Nano-Power Africa

Higher Education for Development Program
United States Agency for International Development

Collaborative Project Between:

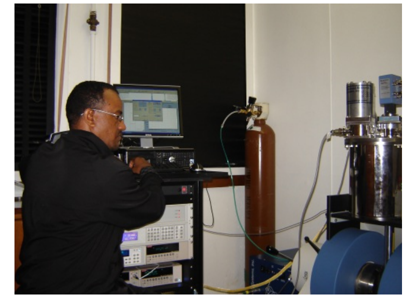
The University of Cincinnati
Oak Ridge National Laboratory
Argonne National Laboratory
Eclipse Film Technologies

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

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

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


NanoPower
Africa




NanoPower
Africa


NETHERLANDS
BELGIUM
PORTUGAL
SWITZERLAND
FRANCE
SPAIN
GERMANY
ITALY
EASTERN EUROPE
UNITED STATES
INDIA
INDIA PART 2
CHINA
CHINA PART 2
UK
JAPAN

Africa-US Higher Education Initiative

Higher education enrollment in SubSaharan Africa (SSA) has tripled from 2005 to present
expected to triple again by 2020

SSA is spending 20% of Gov. Exp. (4% GDP) on Education & 4% of Gov. Exp. on Higher Education

47% Social Sciences/Humanities 22% Education 18% Engineering/Sciences 7% Health 3% Agriculture

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

Higher Education Can Stabilize the Political Environment

Higher Education Can Solve Targeted Development Issues

500 Proposals => 33 Seed Funding => 11 Initial Funding (2 years, began 2011)

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

-Each project identifies **a development issue or problem** of interest related to one of six focus areas of the initiative.

-This issue and its underlying processes, are called the problem model (PM).

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 in that we offer

A) Science/Technology Innovation

B) Engineering

C) Development of an indigenous & local free-enterprise based solar cell industry in Sub-Saharan Africa

D) Potential partnership with US/SA corporations and small businesses

E) Significant involvement of US DOE Labs

F) A viable implementation of entrepreneurial "high-tech" to 3'rd world development.

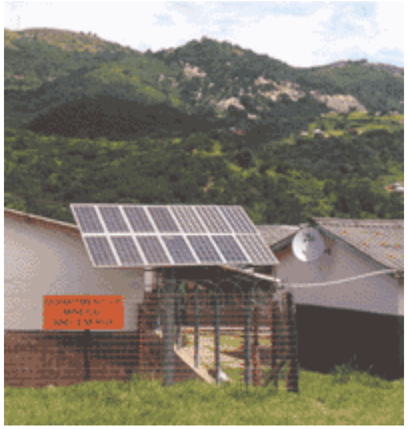
G) Use of the developed, post-apartheid SA university system as a model and as an indigenous leader for growth of Sub-Saharan Universities.

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.

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



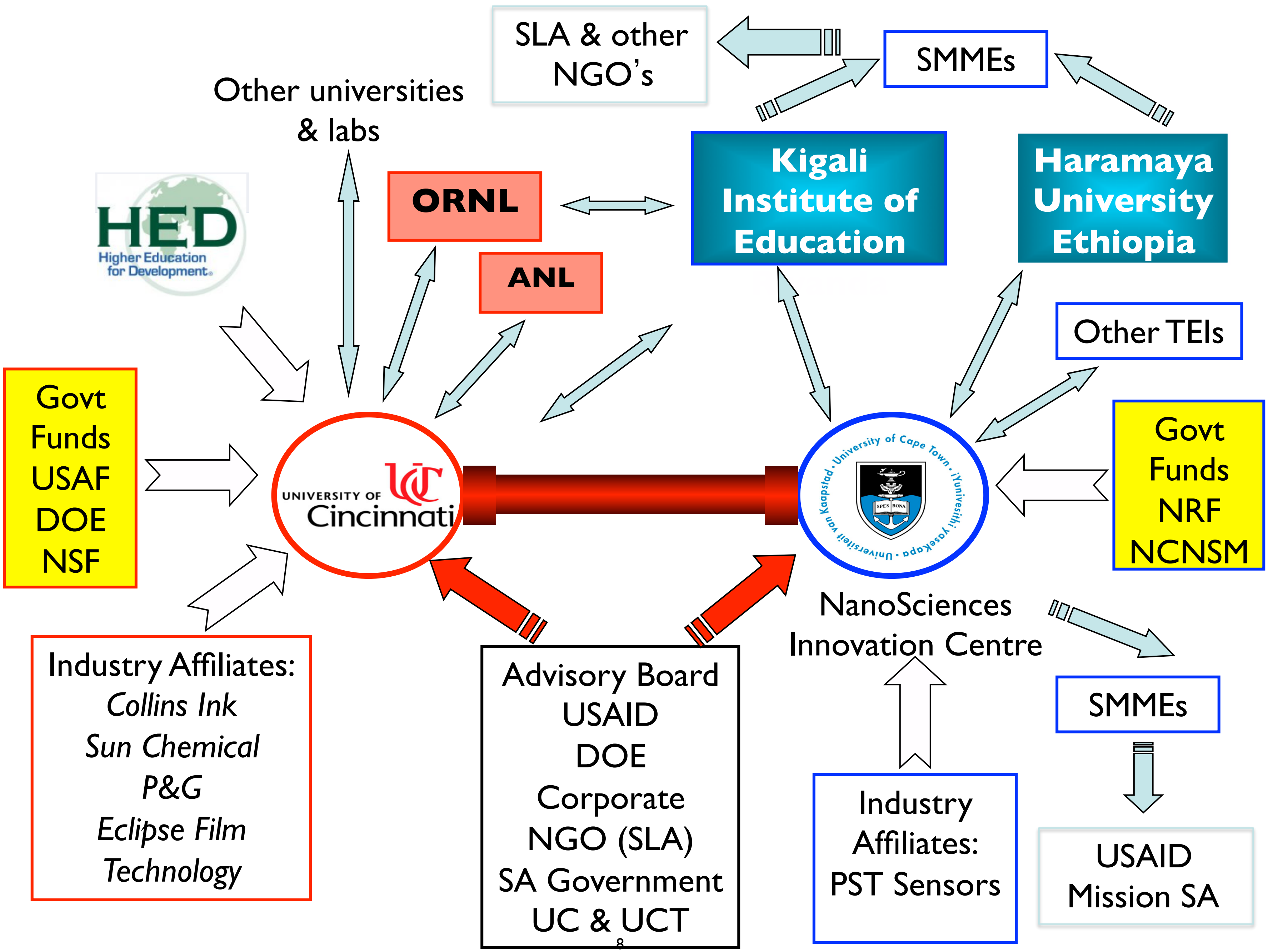
Solar Electric Light Fund
Mthatha, Eastern Cape, SA

