa)

1982 University of Rhode Island, Kingston, RI 02881 ***B.S. Chemical Engineering;*** High Distinction. (Elected to Phi Kappa Phi)

1991 University of Massachusetts, Amherst, MA 01003 ***Ph.D. Polymer Science and Engineering***. Advisor: ***Richard S. Stein***. *A Morphological, Mechanical and Thermodynamic Investigation of the Isotactic-PVME/PS Polymer Blend.*

1991 Sandia National Laboratory, Albuquerque, NM 87185; ***Post Doctoral Fellow***, Organic Materials Group *Characterization of nanomaterials using scattering & scattering theory.*

Appointments

University of Cincinnati, Cincinnati, OH, 45221 ***Professor***, Department of Chemical and Materials Engineering, 2008-present.

University of Cincinnati, Cincinnati, OH, 45221 ***Associate Professor***, Department of Chemical and Materials Engineering, 2000-2007.

ETHZ, Zurich Switzerland ***Visiting Professor*** Funded by Swiss National Science Foundation and Dupont Corporation. 8/2003-8/2004.

University of Cincinnati, Cincinnati, OH, 45221 ***Assistant Professor***, Department of Materials Science and Engineering, 1994-2000.

Sandia National Laboratory, Albuquerque, NM 87185, ***Staff Member***, Organic Materials Group 1815. Cooperative research agreements with U.S. industrial partners. 1993-1994.

US Patent and Trademark Office, Arlington, VA. Patent Examiner Biomedical Materials. 1982-1986.

Other Experience and Professional Memberships

2008 Fellow American Physical Society
2000-2008 Advisory Board Intense Pulse Neutron Source, Argonne Natonal Laboraotry.
2003-present Founding Member of LENS Neutron Scattering Facility at Indiana University
2000-present Founding Member of LSU Synchrotron CAMD SAXS User Group
1980-present Member American Institute of Chemical Engineers
1990-present Member American Physical Society
1992-present Member American Crystallographic Society
2004-2005 Chair of the Small Angle Scattering Special Interest Group ACryS.
2003-2004 Program Chair Small Angle Scattering Special Interest Group ACryS
1995-present Panel and Individual Referee for NSF/PRF/DOE/Commerce Proposals.

10 Related Publications (from 113 peer reviewed H-Index 25)

1) *Towards resolution of ambiguity for the unfolded state.* Beaucage G *Biophysical J.* **95** 503-509 (2008).
2) *Probing the dynamics of nanoparticle growth in a flame using synchrotron radiation.* Beaucage G, Kammler HK, Mueller R, Strobel R, Agashe N, Pratsinis SE and Narayanan T, *Nature Mater.* **3,** 370-373 (2004).
3) *In situ studies of nano-particle growth dynamics in premixed flames.* Kammler HK, Beaucage G, Kohls DJ, Agashe N. Ilavsky J., *J Appl. Phys.* **97**(5) 2005 (Article 054309).
4) *3D Hierarchical orientation in polymer-clay nanocomposite films.* Bafna A, Beaucage G, Mirabella F *Polymer* **44**, 1103-1115 (2003).
5) *A structural model for equilibrium swollen networks.* Sukumaran SK, Beaucage G *Europhysics Letters* **59** 714-720 (2002).
6) *Approximations leading to a unified exponential/power-law approach to small-angle scattering.* Beaucage G, *J. Appl. Crystallogr.* **28**, 717-728 (1995).
7) *Small-Angle Scattering from Polymeric Mass Fractals of Arbitrary Mass-Fractal Dimension.* Beaucage G, *J. Appl. Crystallogr.* **29**, 134-146 (1996).
8) *Determination of branch fraction and minimum dimension of mass-fractal aggregates.* Beaucage G, *Phys. Rev. E*, **70**, 031401 (2004).
9) *Quantification of branching in disordered materials.* Kulkarni A, Beaucage G *J. Polym. Sci. Polym. Phys.* **44** 1395-1405 (2006).
10) *Persistence Length of Short-Chain Branched Polyethylene* Ramachandran R, Beaucage G, Kulkarni AS, McFaddin D, Merrick-Mack J, Galiatsatos V *Macromolecules* In Press (11/2008).

Synergistic Activities

1) *Creation*: Development of scattering theories (the unified function) to describe aggregate

nanostructures, biopolymers, branched structures [1-4,6-10]. *Integration:* Pioneered application of x-ray scattering in situ to pyrolytic synthesis of nanomaterials [2,3]. *Transfer of Knowledge*: Developed and co-developed user software for the analysis of scattering data using the unified function with Jan Ilavsky.

2) *Creation*: Developed aero-sol-gel reactor for room temperature aerosol synthesis.

3) Transfer of Knowledge: Chairman of small-angle scattering group American Crystallographic Association, Organizer for annual meeting of ACA.

4) *Transfer of Knowledge*: Organizer for characterization session in particle technology for AIChE meeting Fall 2005, and Spring (World Particle Congress) 2006. Organizing session on in situ characterization for Fall 2006 AICHE meeting in San Francisco. Organized three sessions for AIChE in Philadelphia 100'th Anniversary Annual Meeting 2008.

5) *Transfer of Knowledge*: 12 web courses (9 pertaining to polymers) extensive notes, lab experiments and data. 235,000 different IP#'s have hit this course suite since 2000 (averaging >70 IP hits/day).

Collaborators & Other Affiliations (past 48 months)

Dr. J. A. van Bokhoven, Professor, ETH, Chem. and Bioengineering, Zurich, Switzerland.

Dr. J. Ilavsky, UNICAT, APS, Argonne National Laboratories, Argonne Illinois.

Dr. F. Mirabella, Independent Consultant, Fort Myers Flordia.

Dr. T. Narayanan, ESRF ID02, Grenoble France.

Dr. S. E. Pratsinis, Process Engineering, ETHZ, Zurich, Switzerland.

Dr. S. K. Sukumaran, Assistant Professor, Yamamoto University Japan.

Dr. T. Trevoort, Materials Science, ETHZ, Zurich Switzerland.

Vassilios Galiatsatos, Senior Scientist, LyodellBasell Cincinnati OH

Peter Smirnoitis, Professor Chemical Engineering, University of Cincinnati

David Britton, Professor Physics, University of Cape Town, South Africa

Graduate & Postdoctoral Advisors

Dr. Richard S. Stein, Emeritus Professor of Polymer Science and Engineering, University of Massachusetts, Amherst, MA. Member NAS and NAE.

Dr. D. W. Schaefer, Professor of Engineering (Formerly Dean of Engineering), U. Cincinnati. Post-doc was with Schaefer and John Curro at Sandia National Laboratory.

Dr. J. G. Curro, Former Head of Polymer Group, Sandia National Laboratory, Albuquerque NM.

Thesis Advisor and Postgraduate-Scholar Sponsor (PhD: 7 , MS: 8, Post Doc: 2)

Current Students: (4 Graduate Students, 2 Funded REU Undergraduate, 1 funded RET High School Teacher, 2 Unfunded Undergraduates)

Durgesh Rai: PhD studies scattering theory.

Sachit Chopras: PhD studies flame-made nanoparticles for nano-catalysts and other applications. Funded by NSF CTS.

Ramnath Ramachandran: PhD studies branching and persistence effects on rheology in polyolefins. Funded by LyondellBasell.

Ryan Breese (MS 2004; PhD 2009): PhD studies on oriented polymer film structure/property relationships. Funded by Equistar and now by Eclipse Film Technologies.

Mangesh Champhekar: (MS 11/2008) Studies of ultra oriented polyolefin/clay nano-composites.

Hao Liu, Senior Project: In situ SAXS studies of Diesel Exhaust at the CHESS Synchrotron.

Kurt Woodford, *Senior Project: Orientation in Polyolefin Films*.

Undergraduate Research Assistant (NSF REU Students): Stephanie Berger, Carbon coated silica for solar cell applications. **Robin Holland,** (Minority REU Student) In situ studies of diesel exhaust nanoparticulates using synchrotrons. **Maesa Idries**, Current REU student.

High School Teacher (NSF RET Participant): Edwin Segbefia Princeton High School Physics Department (Minority teacher). Flame-made hematite nano-particles for arsenic remediation in drinking water.

Select Past Graduated Students/Post Doc

Amit Kulkarni (MS 2004; PhD 2007): Funded by P&G, Intel, Equistar. Currently Research Engineer *GE Plastics Evansville IN (10/2007).*

Doug Kohls, (MS 2002; PhD 2006): Currently Assistant Professor Dept. Materials Science and Engineering University of Cincinnati.

