Nano-Power Africa

Higher Education for Development Program
United States Agency for International Development

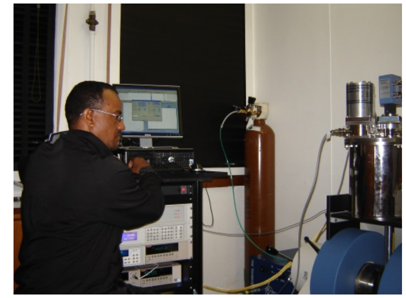
Collaborative Project Between:

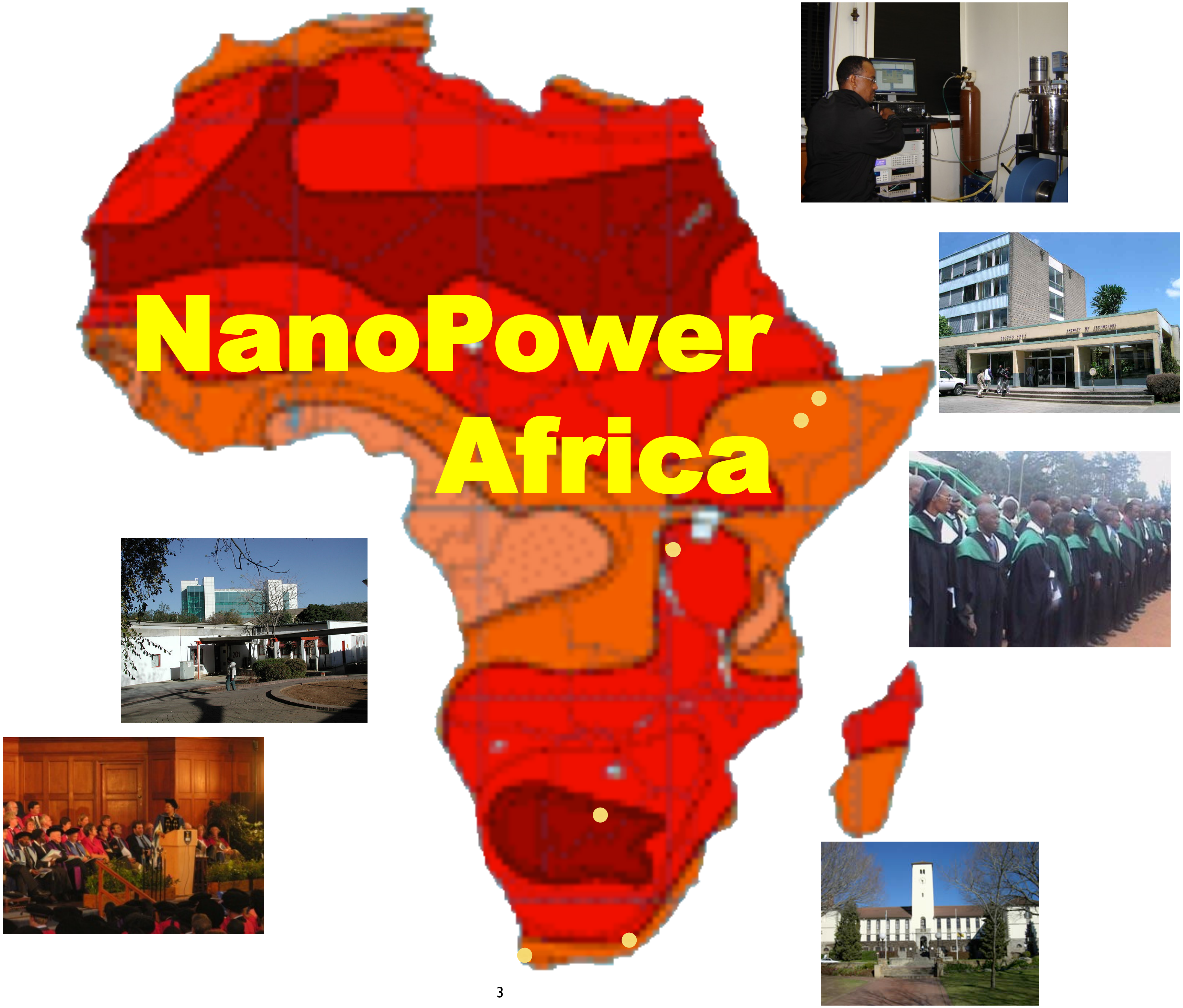
The University of Cincinnati
Oak Ridge National Laboratory
Argonne National Laboratory
Eclipse Film Technologies

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

The University of Botswana, Botswana
Botswana Technology Center (BOTEC)
Rhodes University, South Africa
Addis Ababa University, Ethiopia

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


NanoPower
Africa




NanoPower
Africa

Africa-US Higher Education Initiative

Program addresses tripling of higher education enrollment in SubSaharan Africa (SSA) from 2005 to present and the expected further tripling of enrollment by 2020

SSA 48 “researchers”/million population (US ~4,000/Million)
SSA 3,500 papers/year (16 patents/year) (Europe ~40,000 of each/year)

Higher Education Can:

- Drive Technical Innovation and Entrepreneurial Expansion of the Economy
- Stabilize Political Environment
- Solve Targeted Development Issues

The Africa-US Higher Education Initiative follows a *Problem Model*

NanoPower Africa Project

Realistic indigenous approach to
off-grid power generation for Africa

Inexpensive & functional = High technology

Fundamental science base utilizing
US National Labs, Industry and Universities
to train/assist African researchers in
development of PV & higher education

Develop low cost and robust PV's for
production and use in primitive conditions

NPA is unique in the program

A) Science/technology innovation

B) Engineering/entrepreneurial

C) Development of an indigenous free-enterprise based solar cell industry in Sub-Saharan Africa funded partly by local capital investment