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

NanoPower Africa: Higher Education for Development



December 2009, Cape Town, South Africa Planning Meeting

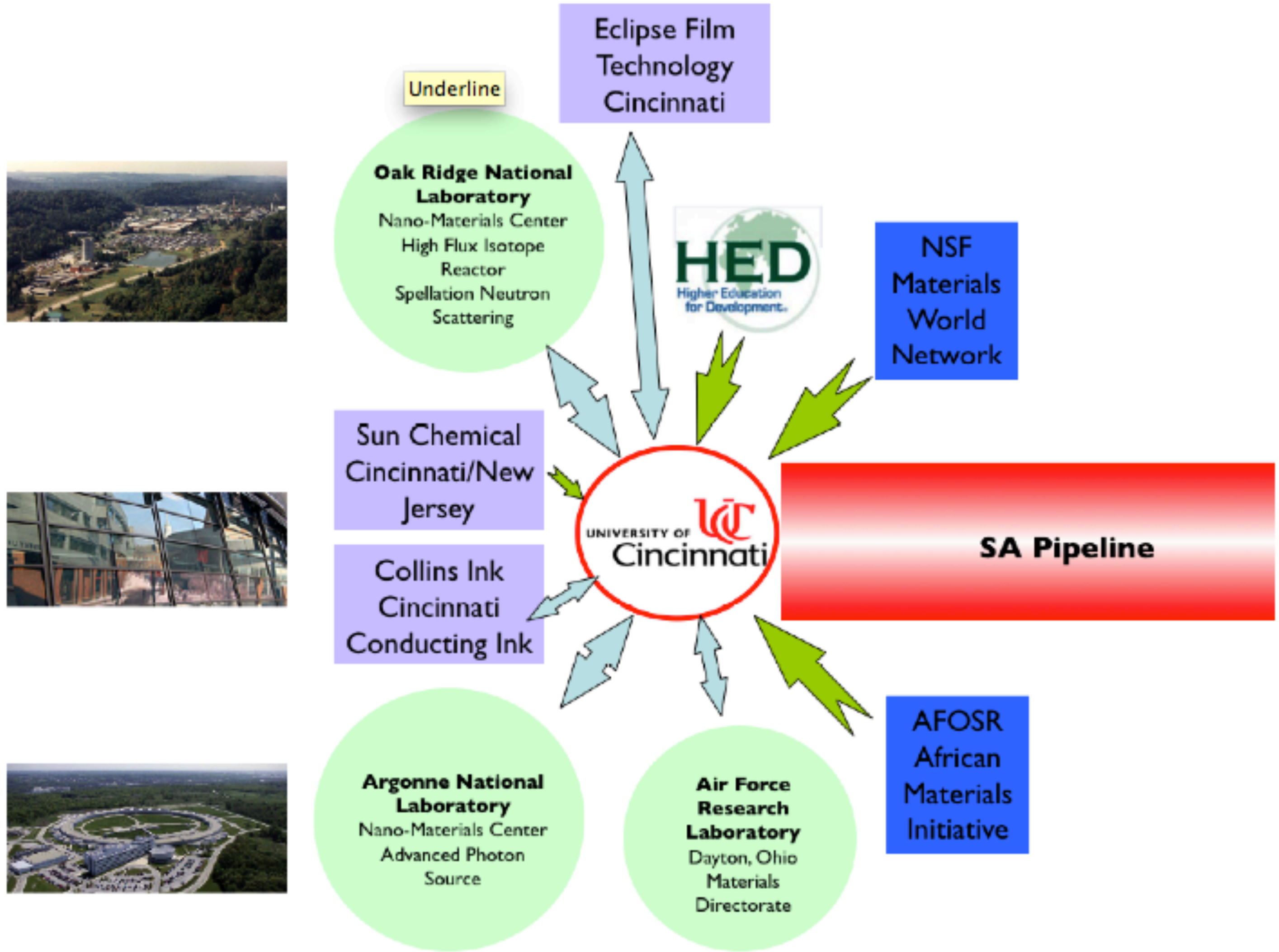
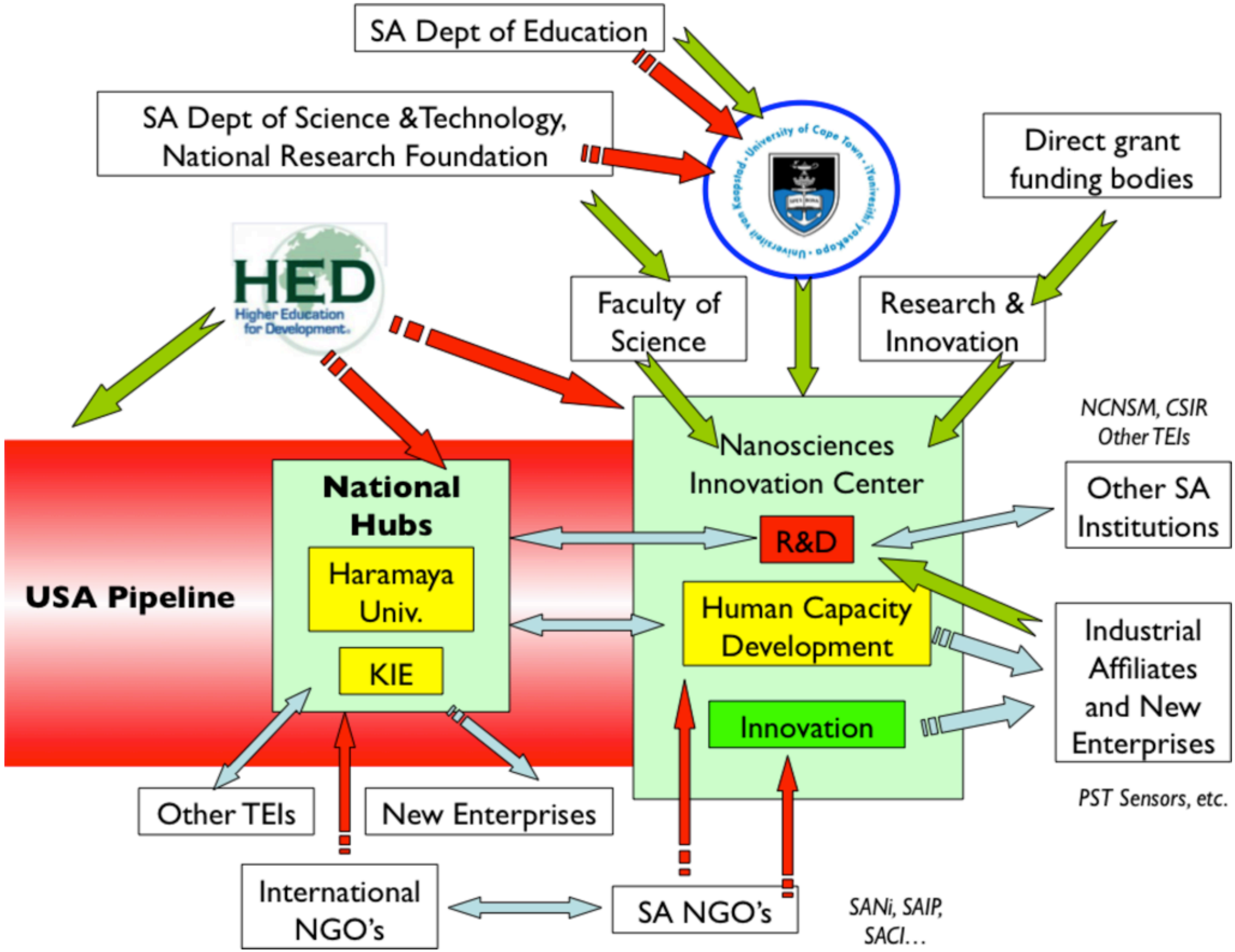
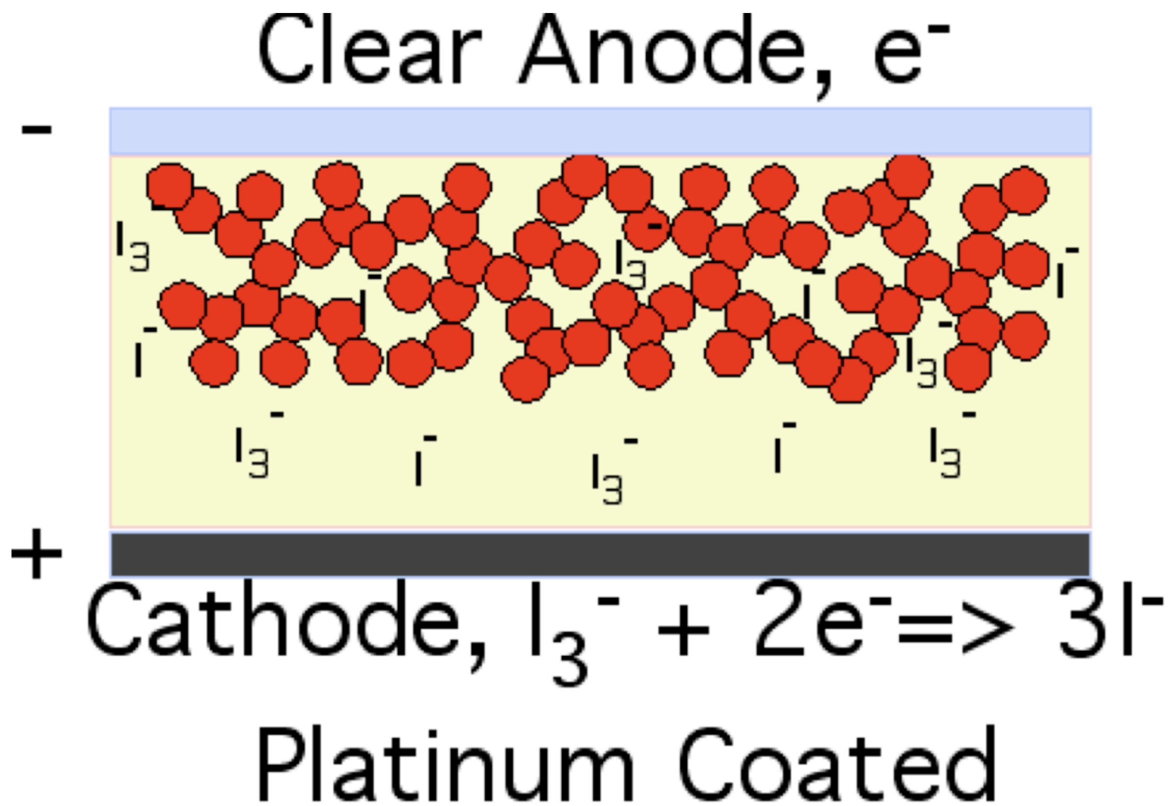