Hashard Chavan (MS 2006) *Bioplastics San Jose CA.*

Ayush Bafna (PhD 2004, MS 2002) *Research Engineer, Dow Chemical Central Research Freeport TX.*

Nikhil Agashe (PhD 2004, MS 2001) *Research Engineer GE Plastics, Evanston IN.*

Suresh Murugesan (PhD Chemistry 2003) *Scientist Texas Research Institute.*

S. Sukumaran (PhD 2002) *Asst. Prof. Polymer Science Yamata University, Japan*.

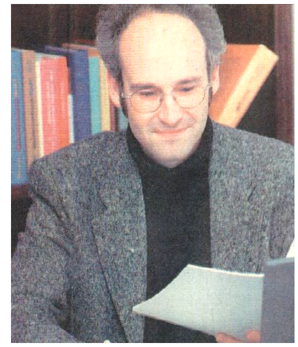
G. Skillas (Post-Doc from ETH Zurich 2001) *Research scientist, GMX Degussa, Hanau Germany.*

J. Hyeon-Lee (PhD 1998) *Research Scientist, Samsung Research Institute, Seoul, South Korea.*

Ling Guo (MS 1997) *P&G Miami Valley Laboratories (Central Research Division).*

S. Rane (PhD 1999) *Senior Research Engineer, Procter& Gamble Beckett Ridge Technical Center Cincinnati.*

Curriculum Vitae: David Thomas **Britton**



Born: 15th October 1959, Huddersfield, England

Sex: Male; Nationality: British (SA permanent resident)

Marital Status: Single

associate Professor,

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South Africa

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Academic Qualifications:

1977 - 81	Imperial College, University of London, B.Sc. (Hons) in *Physics*.
1982 - 83	Bedford College, University of London, M.Sc. in *Nuclear and Elementary Particle Physics*.
1983 - 87	Royal Holloway and Bedford New College, University of London, Ph.D. in *Physics*.
1994	Universität der Bundeswehr München, Dr. Ing. habil. in *Experimenteller Festkörperphysik*.

Previous Employment:

1987 - 88	Interfaculty Reactor Institute, Delft University of Technology, TU Delft Research Fellow.
1988 - 89	Laboratory of Physics, Helsinki University of Technology, Royal Society of London European Exchange Programme Fellow.
1989 - 94	Institut für Nukleare Festkörperphysik, Universität der Bundeswehr München, Research Associate.
1995 - 99	Department of Physics, University of Cape Town, Senior Lecturer .

Biography:

David Britton is an Associate Professor in the Physics Department at the University of Cape Town, where he has been employed since moving to South Africa in January 1995. He is also the past chair of the South African Nanotechnology Initiative (SANi). Professor Britton was born in Huddersfield, UK, and studied at various colleges of the University of London. After obtaining his PhD from Royal Holloway College in 1988, he spent several years as a postdoctoral fellow in the Netherlands, Finland and Germany. His current research interests follow his career path from the characterisation of defects and nanoscale structures, through dynamic processes and transport in solids, to the development and applications of novel nanomaterials, including printable silicon for electronics and solar power. Prof Britton has published approximately 100 peer reviewed papers and is listed as an inventor in 7 families of patent applications.

Recent Publications

1. *Hot-Wire Synthesis of Si Nanoparticles*,
M.R. Scriba, C.J. Arendse, M. Härting, and D.T. Britton,
Thin Solid Films **516**, 844 - 846 (2008)
2. *Theoretical Study of Strain Fields and Local Order in Hydrogenated Amorphous Silicon*,
A.M. Ukpong, M. Härting, and D.T. Britton,
Philosophical Magazine Letters **88**, 293 – 302 (2008)
3. *A Magnetic Transport Middle Eastern Positron Beam*
I.Y. Al-Qaradawi, DT Britton, R. Rajaraman, and D. Abdulmalik,
Applied Surface Science, **255**, 125 - 127 (2008)
4. Determination of the Elastic Modulus of Mesoporous Silica Thin Films by X-Ray Reflectivity via the Capillary Condensation of Water,
S. Dourdain, D.T. Britton, H.Reichert, and A. Gibaud,
Applied Physics Letters **93**, 183108 (2008)
5. *Composition and Crystallinity of Silicon Nanoparticles Synthesized by Hot Wire Thermal Catalytic Pyrolysis at Different Pressures,*
M.R. Scriba, D.T. Britton, C. Arendse, M.J. van Staden, and M. Härting,
Thin Solid Films **517**, 3484 – 3487 (2009)
6. *Size Distribution and Surface Characteristics of Silicon Nanoparticles,*
D.T. Britton, E.A. Odo, G. Goro Gonfa, E.O. Jonah, and M. Härting,
Journal of Applied Crystallography **42**, 448 - 456 (2009).
7. *Fully Printed Field Effect Transistors,*
M. Härting, J. Zhang, D.R. Gamota, and D.T. Britton,
Applied Physics Letters **94**, 193509 (2009).
8. *Ab Initio Pseudopotential Study of Vacancies and Self-Interstitials in hcp Titanium*,
A.T. Raji, S. Scandolo, R. Mazzarello, S. Nsengiyumva, M. Härting, and D.T. Britton,
Philosophical Magazine **89**, 1629 -1645 (2009).
9. *The Mutual Influence of Krypton Implantation and Pre-existing Stress States in Polycrystalline Alpha Titanium,*
S. Nsengiyumva, T.P. Ntsoane, A.T. Raji, M. Topic, G. Kellerman, J.P. Riviere, D.T. Britton, and M. Härting
Nuclear Instruments and Methods B **267**, 2712 - 2715 (2009).
10. *Ab Initio Study of Krypton in hcp Ti: Diffusion, Formation, and Stability of Small Krypton-Vacancy Clusters,*
A.T. Raji, S. Scandolo, R. Mazzarello, S. Nsengiyumva, M. Härting, and D.T. Britton,
Nuclear Instruments and Methods B **267**, 2991 - 2994 (2009).
11. *Sub-Oxide Passivation of Silicon Nanoparticles for Printed Electronics Applications*,
M. Härting, G Goro Gonfa, E.A. Odo, M.R. Scriba, M.J. van Staden, and D.T. Britton,
Submitted for publication.

Published Patents and Applications

1. *A Thin Film Semiconductor Device and Method of Manufacturing a Thin Film Semiconductor Device*,
M. Härting and D.T. Britton
ZA 2005/006095, WO 2004/068536 PCT (2004-08-12), EP1593163 European (2005-11-09), US2006199313 USA (2006-09-07), JP 2006/502374 Japanese (2006-07-06)
2. *Semiconducting Nanoparticles with Surface Modification*
D.T. Britton and M. Härting
ZA 2008/00436, WO 2007/004014 PCT (2007-01-11), EP 1899261 European (2008-03-19), CN 10218168 Chinese (2008-07-09)
3. *Doping of Particulate Semiconductor Materials*
D.T. Britton and M. Härting
ZA 2005/06752 Provisional, WO 2007/023362 PCT (2007-03-01), EP 1926843 European (2008-06-04), CN 101248222 Chinese (2008-08-20)
4. *Thick Film Semiconducting Inks*
M. Härting, D.T. Britton, and E.A. Odo
ZA 2005/10436 Provisional, WO 2007/072162 PCT (2007-06-28), EP1971651 European (2008-09-24),
5. *Method of Producing Stable Oxygen Terminated Semiconducting Nanoparticles*
D.T. Britton and M. Härting
ZA 2008/0727 Provisional, WO 2009/125370 (2009-10-15)
6. *Inkjet Printing of Nanoparticulate Functional Inks*
M. Härting, D.T. Britton and E.A. Odo
ZA 2008/ Provisional
7. *Nanolabeling of Metals*
J.H. Dickerson, D.T. Britton and M. Härting
US 61/135735 Provisional (2008)

Curriculum Vitae

Name: Margit HÄRTING née Neidlinger.
Born: 29th September 1954 in Passau, Germany.
Marital Status: Married.
Citizenship: German, permanent SA resident.
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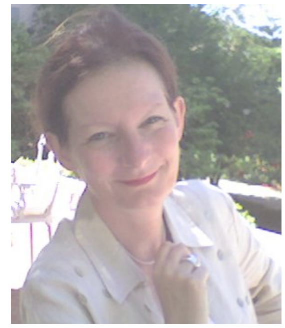

Associate Professor,
Dept. of Physics, University of Cape Town, Rondebosch 7701, South Africa.
Non-excutive director,
National Metrology Institute of South Africa

Academic Qualifications

1975 - 80	University of Applied Science Regensburg, Germany Dipl. Ing. in Electrical Engineering (equivalent to MTech.)
1980 - 86	University of Regensburg, Germany Dipl. Phys. in Physics (equivalent to MSc.)
1989 - 94	University of the Federal Armed Forces Munich, Germany Dr. Ing. in Physics (equivalent to PhD.)