D) Partnership with US/SA corporations and small businesses

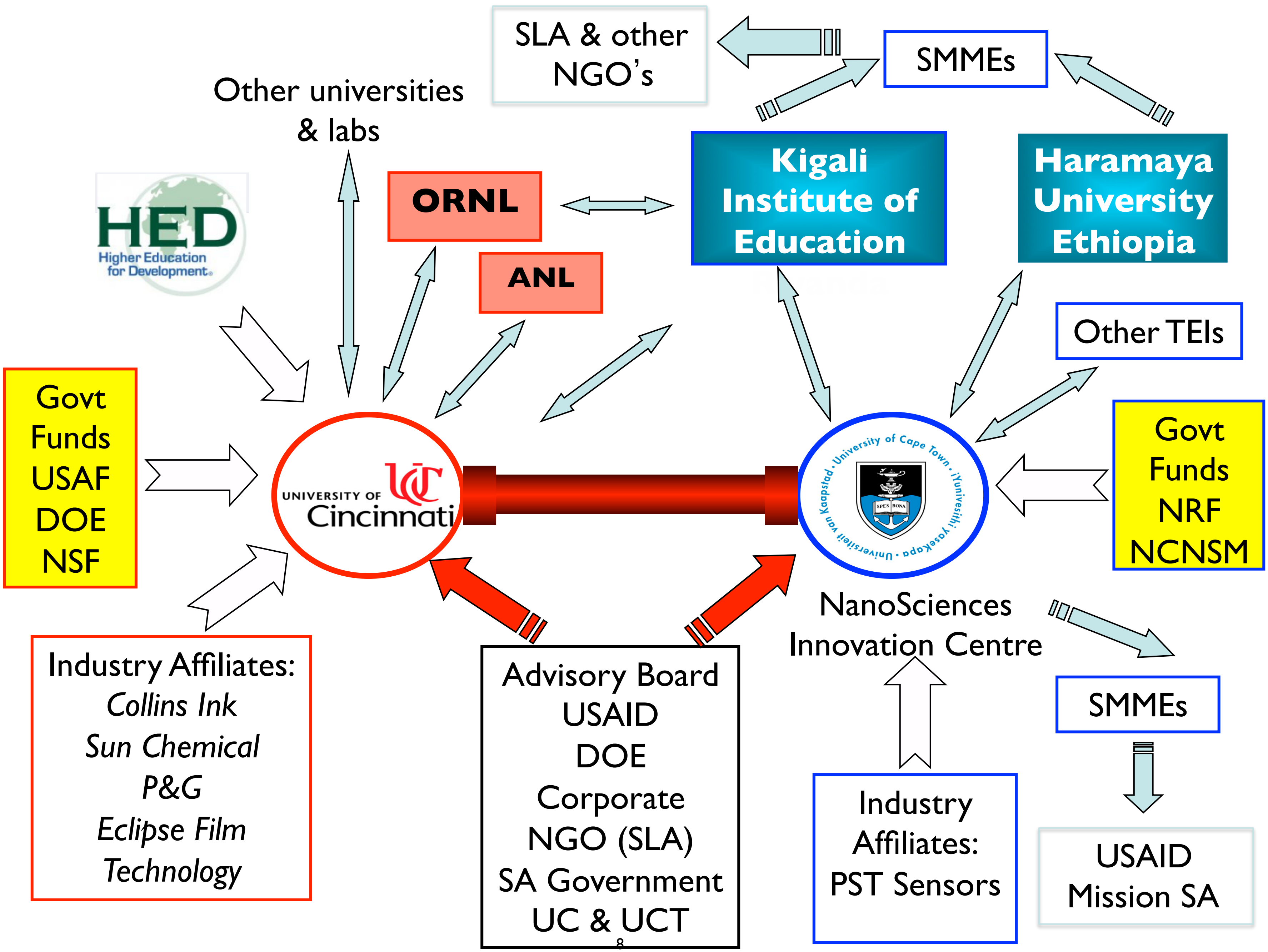
E) Significant involvement of US DOE Labs

F) A viable implementation of entrepreneurial “high-tech” to African development.

G) Use of the developed, post-apartheid SA university system as a model and as an indigenous leader for growth of sub-Saharan Universities (build from strengths).

H) Involvement of free enterprise to develop new local industries to fulfill needs with university based technology aimed at local needs. NGO’s, corporations and HED will to some extent act as venture capitalists.

NanoPower Africa: Higher Education for Development



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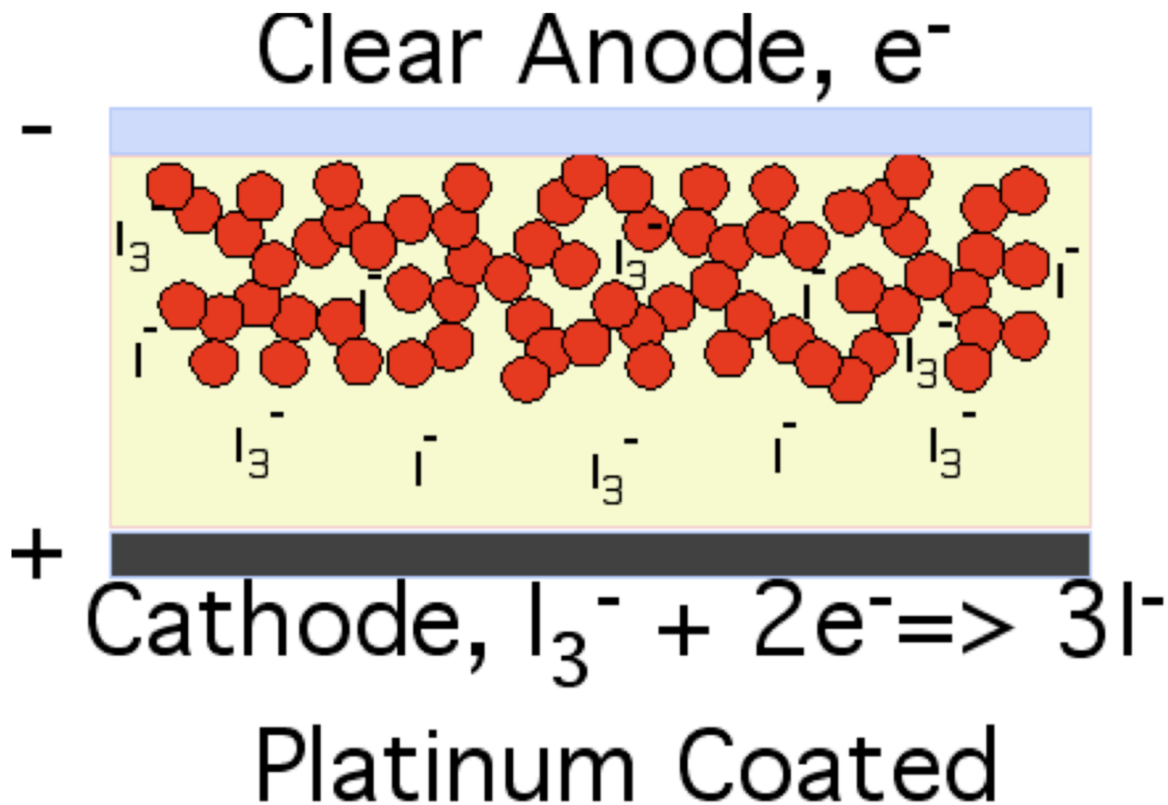
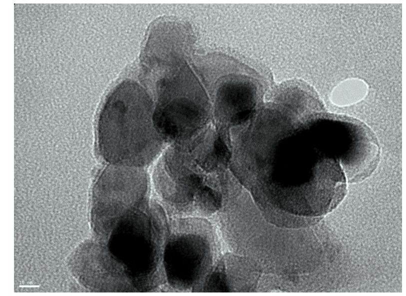
December 2009, Cape Town, South Africa Planning Meeting

One type of simple photovoltaic device that could be produced in Africa



Schematic of a Graetzel Cell. Red circles are titania aggregates coated with a dye. 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.