Figure 4.3. *Cincinnati hub for the Nano-power Africa project*



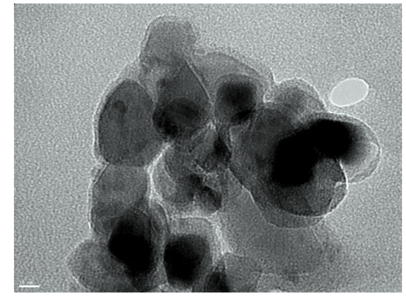
SA Dept of Education
SA Dept of Science &Technology, National Research Foundation
Direct grant funding bodies
HED
Higher Education for Development
Faculty of Science
Research & Innovation
NCNSM, CSIR
Other TEIs
Nanosciences Innovation Center
R&D
Human Capacity Development
Innovation
Other SA Institutions
Industrial Affiliates and New Enterprises
PST Sensors, etc.
USA Pipeline
National Hubs
Haramaya Univ.
KIE
Other TEIs
New Enterprises
International NGO's
SA NGO's
SANi, SAIP, SACI…

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.

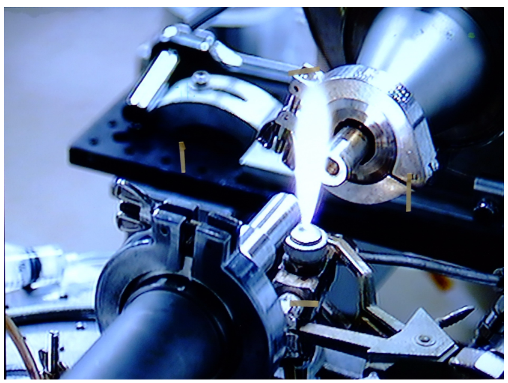
Grätzel Cell Production by Spray Flame

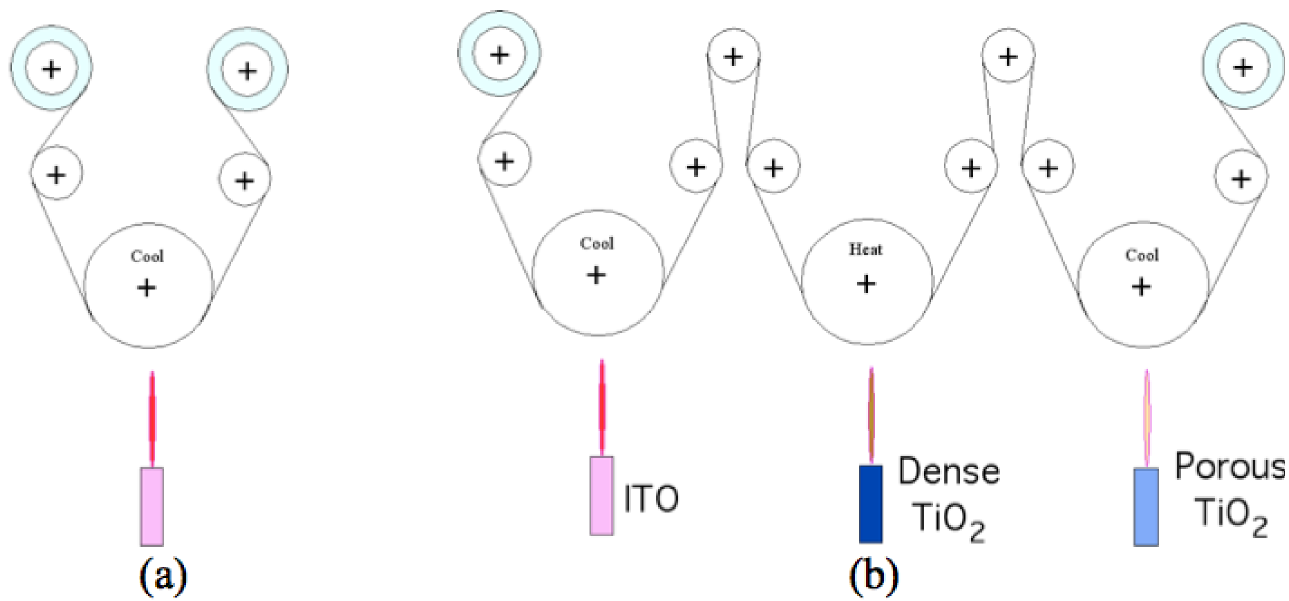