Positions Held

1987 - 89	Institute for Metrology, University of the Federal Armed Forces Munich, Germany. Research Associate.
1989 - 94	Institute for Mathematics and Physics, University of the Federal Armed Forces Munich, Germany Research Associate.
1994 - 95	Institute for Applied Physics, Swiss Federal Institute for Technology (ETH) Zurich, Switzerland. Research Associate.
1995 - 99	Department of Physics, University of Cape Town, South Africa Lecturer
1999 - 2002	Department of Physics, University of Cape Town, South Africa Senior Lecturer

Biography

Margit Härting is an Associate Professor in the Physics Department at the University of Cape Town (UCT), where she has been employed since coming to South Africa in 1995. Professor Härting was born in Passau, Germany and completed her studies in electrical engineering and in physics in Regensburg. After obtaining her doctorate from the Federal Armed Forces University in Munich, she spent several years as a postdoctoral fellow at the ETH in Zurich, Switzerland. Her current research interests range from: fundamental studies of stress driven defect processes, through the characterization of nanoscale structures and materials, to the development of electronic systems based on printed nanoparticulate silicon. Besides being an active researcher and educator (she has graduated 23 MSc and PhD students since joining UCT), Prof Härting has played a significant role in the South African Research and Innovation Community. She was the founder and first convenor of the Cape Initiative on Materials and Manufacturing, and an active member of the electronics sector working group in the development of the Western Cape Provincial Manufacturing Strategy. She is also a former member of the executive committee of the South African Nanotechnology Initiative (SANi). In the Science community she has served as both a referee and evaluator for numerous international journals and funding programmes, and in the Innovation community as an evaluator for the South African Innovation Fund. Currently she is leading the commercialisation of an Innovation Fund project, of which was the coordinator and principal investigator, on the development of printed silicon electronics. Particularly in this area, she has been invited to present this work at both academic and commercial conferences. Notwithstanding these activities, which have led to the filing of six patent families, she is still actively pursuing, and regularly publishing in the public domain, her research in other areas of materials research, and remains active in public service. She therefore currently serves on the board of the National Metrology Institute of South Africa (NMISA).

Recent Publications

1. *Hot-Wire Synthesis of Si Nanoparticles*,
M.R. Scriba, C.J. Arendse, M. Härting, and D.T. Britton,
Thin Solid Films **516**, 844 - 846 (2008)
2. *Theoretical Study of Strain Fields and Local Order in Hydrogenated Amorphous Silicon*,
A.M. Ukpong, M. Härting, and D.T. Britton,
Philosophical Magazine Letters **88**, 293 – 302 (2008)
4. *Composition and Crystallinity of Silicon Nanoparticles Synthesized by Hot Wire Thermal Catalytic Pyrolysis at Different Pressures,*
M.R. Scriba, D.T. Britton, C. Arendse, M.J. van Staden, and M. Härting,
Thin Solid Films **517**, 3484 – 3487 (2009)
5. *Size Distribution and Surface Characteristics of Silicon Nanoparticles,*
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Journal of Applied Crystallography **42**, 448 - 456 (2009).
6. *Fully Printed Field Effect Transistors,*
M. Härting, J. Zhang, D.R. Gamota, and D.T. Britton,
Applied Physics Letters **94**, 193509 (2009).
7. *Ab Initio Pseudopotential Study of Vacancies and Self-Interstitials in hcp Titanium*,
A.T. Raji, S. Scandolo, R. Mazzarello, S. Nsengiyumva, M. Härting, and D.T. Britton,
Philosophical Magazine **89**, 1629 -1645 (2009).
8. *The Mutual Influence of Krypton Implantation and Pre-existing Stress States in Polycrystalline Alpha Titanium,*
S. Nsengiyumva, T.P. Ntsoane, A.T. Raji, M. Topic, G. Kellerman, J.P. Riviere, D.T. Britton, and M. Härting
Nuclear Instruments and Methods B **267**, 2712 - 2715 (2009).
9. *Ab Initio Study of Krypton in hcp Ti: Diffusion, Formation, and Stability of Small Krypton-Vacancy Clusters,*
A.T. Raji, S. Scandolo, R. Mazzarello, S. Nsengiyumva, M. Härting, and D.T. Britton,
Nuclear Instruments and Methods B **267**, 2991 - 2994 (2009).
10. *Sub-Oxide Passivation of Silicon Nanoparticles for Printed Electronics Applications*,
M. Härting, G Goro Gonfa, E.A. Odo, M.R. Scriba, M.J. van Staden, and D.T. Britton,
Submitted for publication.

Published Patents and Applications

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M. Härting and D.T. Britton
ZA 2005/006095, WO 2004/068536 PCT (2004-08-12), EP1593163 European (2005-11-09), US2006199313 USA (2006-09-07), JP 2006/502374 Japanese (2006-07-06)
2. *Semiconducting Nanoparticles with Surface Modification*
D.T. Britton and M. Härting
ZA 2008/00436, WO 2007/004014 PCT (2007-01-11), EP 1899261 European (2008-03-19), CN 10218168 Chinese (2008-07-09)
3. *Doping of Particulate Semiconductor Materials*
D.T. Britton and M. Härting
ZA 2005/06752 Provisional, WO 2007/023362 PCT (2007-03-01), EP 1926843 European (2008-06-04), CN 101248222 Chinese (2008-08-20)
4. *Thick Film Semiconducting Inks*
M. Härting, D.T. Britton, and E.A. Odo
ZA 2005/10436 Provisional, WO 2007/072162 PCT (2007-06-28), EP1971651 European (2008-09-24),
5. *Method of Producing Stable Oxygen Terminated Semiconducting Nanoparticles*
D.T. Britton and M. Härting
ZA 2008/0727 Provisional, WO 2009/125370 (2009-10-15)
6. *Inkjet Printing of Nanoparticulate Functional Inks*
M. Härting, D.T. Britton and E.A. Odo
ZA 2008/ Provisional
7. *Nanolabeling of Metals*
J.H. Dickerson, D.T. Britton and M. Härting
US 61/135735 Provisional (2008)

Dr. Girma Goro Gonfa
Lecturer in Physics
Haramaya University Main Capus, Ethiopia
Haramaya University, Ethiopia
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EDUCATION
University of Cape Town, 2004-2009, PhD
Addis Ababa University 1996-1998, M.Sc. in Physics
Asmara University 1986 – 1990, B.Sc. in Physics
Tikur Anbessa Secondary School , Addis Ababa Ethiopia, 1983 – 1986, School Leaving Certificate.

PROFESSIONAL
Associate Dean, Faculty of Education, 2002 – 2003, Alemaya University
Head, Department of Physics, 2000 – 2002., Alemaya University
Lecturer, Alemaya University, Physics Department, 1998-2003.
Head, Provincial Educational Programming Office 1995-1996, Adama
Principal, Teachers' Training Institute 1995. Adama

SCIENTIFIC AND PROFESSIONAL SOCIETIES
Member, South African Institute of Physics(SAIP), Since 2004
Member, South African Nano-Technology Initiative(SANI), Since 2004
Member, Ethiopian Physical Society, since 1999
Member of Ethiopian Teachers' Association, since 1990.

AWARDS
Awarded ANSTI-UNU fellowship , 2004
UCT-PFO International Scholarship, 2006

PRESENTATION AND CONFERENCE PARTICIPATION
Electrical and Structural Studies of nc-Si For Device Applications, Poster Presentation at SAIP, Bloemfontein, July 2004, South Africa
Hall Effect Studies of Nanocrystalline Silicon, Poster Presentation at SAIP, Pretoria, 2005, South Africa
Synthesis and Characterization of Nanostructured Silicon Powder for Flexible Device Application By Mechanical Attrition, Poster Presentation at ICANS21, Lisbon 2005, Portugal
Effects of Inorganic Salts on the Electrical Properties of Nanoparticulate Silicon Layers, Oral presentation at SAIP, Cape Town 2006, South Africa.

PUBLICATIONS
1***.Girma Goro*** and Bantikassegn Workalemahu." Vibronic states and electronic properties of aluminium junctions with melt-processed poly[3-(2,5-dioctylphenyl) thiophene] (PDOPT)". SINET: Ethiopian Journal of Science, Vol. 22, No.1, June 1999, 1- 14.