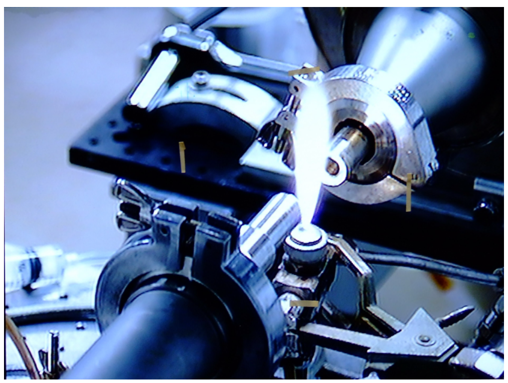
Grätzel Cell Production by Spray Flame

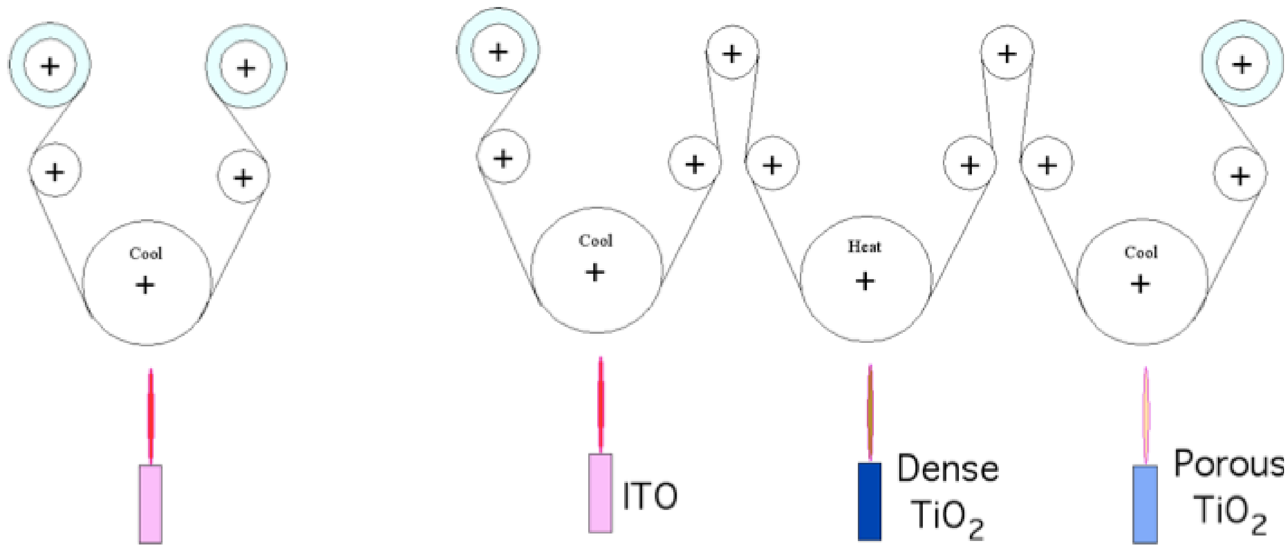


-Dye/titania development for inexpensive single step synthesis

-Use carbon coated titania to enhance interaction
-Use in situ synthesized CdS nano particles supported on titania