-Dye/titania development for inexpensive single step synthesis

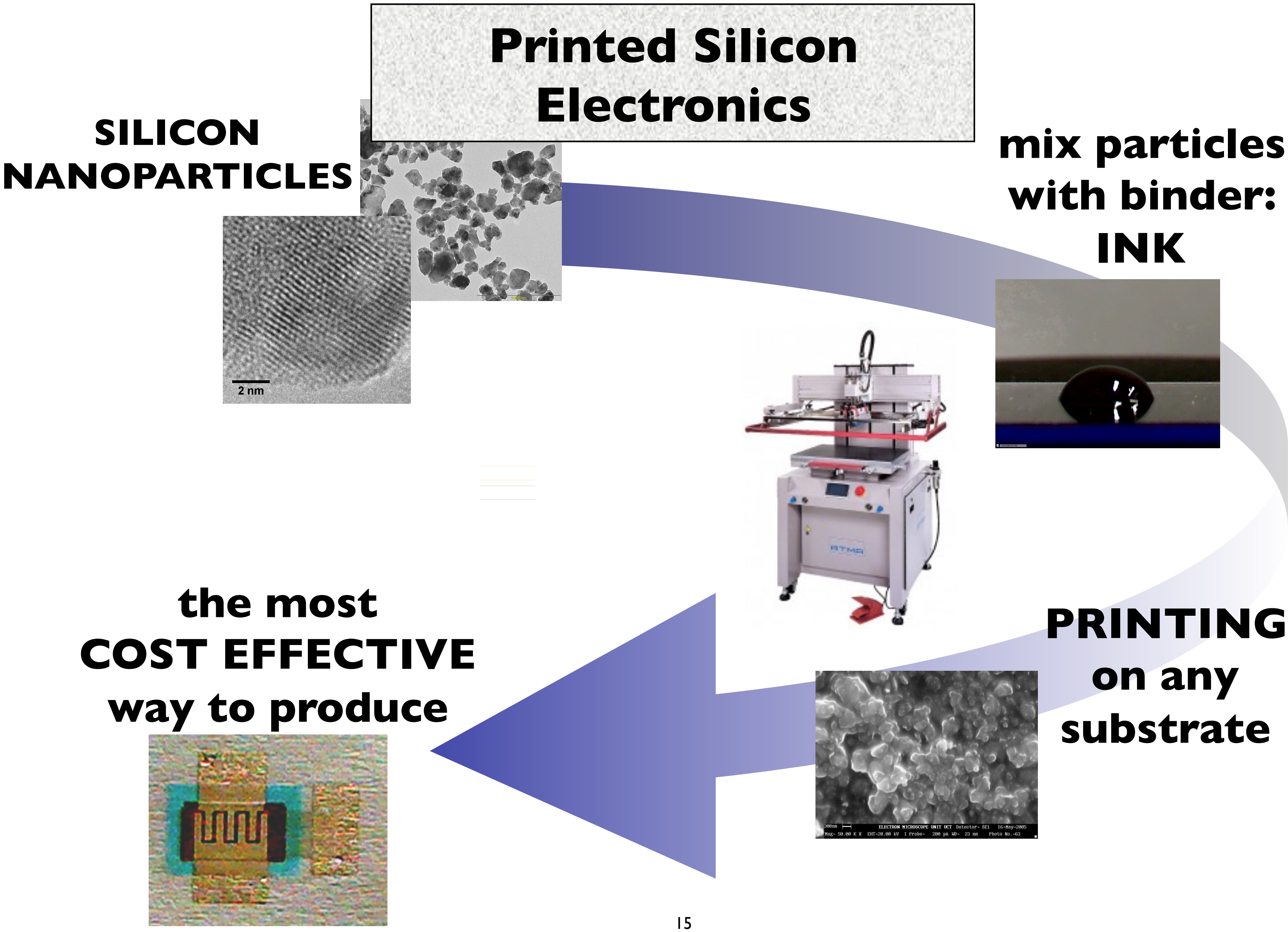
-Use carbon coated titania to enhance interaction
-Use in situ synthesized CdS nano particles supported on titania

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





Alternative simple photovoltaic device for Africa (UCT)



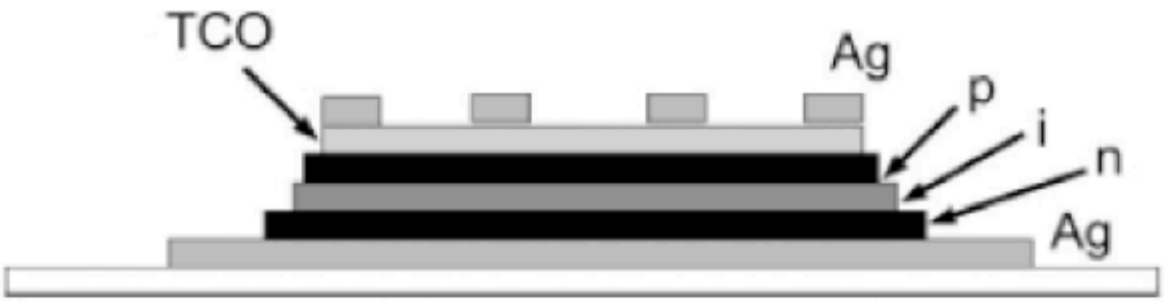
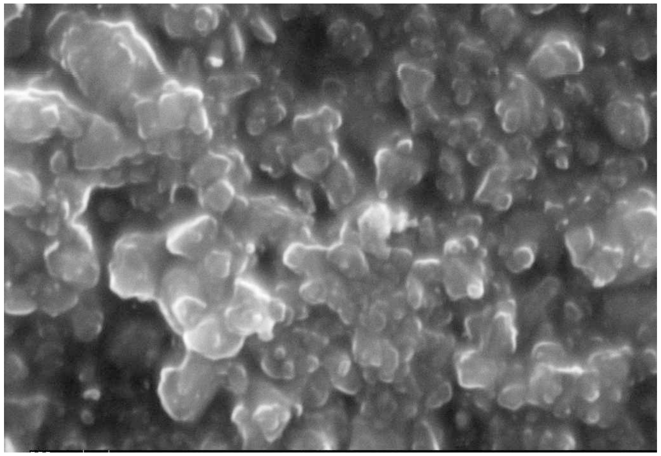


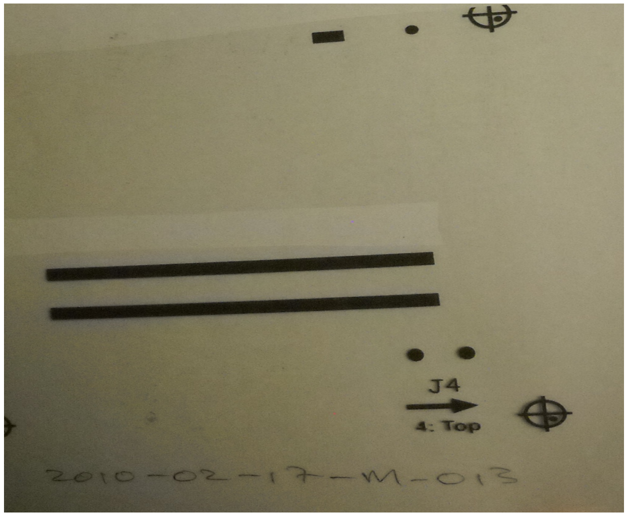
Figure 2.6. *Printing technology using silicon nanoparticles for a solar cell. Schematic diagram of a sample printed silicon device, using nanoparticulate silicon inks. A NIP photodiode structure is shown with the silver bottom contact, N-, I-, P-type silicon layers, the printed transparent semiconducting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