2. G. Goro , E.A. Odo , T. Thovhogi. F.L. Ramukosi , D.T. Britton, and M. Härting , Synthesis and Characterisation of Nanostructured Silicon Powder for Flexible Device Application by Mechanical Attrition. (submitted)
3. Odo, E.A**., Goro, G**., Thovhogi, T., Ramukosi, F., Britton, D.T. and Härting, M. 2004. Production of silicon nanopowder by mechanical attrition. Proceedings of the First Conference on Materials in Manufacturing - Harnessing Local Expertise to Improve Global Competitiveness, University of Cape Town, 14-15 October 2004, 34-35.
4. D.T. Britton, E.A. Odo, **Girma Goro Gonfa**, E.O. Jonah, M Harting, 2009, Size Distribution and surface characterstics of Silicon Nanoparticles, Jurnal of Applied Crystallography, 42, 448
5. M Harting, **Girma Goro Gonfa**, E.A Odo, M. R. Scriba, M van Staaden, D.T. Britoon, 2009, Sob-Oxide Passivated Electrically active silicon Nanoparticles, submitted to Nature Nanotechnology

BOOKS AND CHAPTERS

Participated in the following Teaching material development for Distance Education.
Mechanics and Electro- Magnetism I , Ministry of Education, Ethiopia
Mechanics and Electro-Magnetism II, Ministry of Education, Ethiopia
Introduction to Basic Electronics, Ministry of Education, Ethiopia

UNDERGRADUATE TEACHING EXPERIENCE
Mechanics and Heat I, Alemaya University,
Mechanics and Heat II Alemaya University
Electricity and Magnetism I, Alemaya University
Intro. To Modern Physics, Alemaya University
Quantum Mechanics I, Alemaya University,
Quantum Mechanics II, Alemaya University
Classical Mechanics I, Alemaya University
Experimental Physics, I, Alemaya University
Experimental Physics, II Alemaya University
Experimental Physics, III Alemaya University
Demonstrator and Tutor for Phy110, Phy131/2, Phy210, University of Cape Town
Demonstrator for Phy213, University of Cape Town

References

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PERSONAL IDENTIFICATION

Surname: Nsengiyumva
First name: Schadrack
Place and birth date: Nkumba-Ruhengeri, 23/01/1962
Marital status: Married
Nationality: Rwandese
Title: Mr
Home language: Kinyarwanda
Other languages: French and English (fluent in reading, writing and speaking)

II. EDUCATION

1. Tertiary Education

BSc Honours
Year: 1982-1987
Major subject: Physics
Institution: National University of Rwanda

Master of Science
Year: 2001-2002
Major subject: Physics (Solid State Physics)
Institution: University of Stellenbosch

PhD in Physics (Solid State Physics)
Year: April 2003-2008
Institution: University of Cape Town

III. PUBLICATIONS

1. *Vacancy and Krypton dynamics in Kr-implanted Naturally oxidised Aluminium*, M. Härting, D.F. Kanguwe, C.M. Comrie, S. Nsengiyumva, S.R. Naidoo, T.E. Derry and D.T. Britton, Materials Science and Engineering, 445-446 (2004), pp 102-104.
2. *Krypton-induced surface modification of polycrystalline titanium*, M. Topic, S. Nsengiyumva, R. Bucher, S.R. Naidoo, T.E. Derry, C.M. Comrie, C. Theron, D.T. Britton, and M. Härting, Surface and Coatings Technology, 201 (2007) 5621-5627.
3. *Near surface stress determination in Kr-implanted Polycrystalline Titanium by the X-ray sin2psi method*, M. Härting, S. Nsengiyumva, A.T. Raji, G. Dollinger, P. Sperr, S.R. Naidoo. T.E. Derry, C.M. Comrie, and D.T. Britton, Surface and Coatings Technology, 201 (2007) 8237-8241.
4. *Scientific Visualization: Analysis, Exploration and Presentation of Tri-Axial stress states of Kr+ implanted Titanium determined by X-ray diffraction*, M. Yaman, M. Härting, S. Nsengiyumva, Surface and Coatings Technology, 201 (2007) 8431-8436

5. *The mutual influence of krypton implantation and pre-existing stress states in polycrystalline alpha titanium*, S. Nsengiyumva, T.P. Ntsoane, A.T. Raji, M. Topic, G. Kellermann, J. P. Rivière, D.T. Britton, and M. Härting, Nuclear Instruments and Methods in Physics research B 267 (2009) 2712-2715
6. *Ab Initio Study of Krypton in hcp Ti: Diffusion, Formation, and Stability of Small Krypton-Vacancy Clusters***,** A.T. Raji, S. Scandolo, R. Mazzarello, S. Nsengiyumva, M. Härting, and D.T. Britton, Nuclear Instruments and Methods B **267**, (2009) 2991 - 2994
7. *Ab initio Pseudopotential study of vacancies and self-interstitials in HCP Titanium,* A.T. Raji, S. Scandol, R. Mazzarello, S. Nsengiyumva, M. Härting, and D.T. Britton, Philosophical Magazine, 89 (2009) 1629-1645.
8. *Oxygen measurement by resonance elastic backscattering in Kr-implanted titanium*, S. Nsengiyumva, J.P. Rivière, M. Topic, C. Theron, C.M. Comrie, A.T. Raji, D.T. Britton, and M. Härting, African Physical Review, in press.

IV. EMPLOYMENT RECORD AND TEACHING EXPERIENCE

2009-2010: Post-doctoral fellow at UCT (Physics Department)
2003-2008: Tutor at UCT (Physics Department)
1999-2000: Assistant Lecturer at Kigali Institute of Education (KIE)
1996-1998: Civil servant at the Ministry of Education – Curricula Department
1990-1994: Teacher of Physics at Kigali College
1987-1990: Teacher of Physics at Rambura High School

MINANI Evariste (PhD), Lecturer in Physics (Kigali Institute of Education)

Date and place of birth: 05/09/1967, Kamonyi District, Southern Province, RWANDA

ACADEMIC QUALIFICATIONS
2008 2002
PhD in Physics, Specialisation: Solid state physics MSc in Physics (Solid state physics)

CURRENT POST
From July 2008
From 1999
Kigali Institute of Education
Lecturer (Physics), Science Faculty
Assistant Lecturer (Physics)

PREVIOUS EMPLOYMENT
1997 -1999
MINEDUC
Physics teacher in high school

TEACHING EXPERIENCE
From 1999 up to now: Assistant Lecturer and then Lecturer in Physics (Kigali Institute of Education , Science Faculty)
2008-2009: Visiting Lecturer , ISP Gitwe 1997-1999: Secondary Physics teacher , Group Scolaire St Joseph Kabgayi

TEACHING SPECIALISATIONS
General physics, Modern Physics, Nuclear physics and Solid State Physics

CURRENT RESEARCH
[1]Optical and electrical properties of ZnO and ZnO: SnO nano-structures

PUBLICATIONS
Microstructure, optical characterization and light induced degradation in a-Si:H deposited at different temperatures, *Thin Solid Films*, *Volume 501, Issues 1-2*, *20 April 2006*, *Pages 84-87* **E. Minani**, Z. Sigcau, O. Adgebite, F.L. Ramukosi, T.P. Ntsoane, S. Harindintwari, D. Knoesen, C.M. Comrie, D.T. Britton, M. Härting.

Investigations of intrinsic strain and structural ordering in a-Si:H using synchrotron radiation diffraction, *Thin Solid Films*, *Volume 501, Issues 1-2*, *20 April 2006*, *Pages 75-78* M. Härting, D.T. Britton, **E. Minani**, T.P. Ntsoane, M. Topic, T. Thovhogi, O.M. Osiele, D. Knoesen, S. Harindintwari, F. Furlan, C. Giles.

Local structure reconstruction in hydrogenated amorphous silicon from angular correlation and synchrotron diffraction studies, *Applied Surface Science*, *Volume 252, Issue 9*, *28 February 2006*, *Pages 3194-3200*
D.T. Britton, **E. Minani**, D. Knoesen, H. Schut, S.W.H. Eijt, F. Furlan, C. Giles, M. Härting.

Positron annihilation studies of the effect of gamma irradiation dose in polymers, *Radiation Physics and Chemistry*, *Volume 68, Issues 3- 4*, *October-November 2003*, *Pages 457-461* I. Y. Al-Qaradawi, D. T. Britton, E. E. Abdel-Hady, D. A. Abdulmalik, M. A. Al-Shobaki, **E. Minani**

Light induced changes in the defect structure of a-Si:H, *Thin Solid Films*, *Volume 430, Issues 1-2*, *22 April 2003*, *Pages 149-152* D. T. Britton, Z. Sigcau, C. M. Comrie, D. F. Kanguwe, **E. Minani**, D. Knoesen, M. Härting

Influence of growth temperature on the microcrystallinity and native defect structure of hydrogenated amorphous silicon, *Journal of Non- Crystalline Solids*, *Volumes 299-302, Part 1*, *April 2002*, *Pages 103- 107*
M. Härting, D. T. Britton, R. Bucher, **E. Minani**, A. Hempel, M. Hempel, T. P. Ntsoane, C. Arendse, D. Knoesen.