-A single reel-to-reel, flame-based process for coating of plastic substrates in a continuous process for flexible solar cell sheets.





(a) (b)

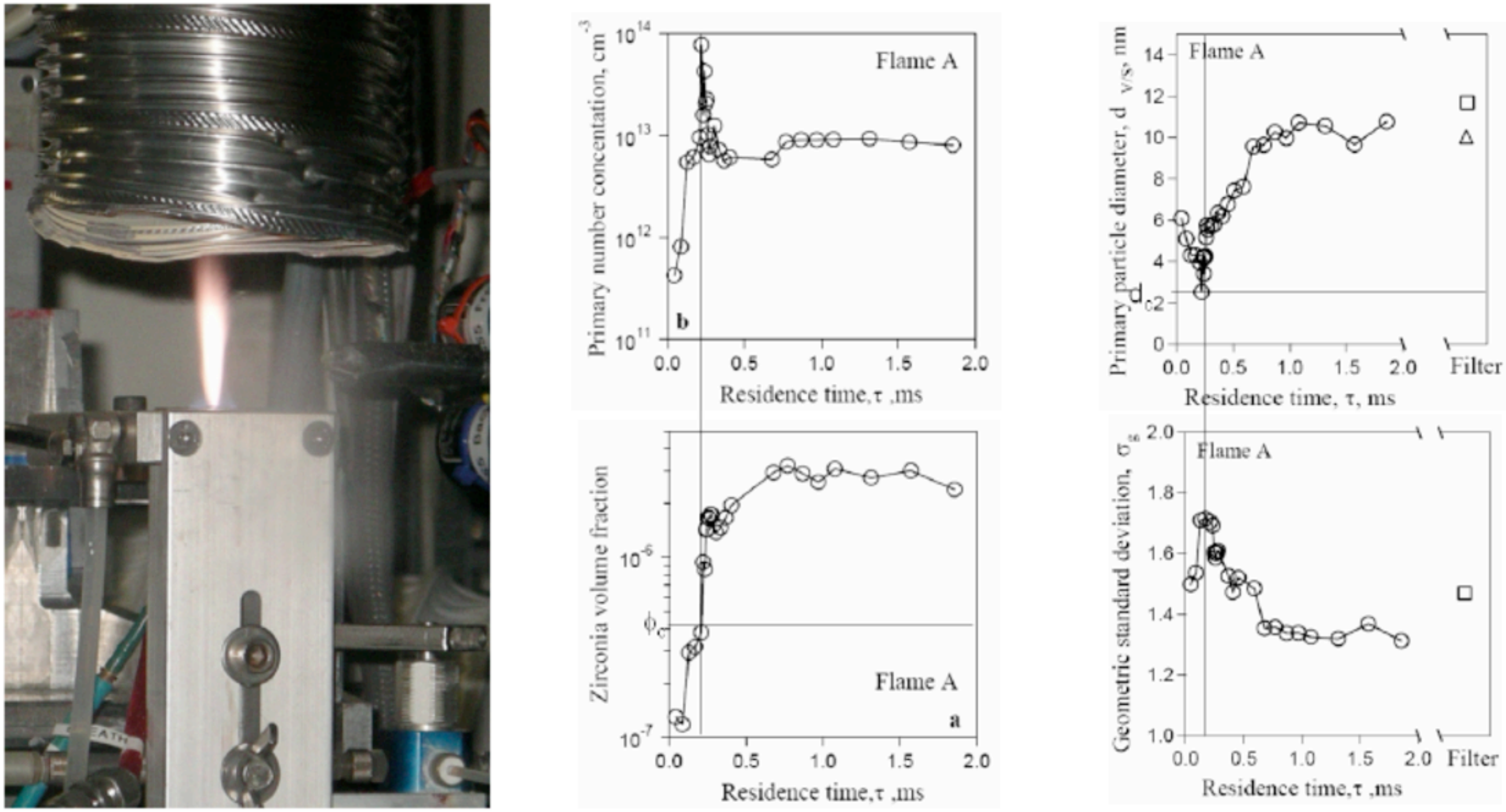
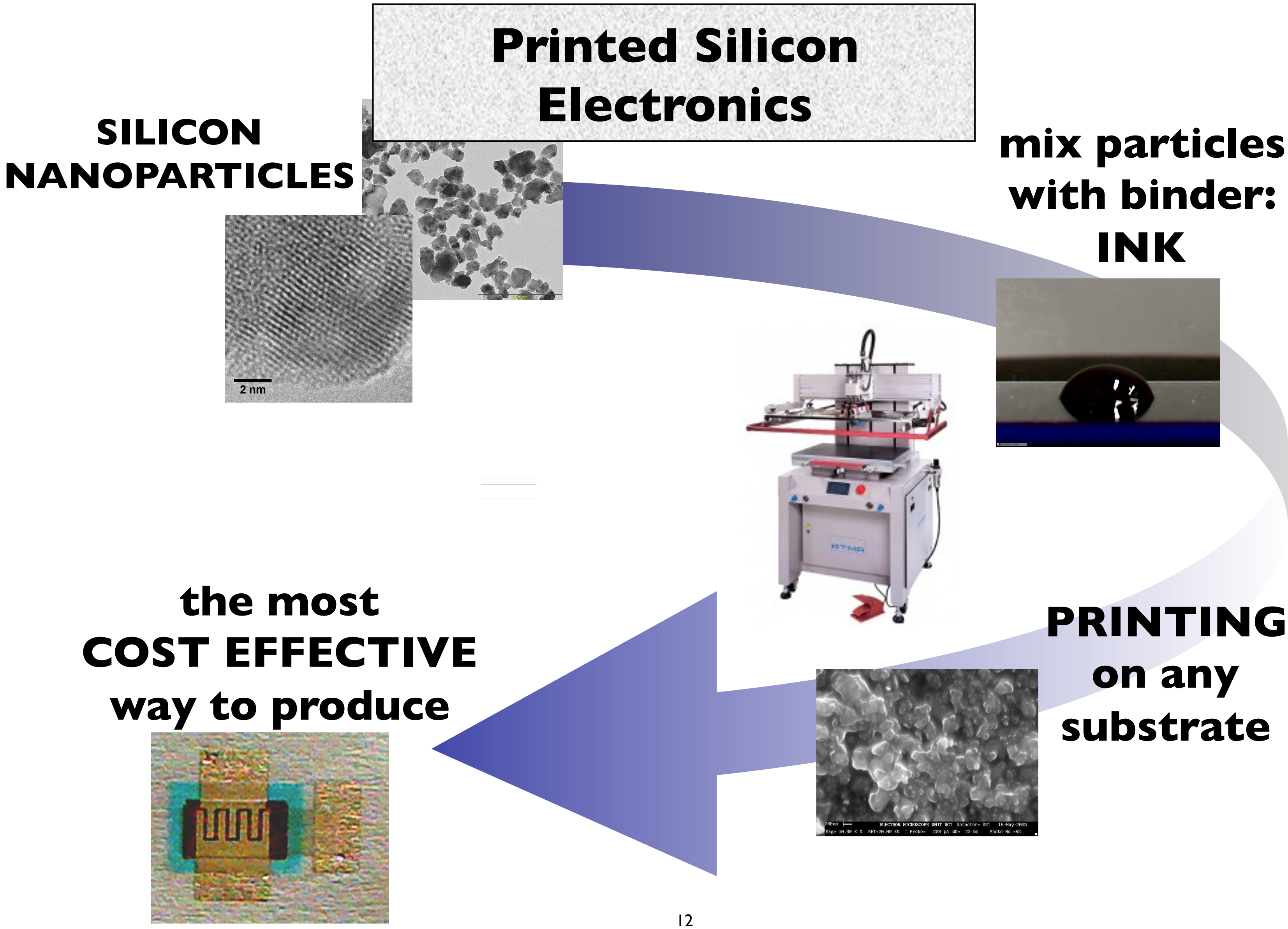
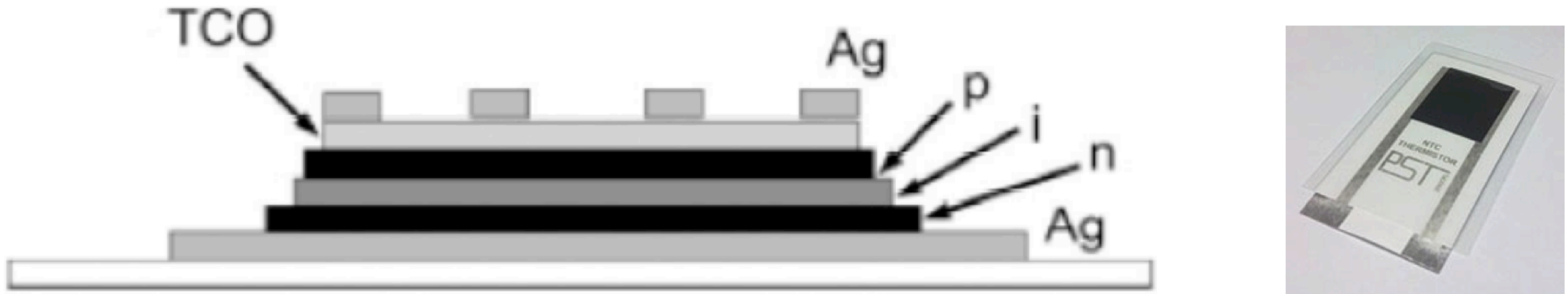