www.pstsensors.com

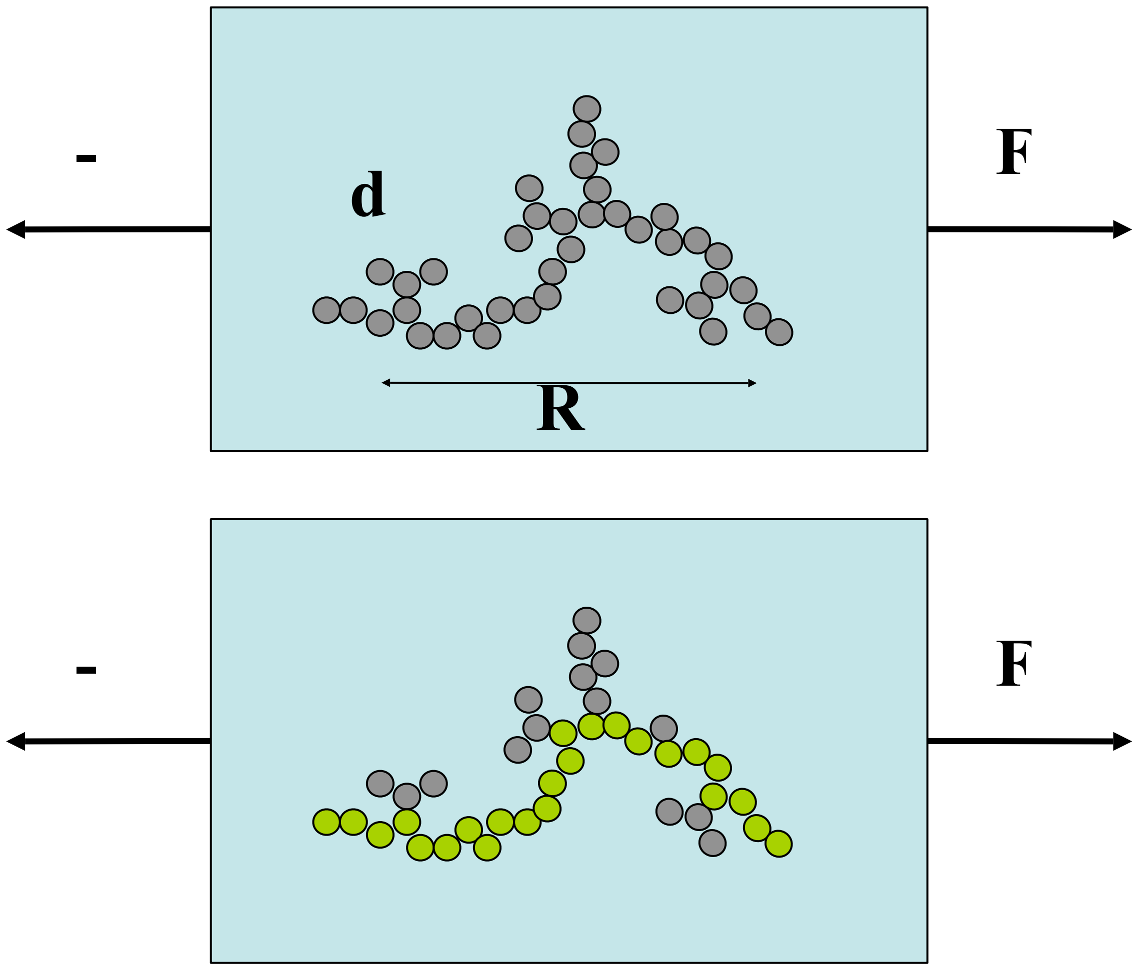
Silicon nanoparticles with binder



Printed Layer



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



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

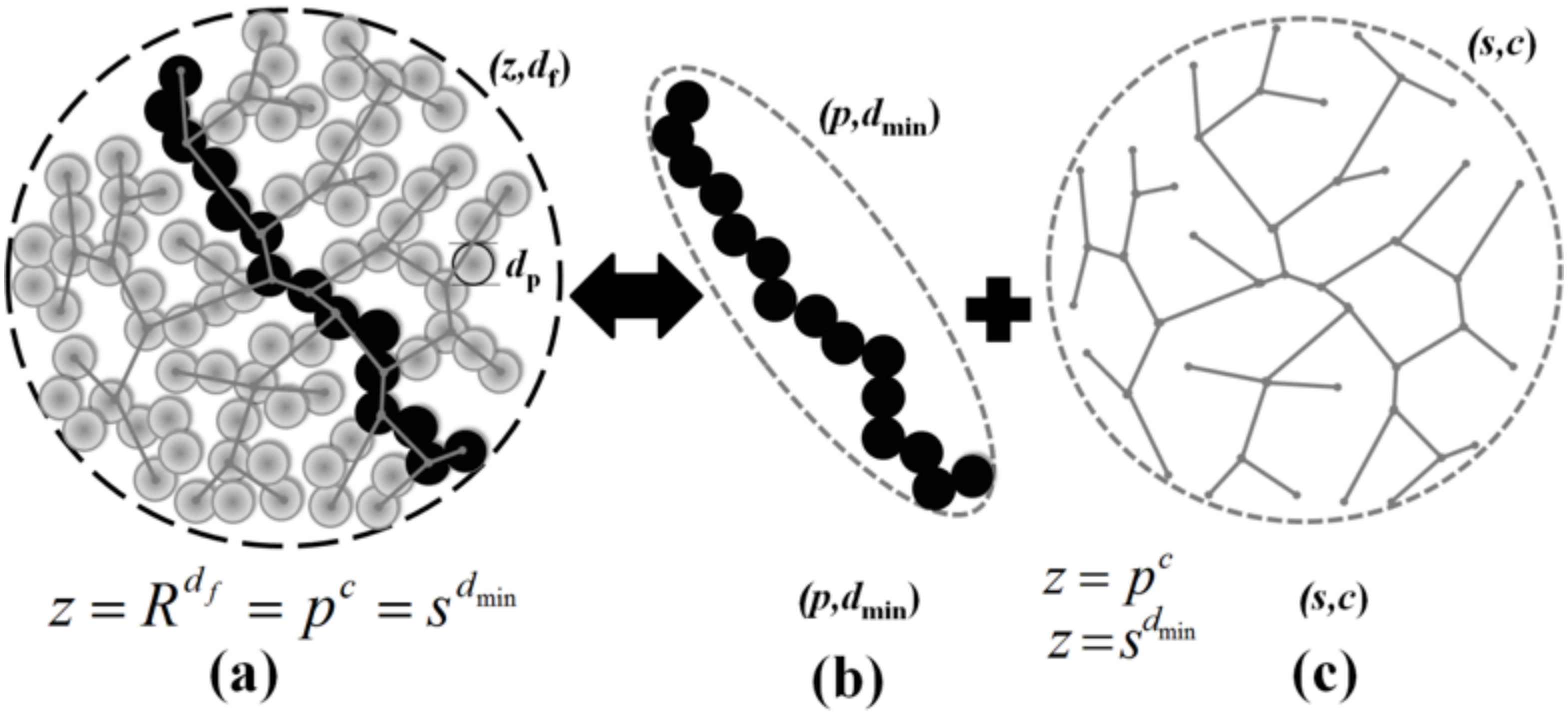
$$p = z_{\min} \sim \left(\frac{R}{d_p}\right)^{d_{\min}}$$