Research Monographs
2008
Evariste Minani. Ph D dissertation: Microstructure, stress and defect evolution under illumination in hydrogenated amorphous silicon (a- Si:H), Cape town , June 2008
Kigali, March 2010

JAN ILAVSKY 630-252-0866
Advanced Photon Source ilavsky@aps.anl.gov
9700 S Cass Ave.
Argonne National Laboratory
Argonne IL 60439 http://usaxs.xor.aps.anl.gov/staff/ilavsky/

Education:	RNDr. (=MS) Solid State Physics	1986
	Charles University, Prague, Czech Republic	
	Ph.D. Materials Science and Engineering	1994
	SUNY at Stony Brook, New York, USA	

Appointments:

7/2004 – present	*Staff Scientist*, Advanced Photon Source, Argonne National Laboratory, Argonne, IL 60439
2002 – 2004	*Visiting Assistant Professor,* Department of Chemical Engineering, Purdue University & *Guest Researcher,* Ceramics Division, Materials Science and Engineering Laboratory, and National Institute of Standards and Technology, Gaithersburg
1999- 2002	*Senior Research Associate*, Department of Chemical Engineering, University of Maryland & *Guest Researcher,* Ceramics Division, Materials Science and Engineering Laboratory, National Institute of Standards and Technology, Gaithersburg.
1996-1998	**Scientist, *Materials Science Laboratory, Institute of Plasma Physics. ASCR, Prague.***
1994-1996	*Post doctoral Research Associate,* The Thermal Spray Laboratory, Department of Materials Science and Engineering, SUNY at Stony Brook & *Guest Researcher*, Ceramics Division, Materials Science and Engineering Laboratory, National Institute of Standards and Technology, Gaithersburg.
1991-1994	*Graduate Research Assistant,* The Thermal Spray Laboratory, Department of Materials Science and Engineering, SUNY at Stony Brook.
1986-1991	Researcher and Graduate Research Assistant, Department of Materials Science, Institute of Plasma Physics, ASCR.

Current interests

Jan Ilavsky is beamline scientist, X-ray Microscopy Group, X-ray Science Division, Advanced Photon Source. He is responsible for operations and instrument development of the USAXS and SAXS instrument installed at APS beamline 15ID, where he provides experiment as well as data analysis user support. He is author or co-author of over 150 journal publications and numerous invited and seminar conference lectures in the area of characterization of materials, mostly using scattering or imaging techniques. He is also the author of three widely used small-angle scattering (SAS) small-angle scattering software packages: "Irena" – SAS data modeling, "Nika" – area detectors data reduction, and "Indra" – USAXS data reduction.

He is known fin the small-angle scattering area for his community outreach work in the absolute intensity calibration of SAXS and SANS instruments around the World, as well as in organization of the educational events such as (ANL and ORNL) X-ray and Neutron summer school or Small-angle scattering short course (organized by APS small-angle scattering special interest group).

Jan is materials scientists by training, personally interested in developing new methods for characterization of complex engineering materials, especially in the areas related to energy production and energy utilization, or in mitigation of impacts of energy production (CO_2 retention etc.). His work on application of small-angle scattering for characterization of thermal barrier (plasma-sprayed & EBPVD) deposits in 1990 to 2000 is considered to be seminal in that area and is currently widely cited in the thermal spray field. Lately he has been collaborating with groups associated with other energy related research. Studying, for example, materials for vehicle (on board) gas storage materials or materials for targets for National Ignition Facility (NIF, LLNL, Livermore, CA).

Other Experience and Professional Memberships

- Associate editor of the *Journal of Thermal Spray Technology (2001-2007)*.
- Member of International Board of Reviewers, Journal of Thermal Spray Technology.
- Member, ASM International (Thermal Spray Society).
- Member, The American Ceramic Society.
- Member, The American Crystallographic Society.
- Member, Neutron Scattering Society of America.
- Peer-reviewer for *Journal of Materials Research*, *Materials Science and Engineering, Thin Solid Films*, Thermal Spray conference proceedings and others. Also served as reviewer for projects submitted to

U.S. Department of State for the FSU Science Centers (ISTC - International Science & Technology Center in Moscow - & STCU - Science & Technology Center in Ukraine in Kiev).

- Peer reviewer for proposals at NIST reactor and SSRL synchrotron source.
- Chair of Special Interest Group, Small-angle X-ray Scattering, Advanced Photon Source

10 related publications (from > 120 peer reviewed):

1. F. Zhang, J. Ilavsky, G. Long, J. Quintana, A. Allen, and P. Jemian, Glassy Carbon as an Absolute Intensity Calibration Standard for Small-Angle Scattering, *Metallurgical and Materials Transactions A*, 2010, **41** (5), p. 1151-1158
2. F. Zhang, and J. Ilavsky, Ultra-Small-Angle X-ray Scattering of Polymers, *Journal of Macromolecular Science, Part C: Polymer Reviews*, 2010, **50** (1), p. 59-90
3. J. Ilavsky, Characterization of Complex Thermal Barrier Deposits Pore Microstructures by a Combination of Imaging, Scattering, and Intrusion Techniques, *J. Therm. Spray Technol.*, 2010, **19** (1-2), p. 178-189
4. P. Akcora, S.K. Kumar, J. Moll, S. Lewis, L.S. Schadler, Y. Li, B.C. Benicewicz, A. Sandy, S. Narayanan, J. Ilavsky, P. Thiyagarajan, R.H. Colby, and J.F. Douglas, "Gel-like" Mechanical Reinforcement in Polymer Nanocomposite Melts, *Macromolecules*, 2010, **43** (2), p. 1003-1010
5. T.E. Mares, A.P. Radlinski, T.A. Moore, D. Cookson, P. Thiyagarajan, J. Ilavsky, and J.r. Klepp, Assessing the potential for CO2 adsorption in a subbituminous coal, Huntly Coalfield, New Zealand, using Small Angle Scattering techniques, *International Journal of Coal Geology*, 2009, **77**, p. 54-68
6. J. Ilavsky, P.R. Jemian, A.J. Allen, F. Zhang, L.E. Levine, and G.G. Long, Ultra-small-angle X-ray scattering at the Advanced Photon Source, *J. Appl. Crystallogr.*, 2009, **42** (3), p. 469-479
7. J. Ilavsky, and P.R. Jemian, Irena: tool suite for modeling and analysis of small-angle scattering, *J. Appl. Crystallogr.*, 2009, **42** (2)
8. A.J. Allen, J. Ilavsky, and A. Braun, Multi-scale Microstructure Characterization of Solid Oxide Fuel Cell Assemblies with Ultra Small-Angle X-Ray Scattering, *Advanced Engineering Materials*, 2009, **11** (6), p. 495-501
9. P. Akcora, H. Liu, S.K. Kumar, J. Moll, Y. Li, B.C. Benicewicz, L.S. Schadler, D. Acehan, A.Z. Panagiotopoulos, V. Pryamitsyn, V. Ganesan, J. Ilavsky, P. Thiyagarajan, R.H. Colby, and J.F. Douglas, Anisotropic self-assembly of spherical polymer-grafted nanoparticles, *Nat Mater*, 2009, **8** (4), p. 354-359
10. J.F. McCarthy, J. Ilavsky, J.D. Jastrow, L.M. Mayer, E. Perfect, and J. Zhuang, Protection of organic carbon in soil microaggregates via restructuring of aggregate porosity and filling of pores with accumulating organic matter, *Geochimica et Cosmochimica Acta*, 2008, **72** (19), p. 4725-4744

Invited lectures and workshops

2010 invited lecture University of Cincinnati, IN, USA; invited lecture TMS Spring meeting, Seattle, WA

2009 invited lecture International Thermal Spray Conference 2009, Las Vegas, NV; invited lecture SAS 2009, Oxford, UK; invited lecture S2TS conference, Lille France; invited lecture University of Belfort, France

2008 Session organizer, "2008 Denver X-ray Meeting", Denver, CO.

2008 3 invited lectures University of Limoges, France; invited lecture CEA, Mont, France

2008 Co-organizer SAS session on APS users meeting 2008.

2007 Workshop lecturer, "2007 Denver X-ray Meeting", Colorado Springs, CO, July/August 2007, "SAS data analysis"

2007 Organizer & chair, USAXS/USANS session on American Crystallographic Association meeting 2007, Salt Lake City, July 2007.

2006 Member of International Advisory board for International Conference on Advances in Mechanical Engineering (AME 2006), Panjab, India.