Figure 3. *Titania spray flame and plots of number density, volume fraction, Sauter mean diameter and geometric standard deviation. At a critical volume fraction ϕ_c, the number density peaks (log scale) particle size reaches a minimum and polydispersity reaches a maximum* [*Nanomaterial growth dynamics in jet flames.* Jossen R, Beaucage G, Heine MJ, Pratsinis SE *Adv. Mat.* submitted (2013).].

Alternative simple photovoltaic device for Africa (UCT)





(a) (b)

Figure 2. *Printing technology using silicon nanoparticles for a solar cell. a) 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. b) Prototype device.*

a)

b)

a) David Britton and Margit Härting win Award. b) Burning bright: UCT NanoSciences Innovation Centre's Prof Margit Harting (right) and students Ulrich Mannl, Batsirai Magunje and Stanley Walton show off a newly printed tiger design large area temperature sensor, produced in collaboration with Austin-based company Novacentrix, using their unique copper ink and processing methods. The design is the first step towards replacing expensive silver inks. For this and other innovations, UCT's nanovators won the recent 2011 Printed Electronics USA Best in Show Award.

Oak Ridge National Laboratory

Spallation Neutron Source

High Flux Isotope Reactor

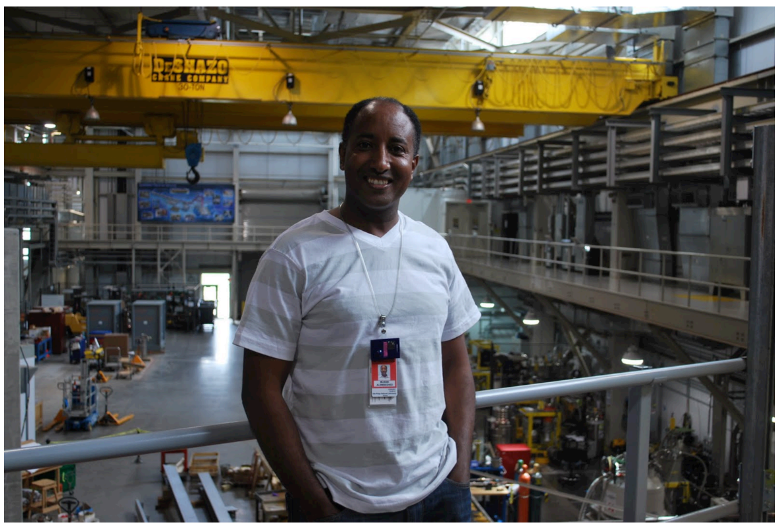
Center for Nanoscale Materials Science

Chemistry Division

Argonne National Laboratory

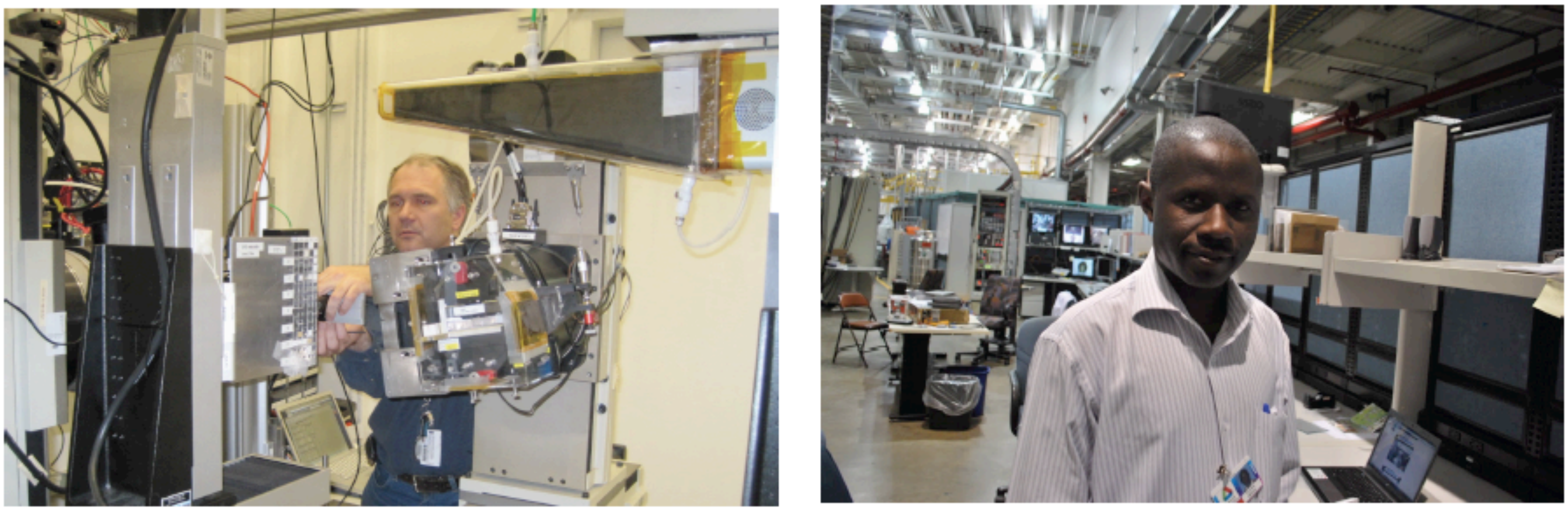
Advanced Photon Source

Eclipse Film Technology



(a) (b)

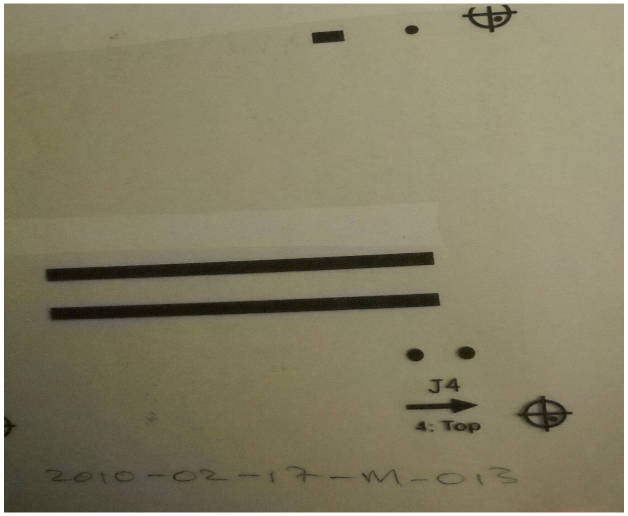
Figure 1. (a) Drs. Hu and Alemseghed at the new synthetic lab in Oak Ridge developed by Alemseghed. (b) Dr. Alemseghed at the SNS EQSANS instrument measuring printed electronics components for photovoltaic devices.



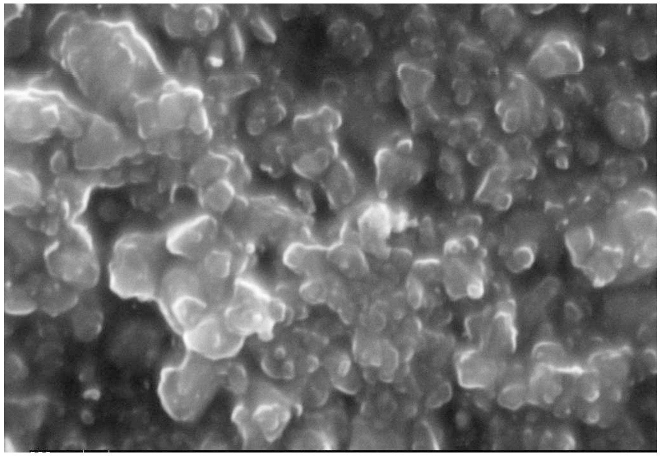
a) b)

Figure 3. a) Dr. Jan Ilavsky instructs African scientists on the use of the USAXS instrument at the Advanced Photon Source at Argonne National Laboratory. b) Prof. Evariste Minani from Kigali Institute of Eduation, RW at the Advanced Photon Source.