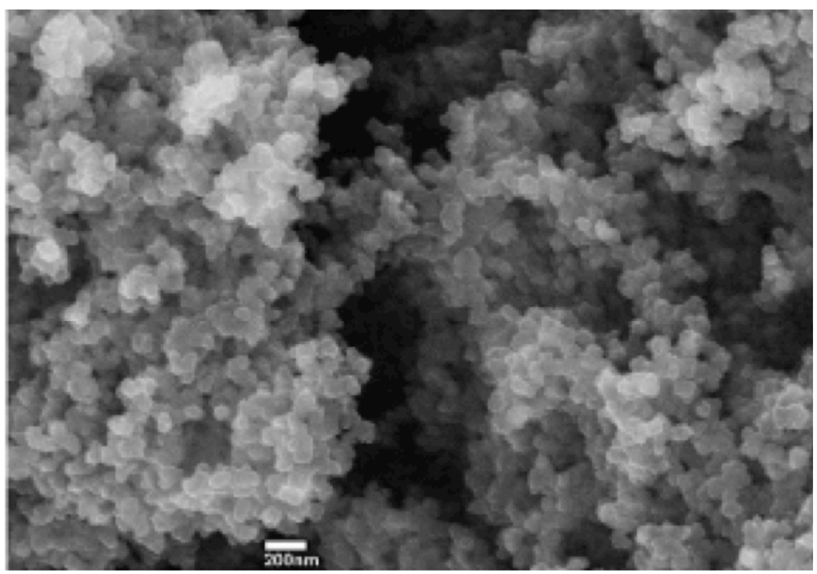
$$z \sim p^c = p^{d_f/d_{\min}}$$

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

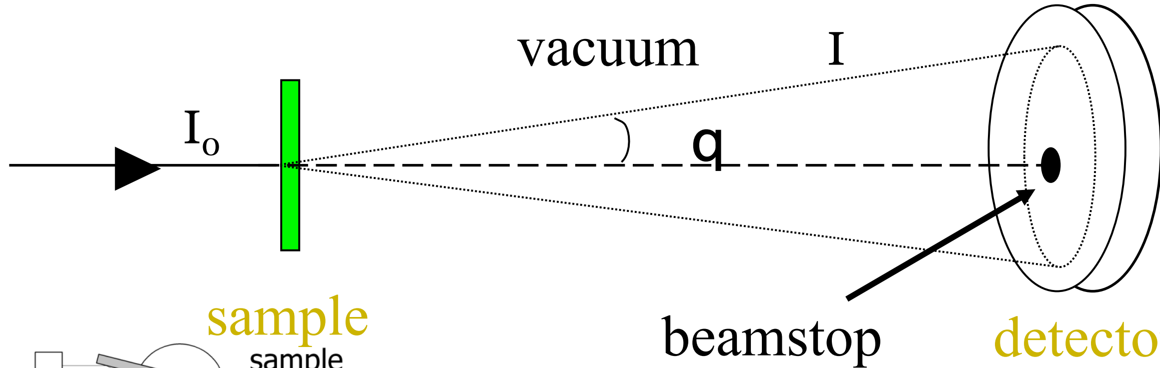
d_{min} should effect perturbations & dynamics.

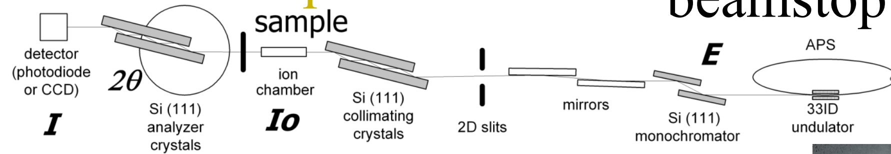
Beaucage G, *Determination of branch fraction and minimum dimension of fractal aggregates* Phys. Rev. E **70** 031401 (2004).