2006 Invited lecture XIII International Conference on Small-Angle Scattering, Kyoto, Japan, "USAXS instrument at the APS"

2005 Invited lecture, 10th ISPMA meeting, Prague, Czech Republic.

2005 Workshop lecturer, "Materials Characterization by Small-Angle X-ray Scattering", Rodman Materials Research Laboratory, Aberdeen Proving Grounds, Maryland, July 2005, Sponsored by the U.S. Army Research Laboratory, the Maryland Chapter of the American Chemical Society, & the Army Research Office.

Education and mentoring

2010 Organizer, Summer X-ray and Neutron School, ANL

2010 Organizer of "Beyond Rg 2010" SAS short course, APS, ANL

2009 Organizer, Summer X-ray and Neutron School, ANL

2008 Summer student supervisor

2008 Organizer of "beyond Rg 2008" SAS short course, APS, ANL

2007 Summer student supervisor (DOE SULI program)

2007 Organizer, Summer X-ray and Neutron School, ANL

2007 PhD thesis advisor, Purdue University, IN, USA

2006 PhD thesis advisor, DLR, Germany

2006 Summer student (3 students) supervisor (DOE FAST program)

2006 Summer X-ray and Neutron School, ANL, experiment staff

2005 Summer X-ray and Neutron School, ANL, experiment staff

Awards*

2006 Best paper award, Cocoa Beach 2007 Conference, The American Ceramic Society

2006 Best paper award for 2005, Journal of Thermal Spray Technology, ASM International

Gregory Scott Smith

EDUCATION
Ph.D. in Condensed Matter Physics, Iowa State University, 1985
Bachelor of Science in Physics, Marietta College, 1978.

EXPERIENCE
July 2008- Present: Neutron Scattering Sciences Division Office- HFIR Operations Coordinator.

Dec. 2007- July 2008: Interim Deputy Division Director at the Neutron Scattering Science Division, Oak Ridge National Laboratory.

Sept. 2006-present: Group Leader for the Low Q Scattering Group at the Neutron Scattering Science Division, Oak Ridge National Laboratory.

2002-2006: Group Leader for the Neutron Scattering User Program at the HFIR Center for Neutron Scattering, Oak Ridge National Laboratory.

1995 – 1999; 2002: Acting Deputy Center Director at the Manuel Lujan Jr. Neutron Scattering Center.

1997(for ~ 6 months): Acting Center Director at the Manuel Lujan Jr. Neutron scattering Center.

1988-2002: Instrument Scientist at the Los Alamos Neutron Scattering Center, Los Alamos National Laboratory.

1988 - 1994: Scientist responsible for the sample environment equipment throughout the LANSCE facility.

1985 - 1988: Post-doctoral research assistant in a joint collaboration between the University of Colorado Physics Department and the Exxon Research and Engineering Company Condensed Matter Laboratory.

1980 - 1985: Graduate research assistant with the neutron scattering group of the Ames Laboratory (U.S. D.O.E.) and Iowa State University.

Sept 1978 - Sept 1980: Graduate teaching assistant in the Physics Department at Iowa State University.

ACADEMIC AND PROFESSIONAL HONORS
- Co-Chair of International Conference on Neutron Scattering, 2009.
- Guest editor of Journal of Polymer Science B: Polymer Physics, 2004.
- Elected Membership Secretary of the Neutron Scattering Society of America, 2003-2005, 2006-2008
- Elected to Fellowship in the American Physical Society, 2001

- DOE Defense Programs Award of Excellence for Significant Contributions to the Stockpile Stewardship Program, 2001
- First Recipient of the LANSCE Director's Award for Scientific Excellence, 2000
- Los Alamos Achievement Award, 1999

External Committees

- Member of the U.S./Japan Steering Committee 2005-Present
- Chair NIH Institute On Aging Special Emphasis Panel 2007-2008
- U. of Penn. NSF MRSEC Review Panel, Dec. 2003
- Neutron Scattering Society of America Membership Secretary 2003-2008
- DOE Lehman Review Committee, SNS Instruments, 2002-2003
- SNS Target/Instrumentation Advisory Committee, 1998-2000
- Member of the Complex Materials Consortium Collaborative Access Team at the Advanced Photon Source at ANL 1994-present; CMC Executive Committee 1997-2002
- Argonne National Laboratory Intense Pulsed Neutron Source Experiment Proposal Evaluation Committee (SANS and Reflectometry) 1996-2000

SELECTED PUBLICATIONS

L. Porcar, K. Hong, P.D. Butler, K.W. Herwig, G.S. Smith, Y. Liu and W.-R. Chen, "Intra-molecular Structural Change of PAMAM Dendrimers in Aqueous Solutions Revealed by Small Angle Neutron Scattering," J. Phys. Chem B., **144(5)**,1751(2010).

T. Li, K. Hong, L. Porcar, R. Verduzco, P. Butler, G.S. Smith, Y. Liu, W.-R.Chen, "Assess the Intramolecular Cavity of a PAMAM Dendrimer in Aqueous Solution by Small-Angle Neutron Scattering," Macromolecules, **41**, 8916(2008).

J.-H. Cho, G.S. Smith, W.A. Hamilton, D. Mulder, T.L. Kuhl, and J. Mays, "Neutron Surface Force Confinement Cell for Neutron Reflectometry Studies of Complex Fluids Under Nano-Confinement," Rev. Sci. Instr., **79**, 103908(2008).

G.S Smith, T.L. Kuhl, W.A. Hamilton, D.J. Mulder, and S. Satija, "Structure of Confined Polymer Thin Films Subject to Shear," Physica B- Cond. Matt., 385 (Pt. 1), 700(2006).

W.A. Hamilton, G.S. Smith, N.A. Alcantar, J. Majewski, R.G. Toomey, and T.L. Kuhl, "Determining the Density Profile of Confined Polymer Brushes using Neutron Reflectivity," J. Poly. Sci. B: Poly. Phys., 42 (17), 3290(2004).

G.S. Smith, C.B. Skidmore, P.M. Howe, and J. Majewski, Diffusion, Evaporation, and Surface Enrichment of a Plasticizing Additive in an Annealed Polymer Thin Film," J. Poly. Sci. B: Poly. Phys., 42, 3258(2004).

Appendix B: Letters of Commitment to Advisory Board

Letters of Commitment to participate in the Advisory Board are provided by:

Dr Ian Anderson, Oak Ridge National Laboratory, Oak Ridge TN
Dr. Gabrielle Long, Argonne National Laboratory Argonne, IL
Dr. Russell Schwartz, Sun Chemical Corporation
Carol Smith Hathaway, Solar Light for Africa

OAK RIDGE NATIONAL LABORATORY NEUTRON SCIENCES

MANAGED BY UT-BATTELLE FOR THE U.S. DEPARTMENT OF ENERGY

Dr. Ian S. Anderson
Neutron Sciences Directorate
P. O. Box 2008
Oak Ridge, TN 37831-6477
865-241-1499
Fax: 865-576-3041

March 26, 2010

Dr. Gregory Beaucage
ENGRG-Chemical & Materials Engineering
Rhodes 492
Cincinnati, Ohio 45221

Dear Dr. Beaucage:

Letter of Support

I am writing this letter to confirm that I will be happy to serve on your Advisory Board for the Nano-Power for Africa project. I have read the information on your proposed project and have discussed it with Dr. Greg Smith one of your colleagues on the proposal.

As the Associate Laboratory Director for Neutron Sciences at Oak Ridge National Laboratory, I am well aware of the importance of the study of advanced energy technologies for production of clean energy. The two neutron sources within my Directorate represent the best facilities of their type in the world. We provide researchers world over with state of the art research instruments to study the structure and dynamics of materials.

The proposal describes an ambitious program to understand and develop the use of nanoparticles for the conversion of solar power into electricity. The appeal of this project as a whole lies in using this current, scientifically challenging problem to help advance the educational and research capacity of African Universities while at the same time developing an inexpensive technology which could be marketed by Africans in Africa for the production of electricity in remote areas.

I am excited to be an advisor to this project and glad that Oak Ridge National Laboratory can actively participate by providing the opportunity for research in Neutron Scattering to the project's participants. Furthermore, I support the participation of one of my employees, Dr. Smith, in partnership with the University of Cincinnati and the University of Cape Town to educate and train young scientists throughout Africa in universities starting with Kigali Institute in Rwanda and Haramaya University in Ethiopia.

Best regards,

Dr. Ian Anderson
Associate Laboratory Director
Neutron Sciences Directorate

SOLAR LIGHT FOR AFRICA, Ltd.