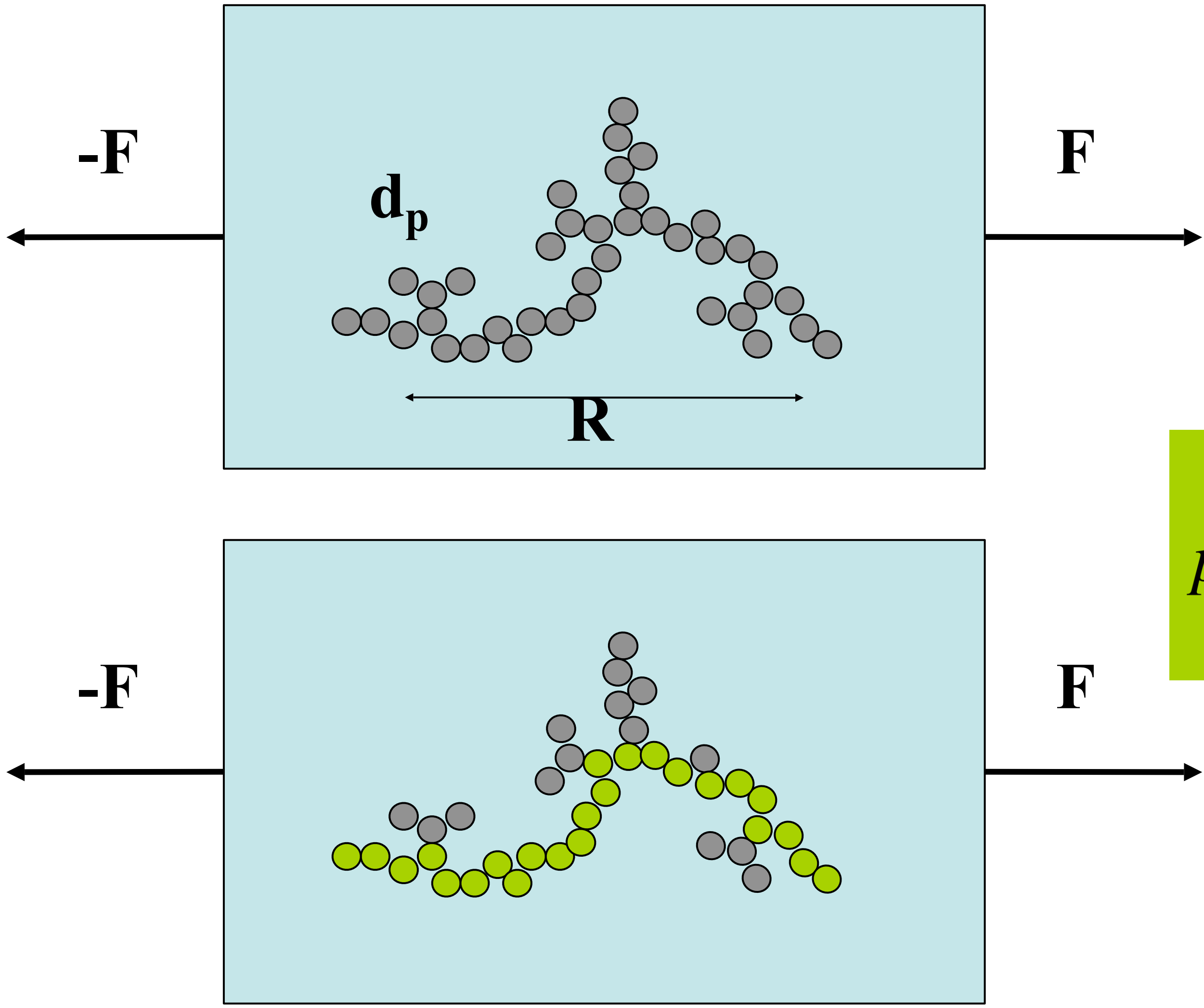
Printed Layer



Silicon nanoparticles with binder



Fractal dimensions: d_f, d_{min}, c, the degree of aggregation (z), minimum path (p)



$$z \sim \left(\frac{R}{d_p}\right)^{d_f}$$

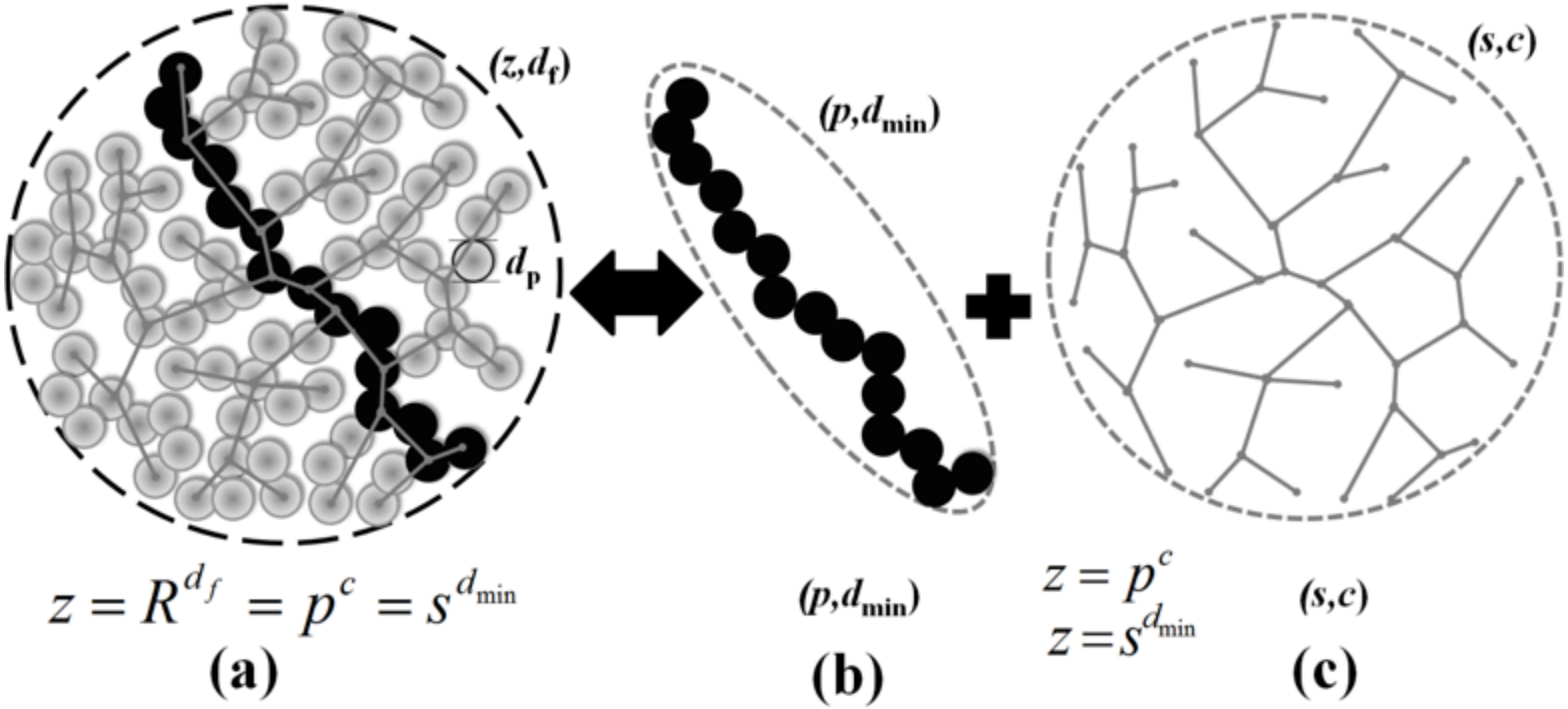
$$p = z_{\min} \sim \left(\frac{R}{d_p}\right)^{d_{\min}}$$