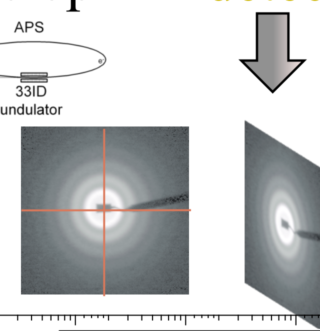

(z,d_f)
d_p
(p,d_min)
(s,c)
z = R^{d_f} = p^c = s^{d_min}
(a)
(p,d_min)
(b)
z = p^c
z = s^{d_min}
(s,c)
(c)


200nm

USAXS



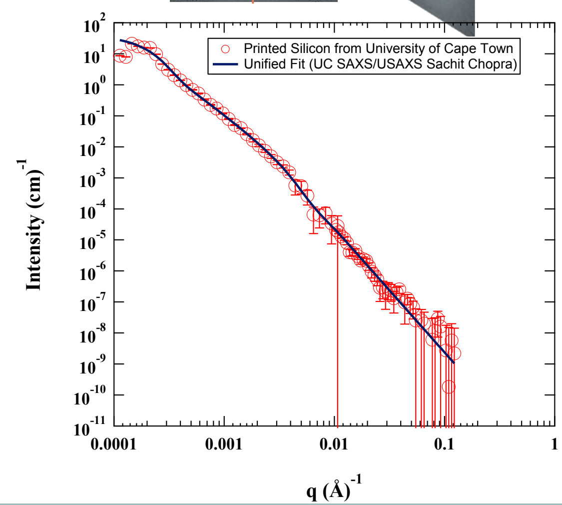




Guinier's Law $I(q) = G\exp\left(\frac{(-q\,R_g)^2}{3}\right)$

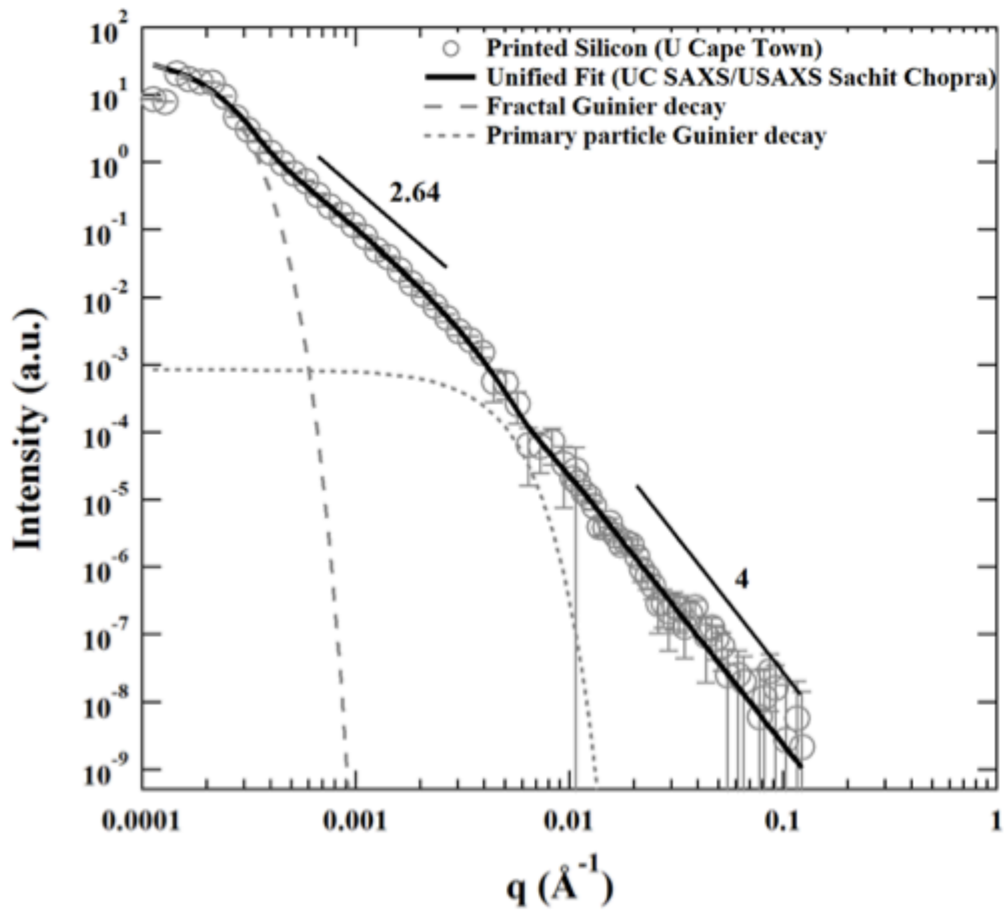
Power Law $I(q) = B_f\, q^{-d_f}$

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

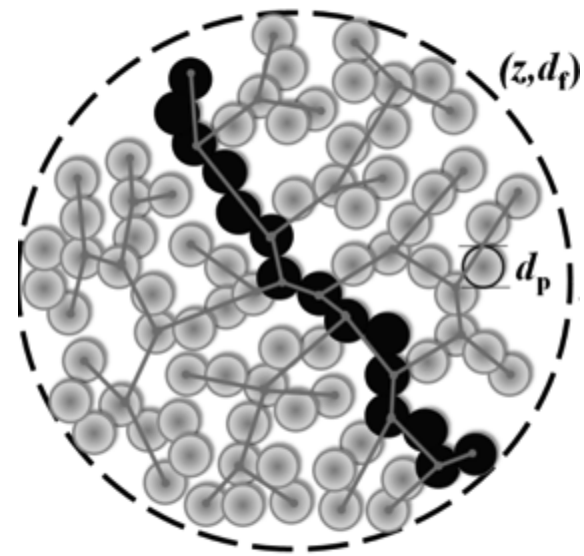


Beaucage G. Journal of Applied Crystallography 28 (1995) 717; Journal of Applied Crystallography 29 (1996) 134.

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±0.1×10^{-13}	1.3±0.1×10^{-9}
Guinier prefactor, G	8.4±0.4×10^{-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



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

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

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