2475 Northwinds Parkway, #200
Alpharetta, Georgia 30009
Phone: 770-753-6068
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Email: info@solarlightforafrica.org
www.solarlightforafrica.org

March 30, 2010

Prof. Gregory Beaucage
492 Rhodes Hall
Department of Chemical and Materials Engineering
University of Cincinnati
Cincinnati OH 45221-0012

Dear Greg,

Thank you for the opportunity to come to Cincinnati and to speak with your Nano-Power for Africa Project participants. We believe there are many avenues toward partnership that would provide mutual benefit to your project initiatives and to our work in Africa – providing great possibilities for real growth in access to solar power for Africa.

There are a number of areas of likely interaction and symbiosis between *Solar Light for Africa (SLA)* and the *Nano-Power for Africa (NPA)* Project. These include visits by the participants in your program to our sites to assess the need and application for technology being developed in the African Universities. We could also provide a potential link between our volunteer work force and your educational programs by encouraging our young volunteers to pursue technology degrees associated with *Nano-Power for Africa.*

We can foresee that the project could possibly provide a source for indigenously produced solar panels which would solve some issues concerning local maintenance, shipping from North America or China and customs that we must currently deal with. This could be of great importance in countries such as Ethiopia where these problems have, for the most part, precluded our work. Other advantages to SLA are contacts in new areas of Africa such as West Africa and South Africa, as well as the potential for enhancement of our efforts by allowing local investment of donated funds towards solar panels and other components needed in our work.

Thank you for the invitation to be a member of the Advisory Board for NPA. I will be happy to serve on this Board and to assess the progress of this project towards the strategic goal of producing solar panels that are viable in African villages and for uses such as refrigeration of medical supplies and lighting. I, or a substitute executive of SLA, should be available to travel to Cape Town or other African locations once a year funded by the NPA project for the Board meeting and project workshop.

We have found that solar power is a transformative technology, so we have great hopes for the spread of solar energy technology throughout Africa where grid power is not available or as a backup to or alternative for grid power. Cooperation between SLA and NPA could be an important component to further encourage the spread of solar technology in Africa.

I am forwarding this letter via email – please consider this electronic copy an original until I can sign and forward a copy from our office on 3/31/2010. If you have questions, please contact Emily Ridgway, our Development Coordinator at 770-753-6068.

Kind regards,

Carol Smith Hathaway /ER

Carol Smith Hathaway
Executive Director

Transforming Lives…Empowering Africa…One Light at a Time…

Appendix C: Letters Supporting Cost-Share Arrangements

Cost-share letters provided by:

Dr. Ryan Breese, Eclipse Film Technology, Cincinnati OH
Dr. Russell Schwartz, Sun Chemical
Mr. Lawrence Gamblin, Collins Ink
Dr. Gregory S. Smith, Oak Ridge TN
Dr. Jan Ilavsky, Argonne National Laboratory
Dr. Ray Chen, Omega Optics

eclipse
film technologies

4434 Muhlhauser Road
Suite 200
Hamilton, Ohio 45011
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513.942.1444 fax
www.eclipsefilmtech.com

March 22, 2010

Professor Greg Beaucage
Chemical and Materials Engineering Department
University of Cincinnati
Cincinnati, Ohio 45221-0012

Dear Dr. Beaucage,

After reviewing the USAID project, Eclipse Film Technologies collaborative contribution to the project is:

- Various polymer films to be used for prototype development: $120,000/yr.
- Operational materials necessary for producing prototypes: $72,000/yr
- Lab rental space and utilities: $14,400/yr.
- 10 hours/month of product and process development support: $60,000/yr.
- 10 hours/month of operational training support and safety training for visiting researchers: $12,000/yr.
- Use of Eclipse Film Technologies testing equipment and laboratory: $13,500/yr.

The total collaborative contribution from Eclipse Film Technologies totals at $277,500/yr. This will cover the operational costs of developing prototype films for the USAID project.

Best Regards,

D. Ryan Breese

D. Ryan Breese, Ph.D.
Technical Director

ONE TIME COSTS

Equipment

Item	Quantity	Cost/Unit	Total Cost	Supplier	Funded
MDO	1	$70,000	$70,000	Collin	Grant
Spare parts for MDO	1	$500	$500	Collin	Grant
Heating Units	3	$5,000	$15,000	Collin	Grant
Transformer	1	$550	$550	Rex Mfgr	Grant
Air Compressor	1	$250	$250	Lowes	Grant
Hoses	24	$150	$3,600	Collin	Grant
			$89,900		

Facilities

Item	Quantity	Cost/Unit	Total Cost	Supplier	Funded
Lab Structure	1	$8,000	$8,000	C&H Distributors	Grant
Electrical	1	$7,000	$7,000	Ohio Valley Electrical	Grant
			$15,000		

MONTHLY COSTS

Supplies

Item	Quantity	Cost/Unit	Total Cost	Annual Cost	Supplier	Funded
Shipping	1	$100	$100	$1,200	FedEx	Grant
Materials	1	$733	$733	$8,800	Misc	Grant
Film	100	$100	$10,000	$120,000	Eclipse	Eclipse
Cores	240	$20	$4,800	$57,600	Eclipse	Eclipse
			$14,800	$177,600		

Resources

Item	Quantity	Cost/Unit	Total Cost	Annual Cost	Supplier	Funded
Lab Space Rental	240	$5	$1,200	$14,400	Eclipse	Eclipse
Ryan Breese	20	$250	$5,000	$60,000	Eclipse	Eclipse
Operator	10	$100	$1,000	$12,000	Eclipse	Eclipse
Testing Equipment Use	15	$75	$1,125	$13,500	Eclipse	Eclipse
			$8,325	$99,900		

One Time Costs	
Grant Contribution =	$104,900
Eclipse Contribution =	$0
Monthly Costs	
Grant Contribution =	$833
Eclipse Contribution =	$23,125
Annual Costs	
Grant Contribution =	$10,000
Eclipse Contribution =	$277,500

Collins Ink
Corporation

03/30/10

Associate Vice President for Research
University of Cincinnati
540 University Hall ML 0222
Cincinnati, OH 45221-0222

Dear Sir/Madam,

Collins Ink Corporation was founded 20 years ago and has grown steadily since its inception. Collins Ink manufactures water based, solvent based and UV curable inkjet inks for thermal, piezo, CIJ (continuous inkjet) printheads. Our inks are used to print in different types of substrates which includes corrugated card board, plastic card, PVC sheets, office paper, glossy paper, cartons to name a few. Collins has also focused on developing specialty inks such as invisible inks which can only be read by IR radiations or UV radiations, magnetic inks for security applications, conductive for printed electronics and decorative inks. Collins takes pride in that we have such myriad choice of inks for a wide range of needs and applications the developing inkjet industry demands.

Collins expects that the nano-power Africa venture would be a mutually beneficial undertaking to collaborate on and we are willing to dedicate some of our resources to hopefully assist in the successful completion of project. Dr. Beaucage's research group has done extensive research in making nanometer size inorganic particles such as TiO_2, SiO_2 and similar particles. These particles have narrow range of particle size distribution, which makes easier to disperse them in a given solvent or media. His group will be involved in making the two sets of nanoparticles viz, silicon and conducting metallic nanoparticles. Silicon will be printed as semiconductor matérial for the electronics like in any silicon wafer based electrical component such as, computer chip. Major electrical components and their connections in the device will be made by the conducting metallic inks.

1201 Edison Drive • Cincinnati, OH 45216 • Tel: 513 / 948.9000 • Fax: 513 / 948-8900 • http://www.collinsink.com

Collins has extensive research experience in formulating/dispersing such pigments in solvents like water, which will be the primary solvent base for ink in this proposal. Different types of inks will be formulated based on the printing technology. In exchange, Collins ink can have access to the wide range of sophisticated tools available at UC for analysis and characterization of these inks if and as required.

Dr. Suresh Murugesan, Sr. Researcher at Collins will provide his extensive research experience in conductive materials and formulating conductive inks to the successful completion of printed solar panel manufacturing. Dr. Murugesan has a Ph.D. in Chemistry from University of Cincinnati. His research experience includes formulating conductive inks, water based and UV-curable inks, materials modification and characterization for MEMS devices, organic and inorganic nanowires, organic-organic and organic-inorganic nanocomposites.

Collins ink will be spending an equivalent of $41000 per year in its resources during the collaboration. This would include research time, materials, travel related to communication and presentation in major printed electronics conferences and other miscellaneous expenses. We understand that this will be used as cost sharing in the project.

Please feel free to contact me if you have any questions.