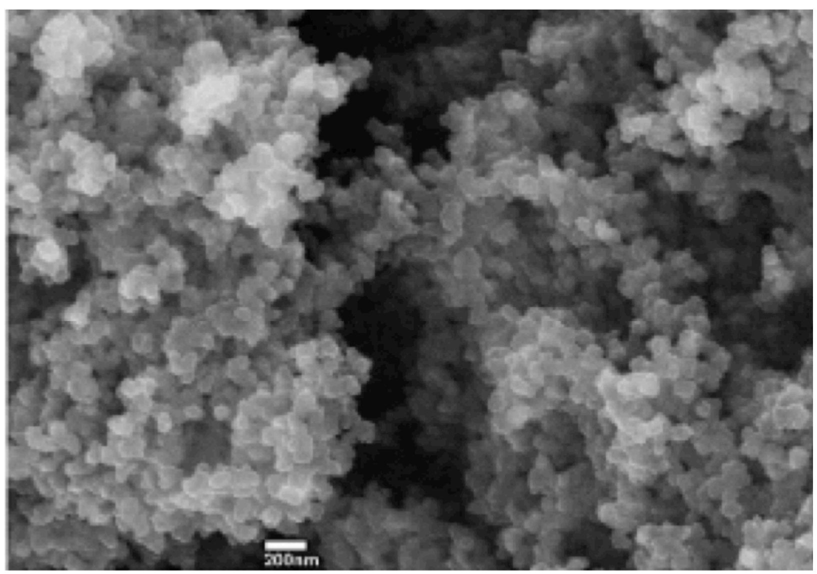
$$z \sim p^c = p^{d_f/d_{\min}}$$

$$d_f = c\, d_{min}$$

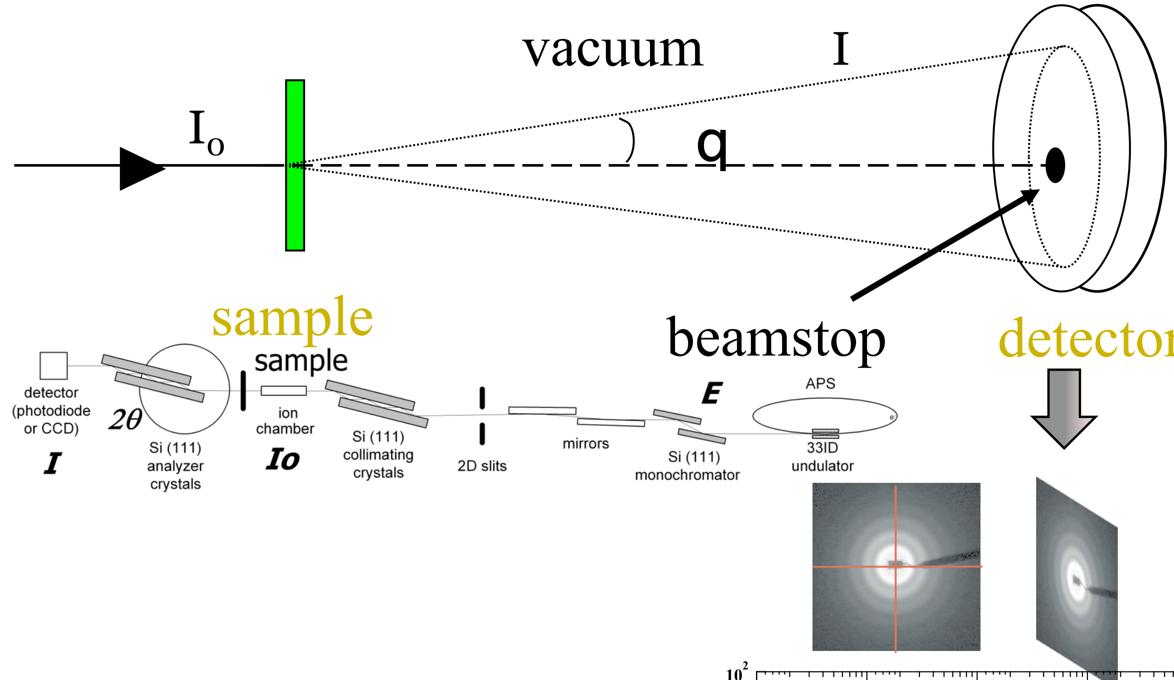
d_{min} should effect perturbations & dynamics.

Beaucage G, *Determination of branch fraction and minimum dimension of fractal aggregates* Phys. Rev. E **70** 031401 (2004).


(z,d_f)
(p,d_min)
(s,c)
d_p
z = R^{d_f} = p^c = s^{d_min}
(a)
(p,d_min)
(b)
z = p^c
z = s^{d_min}
(s,c)
(c)