Best regards

Lawrence Gamblin
President

OAK RIDGE NATIONAL LABORATORY

MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Gregory S. Smith
Group Leader, Low Q
Neutron Scattering Science Division
P.O. Box 2008
Oak Ridge, TN 37831-6393
(865) 241-1742
Email: smithgs1@ornl.gov

March 19, 2010

Professor Greg Beaucage
Chemical and Materials Engineering Department
University of Cincinnati
Cincinnati, Ohio 45221-0012

Dear Dr. Beaucage:

After talking with our business manager, our collaborative contribution to the USAID project is:

- Office space, utilities, supplies, etc., to support a post doc or student per year: $21,600/yr (For us, if we hire a post doc, this would be our Division overhead.)

- 5% of my cost per year to work on the project: $18,740/yr

This will cover the costs to train a post doc and to perform research at Oak Ridge National Laboratory.

Sincerely,

Gregory S. Smith

Gregory S. Smith
Group Leader, Low-Q Scattering Group

GS:sl

J. Murray Gibson
Associate Laboratory Director
Photon Sciences
Director, Advanced Photon Source

Argonne National Laboratory
9700 South Cass Avenue, Bldg. 401
Argonne, IL 60439-4800

1-630-252-7990 phone
1-630-252-4599 fax
1-630-849-3657 mobile
jmgibson@aps.anl.gov

March 30, 2010

Gregory Beaucage
Prof. Chemical and Materials Engineering
University of Cincinnati
Cincinnati, OH 45221-0012
513 556 3063
beaucag@uc.edu

Dear Prof. Beaucage,

I am writing this letter to express support and interest to collaborate with you on the grant proposal "Nano-Power for Africa (NPA) to USAID (United States Agency for International Development)".

The Advanced Photon Source (APS) at the Argonne National Laboratory (ANL) is a major scientific user facility supporting user science from all over the world. Mentoring new users and extend our user community is part of our mission. As part of the Department of Energy Complex, research in energy materials, as you are proposing is close to our hearts – and mission.

We are excited about the participation of our staff scientist, Dr. Jan Ilavsky, in your program. As you well know, is the leading scientist of the Ultra-Small Angle X-ray Scattering (USAXS) program at the APS, and he is very much interested in the advancement in materials science, especially in the area of energy production and utilization. As a material scientist by training, this area is of special interest to Dr. Ilavsky and it is also of prime interest to DOE supported laboratories such as ANL. Our USAXS facility is uniquely suited for the development of understanding of the hierarchical microstructures of engineering materials from nano-scales to micro-scales.

The plan of our collaboration includes the APS participation in this project by providing, through our general user program (GUP), access to USAXS and other instrumentation. As you know, all beamtime is allocated through a peer-reviewed proposal system, with three proposal cycles per year. Because of this system, we cannot guarantee access to our beamlines for any proposed experiments in advance. Despite this restriction, as illustrated by your ongoing success in obtaining adequate beamtime for your work in the past proposal cycles, I think this project will have an excellent chance of promptly receiving the beamtime you will need in the future project.

Our further participation will include hosting African students and post-docs at our facility for extended periods of time. During this stay, these students and post-doctoral fellows can develop understanding and expertise in our techniques, necessary for the design of nano-materials for solar cells and other energy related technologies. Note, that the APS is adjoined to the Center for Nanoscale Materials (CNM) which can also be taken advantage of by these students and post-docs. The Advanced Photon Source, with its instrumentation, is a unique facility that is not available in Africa. Further, the USAXS instrument is one of only two user-accessible instruments of this type in the world.

We are sure that our collaboration will be of major importance to your proposed development of photovoltaic devices and other technologies. Moreover, the collaboration will be useful in the general training of scientists and engineers from Africa. I believe that this interaction will lead to growth of a stronger science and technology culture in Africa, especially among underrepresented groups.

For the purpose of your program financing, our contribution to the program will be about $25.3K for office space, utilities, supplies, etc. to support a post-doc or student per year. Further, Dr. Jan Ilavsky will contribute up to 10% of his time to this project – for experiments, mentoring the students and post docs, and for travel to Africa for workshops– which represents additional $25.7K/year.

Sincerely,

Murray Gibson

J. Murray Gibson
Associate Laboratory Director
Photon Sciences

Omega Optics, Inc.

10306 Sausalito Dr., • Austin, TX, 78759 • Phone: (512)996-8833 • Fax: (512)873-7744

Date: 3/29/2010
Professor Margit Harting
Department of Physics
University of Cape Town

Dear Prof Härting,

Thank you for the invitation to our company, Omega Optics, to make a contribution to your USAID HED project, Nano-Power Africa, in collaboration with the University of Cincinnati, Haramaya University, and Kigali Institute of Education. From the outset, I must say that we are very interested in assisting in the development photovoltaic devices, particularly those based on printed electronics technologies. Furthermore, having reviewed the information which you have kindly provided, I firmly believe that many aspects of our existing collaboration on printed siliocn electronics can be extended to fall within the scope of the USAID HED project. Accordingly, Omega Optics intends, subject to the usual operational constraints, to make the following in-kind matching contributions to the Nano-Power Africa project, with an annual value of

1. Services of external printed electronics consultants: $4 800

2. Use of Omega optics testing equipment and laboratory: $5 200

3. Printing of sample substrates and test structures,including materials: $10 000

4. Approximately 40 hours per year operational support, including use of facilities, for visiting scientists and students: $40 000.

5. Payment to third parties in the Austin area for use of facilities related to this project; $15 000

The total annual contribution of Omega Optics in this letter of intent to the Nano-Power Africa project can therefore be estimated to have a value of $75 000 with the overhead 68% of all cost, the contribution shall be equivalent to 126,000. Shall you need any further information, please let us know. We expect to have a fruitful contribution for our mutual benefits.

Sincerely,

Dr. Ray Chen
Founder and Chief Technical Officer

Apendix D: Budget Approvals

The University of Cincinnati
The University of Cape Town

UNIVERSITY OF Cincinnati

University of Cincinnati
PO Box 210222
Cincinnati, Ohio 45221-0222

51 Goodman Drive
University Hall, Suite 530
Cincinnati, OH 45221-0222
(513) 558-0263 Phone
(513) 556-4346 Fax

March 29, 2010

Dr. Teshome Alemneh, Program Officer
Africa-US Higher Education Initiative Planning Grants
Higher Education for Development (HED)
Tel (202) 243-7684
Email: talemneh@HEDprogram.org

Dear Dr. Alemneh,

This letter is to confirm that the University of Cincinnati Sponsored Research Services has approved the enclosed application from Principal Investigator, Dr. Gregory Beaucage, Professor of Chemical and Materials Engineering, University of Cincinnati.

The Project Title is: "Nano-Power for Africa".
The application represents funding requested from the United States Agency for International Development (USAID) and the Higher Education for Development (HED) office.

All correspondence related to this award should be sent to the Sponsored Research Services, University of Cincinnati, P.O. Box 210222, Cincinnati, Ohio 45221-0222/ email address is ospaward@uc.edu. In addition, any checks should be made payable to the University of Cincinnati, Attention: Cashier's Office, Department A, P.O. Box 210061, Cincinnati, Ohio 45221-0061.

All costs cited in this proposal conform to established institutional policies and practices. Thank you very much for the opportunity to submit this proposal.

Sincerely,

Diane Douglas

Diane Douglas, BA, CRA
Sr. Grant Administrator
Grants Division
Sponsored Research Services
University of Cincinnati
Phone: 513-556-2870
Fax: 513-556-4346

UNIVERSITY OF CAPE TOWN
iYunivesithi YaseKapa
Universiteit van Kaapstad

Professor Danie Visser: Deputy Vice-Chancellor

Private Bag X3, Rondebosch, 7701, South Africa
Room 202, Bremner Building, Lower Campus, Lovers' Walk, Rondebosch, Cape Town, 7700
Tel: +27 (0) 21 650-2173/4 Fax: +27 (0) 21 650-5099
E-mail: danie.visser@uct.ac.za Website: www.uct.ac.za

30 March 2010

Dr. Teshome Alemneh,
Program Officer, Africa-US Higher Education Initiative
Higher Education for Development
One Dupont Circle NW
Washington DC 20036

Fax (202) 243-7684
talemneh@hedprogram.org

Dear Dr. Alemneh,

This letter is to confirm that the University of Cape Town has approved and wholeheartedly supports the strategic plan, submitted via the University of Cincinnati under the title *Nano-Power Africa*, for an Institutional Partnership between the University of Cape Town (South Africa), the University of Cincinnati (USA), Haramaya University (Ethiopia), Kigali Institute of Technology (Rwanda), Oak Ridge National Laboratory (USA), and Argonne National Laboratory (USA).

Yours sincerely

PROFESSOR D P VISSER
Deputy Vice-Chancellor

"Our Mission is to be an outstanding teaching and research university, educating for life and addressing the challenges facing our society."