200nm

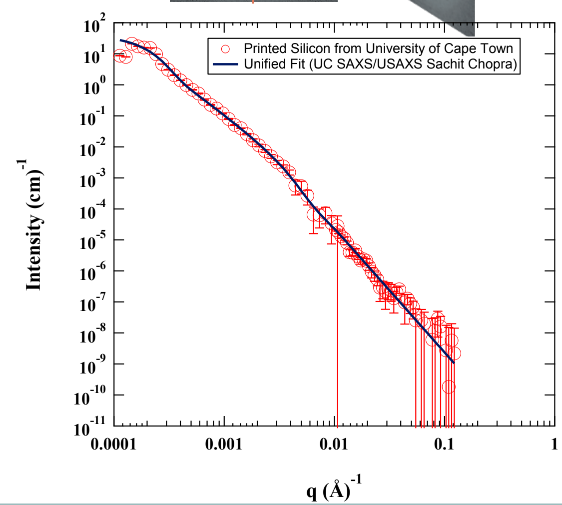
USAXS



Guinier's Law $$I(q) = G\exp\left(\frac{(-q\,R_g)^2}{3}\right)$$

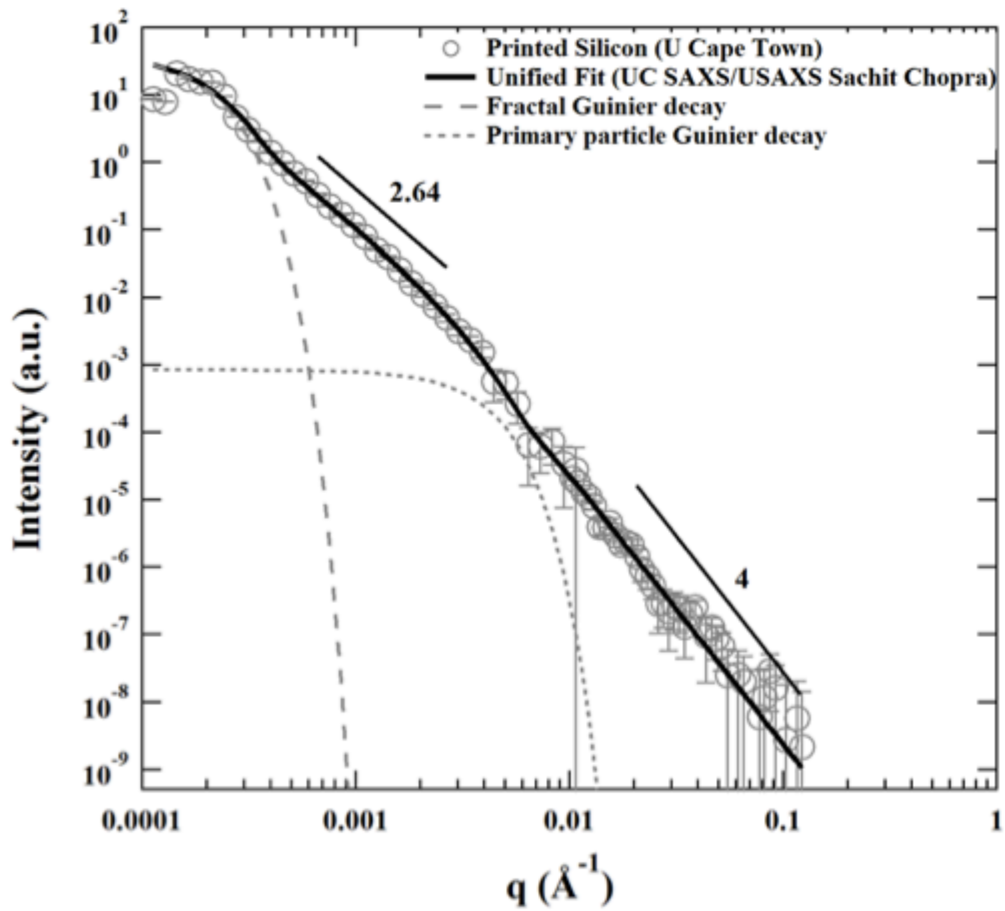
Power Law $$I(q) = B_f\, q^{-d_f}$$

Scattering Vector $$q = \frac{4\pi}{\lambda}\sin\left(\frac{\theta}{2}\right)$$

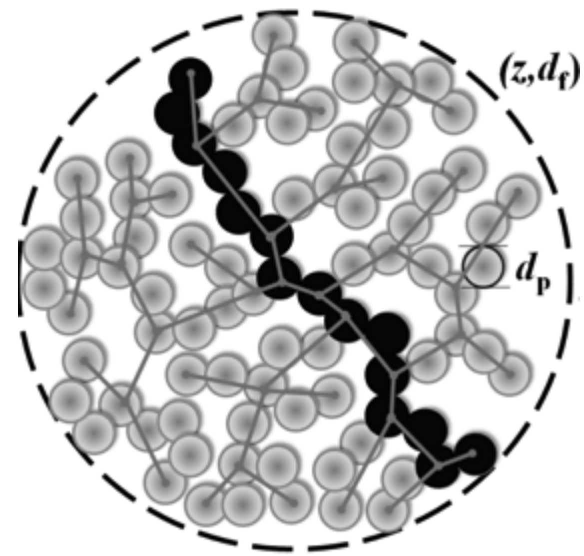


Beaucage G. Journal of Applied Crystallography 28 (1995) 717; Journal of Applied Crystallography 29 (1996) 134.

Fitting Parameters	Primary Particle Regime	Fractal Regime
Fractal dimesnion, d_f	-	2.64±0.03
Radius of gyration, R_g	490±10 Å	9,390±40 Å
Power law prefactor, B	$2.4 \pm 0.1 \times 10^{-13}$	$1.3 \pm 0.1 \times 10^{-9}$
Guinier prefactor, G	$8.4 \pm 0.4 \times 10^{-4}$	40.1±0.3



Calculated Scaling Parameters	Magnitudes
Degree of aggregation, z	47,600±300
Sauter mean diamter, d_p (nm)	42.9±0.7
Geometric standard deviation, σ_g	1.54
Minimum dimension, d_{min}	1.14±0.04
Connectivity dimension, c	2.32±0.02
Branch fraction, ϕ_{br}	0.998±0.007
Meandering fraction, ϕ_m	0.733±0.009
Number of branch points in aggregate, n_{br}	6,710±70
Number of branch points in minimum path, $n_{br,p}$	28±1
Total number of segments in aggregate, $n_{s,z}$	13,420±90
Number of primary particles per branch, z_{br}	1,700±30
Average number of particles per segment, z_s	3.6±0.4
Number of inner inner segments, n_i	6,680±70
Average coordination number, C_N	2.14±0.05



$$E_f = E_p\left(\frac{d_p}{R_{g,f}}\right)^{(3+d_{\min})}$$

$$\Omega(z) \sim \left(\frac{z^{1/c}}{d_p{}^{2}}\right)$$

Figure 3. a) Discussion with African Initiative Conference attendee left to right, Prof. David Britton, UCT, Dr. Mussie Alemseghed, ORNL, and Prof. Goro Gonfa, HU. b) Dr. Mussie Alemseghed at Haramaya University presenting a discussion on organic photovoltaics for indigenous PV manufacture in SSA.

(a) (b)

Figure 5. *a) Dr. Greg Smith from Oak Ridge National Laboratory discusses collaborative efforts in the NanoPower Africa project with a group of scientists and administrators from the Ministry of Energy, Education and scientist from BOTEC and the University of Botswana. Also in attendance are Dr. Jan Ilavsky form Argonne National Laboratory and Prof. Greg Beaucage from the University of Cincinnati. b) NPA team visits BOTEC/UB solar chimney test site.*

Figure 6. *Lunch with US Embassy Staff at Lucy's Restaurant, Addis Ababa. Faculty from Haramaya University and UC, embassy staff and visitors from One Laptop per Child discuss possible interactions between OLPC and the NanoPower Africa project.*

a) b)

a) From right, Prof. Goro Girma Gonfa, Haramaya University, Ethiopia, Prof. Schadrack Nsengiyumva, South Africa, and representatives from the Rotary Club; Carl Sedacca, and Kay Atkins. b) Informal meeting of African Scientists and the home of Deborah Schultz with Cincinnati Rotary Club business advisors. Cincinnati Rotary Club members Janet Metzelaar and Dan Gist with Schadrack Nsengiyumva and Goro Gonfa.

Haramaya University/University of Cincinnati Program for Student & Faculty Interaction and Community Outreach. Through PV Installation in Kersa Farmer's Association

Administrative building at Haramaya University

Qeransa-Darraba health post about 7 km from Haramaya University

Live web class showing speaker from Cape Town (Prof. David Britton on left screen) and students in the US asking questions with Course Coordinator Prof. Greg Beaucage at UC. Students at Haramaya University in Ethiopia, KIE in Rwanda and at Rhodes University in South Africa are also participating via live web link.

Photographs of The Site

Qeransa-Darraba health post About 7 km from Haramaya University Has three rooms No tree shade Electric line installation is completed	
	QD-Health Post-1
Qeransa-Darraba health post Inside the room, no bulb	
	QD-Health Post-2
Qeransa-Darraba Primary School Directors office Two class room Possible to place the panel on this block About 10 km from Haramaya University	
	QD-School-1

Two more rooms in this block to be powered	
	QD-School-2
	

MANA BARUMSA

(a) (b)

(c)

Figure 8. *a) UC and HU undergraduate students design a mount for solar panels on a health clinic in Ethiopia. b) Installation of solar panels at the Qeransa-Darraba health post about 7 km from Haramaya University. c) UC and HU students with local children near the health clinic.*

Summary

-Development of Indigenously Manufactured and Used PV's for Africa

-Use PV technology as a Catalyst to Grow Higher Education

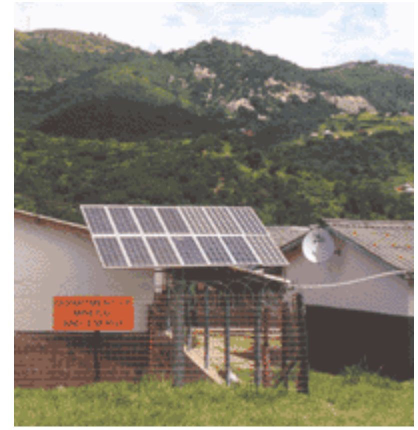
-Targeted Expansion of Higher Education aimed at Development Issues

-Work in Coordination with USAID Missions, Local Governments, Local Universities, NGO's, Startup Companies, Large Corporations

Solar Power is Already Contributing to Quality of Life in Off-Grid applications in sub-Saharan Africa largely through NGO's

1.6 billion off grid world wide
1/2 vaccine lost due to lack of refrigeration
kerosine lamps, diesel generators

Solar Light for Africa
Tanzania, Uganda, Rwanda, Liberia



Solar Electric Light Fund
Mthatha, Eastern Cape, SA

Rwanda, Lesotho, Nigeria

"The solar-powered computer center has had a huge impact on enhancing the culture of learning and teaching in our schools. The school dropout rate has declined considerably over the past two years ... You will never understand how much the intervention of SELF has made in the education of an African child."

- Melusi Zwane, Principal
Myeka High School