World Class Professors

Wole Soboyejo
Department of Materials Science & Engineering
African University of Science and Technology (AUST)
Abuja, FCT, Nigeria
And
Department of Mechanical & Aerospace Engineering
Princeton University
Princeton, New Jersey, USA

Acknowledgements

- Prof. Oyewole (VC – FUNAAB)
- Dr. Akinyemi + VC's team
- My Parents – Prof. Alfred Soboyejo and Mrs. Antonia Soboyejo
- My Mentors – Prof. John Knott (Cambridge) and Prof. Frank McClintock (MIT)
- My Students and Colleagues

Congratulations to FUNAAB

- Congratulations to FUNAAB on its 25th Anniversary
- This is a great milestone and I wish the university many more years…. As an Egba man, I am very proud of FUNAAB and its achievements
- However as you know FUNAAB should have been the first university in Nigeria……
- Story of Rev. Kuti and the Alake
- How the Olubadan helped to start the University of Ibadan
- The subsequent establishment of UNAAB and FUNAAB and it progress over the years…..

Outline

- Background and Introduction
- Nigerian Case Studies
- Global Case Studies
- The African University of Science and Technology (AUST) and ARIST
- Lessons Learned and Concluding Remarks

Background and Introduction

- I feel very humbled by the task that I have before me today
- This is because it is difficult to summarize the qualities that make a professor great
- However, in my life so far, I have had the opportunity to meet a few professors that I consider to be great…….
- I will therefore present case studies of their lives and try to identify what made them great
- I will also try to identify lessons learned and their potential implications for FUNAAB and African Universities in general
- I will then present some examples of recent efforts to rebuild the development of a pipeline of great future African academics

My Background

- Grew up on the campus of the University of Lagos
- Went to school in England (King's College London and Cambridge University)
- Worked in the USA (The Ohio State University, MIT, Princeton)
- Currently serving at The African University of Science and Technology (AUST) in Abuja

Nigerian Case Studies

- Nigeria has had its own fair share of world class professors – some examples
- Sciences
  - Prof. Adeoye Lambo (Ibadan)
  - Prof. John Amazigo (Nsukka)
- Humanities
  - Prof. Wole Soyinka (Ibadan&OAU)
  - Prof. Ade Ajayi (Ibadan & Lagos)

Prof. Adeoye Lambo

- Trained as a medical doctor
- Returned to Nigeria to practice medicine – without tools or adequate hospitals
- Responded by thinking out of the box
- First he introduced community-based medicine by going from village to village
- He then combined his Western training with studies of mental illness
- Published in world class journals from Nigeria
- Ended up as VC – University of Ibadan and the No. 2 Man at UNESCO

Prof. John Amazigo

- Trained in mathematics and solid mechanics at RPI and Harvard University
- Established a solid reputation at RPI in the 1960's and 1970's
- Returned to Nigeria to teach at UNN
- Periodic visits to Harvard to do world leading work with Budiansky, Hutchinson and Evans
- Emeritus Professor at UNN

Prof. Wole Soyinka

- Trained at the University of Ibadan in English
- Then went on the University of Leeds to redo his degree
- Returned to the University of Ibadan and then moved on to the Obafemi Awolowo University
- The deepest writer from the African continent – The Interpreters, The Man Died, Ake…..
- Received the Nobel Prize in Literature
- Continues to write and provide critical insights

Prof. J. F. Ade Ajayi

- Brilliant student that could have studied any subject
- Chose to study History
- Lifelong commitment to the field
- Encyclopedic knowledge of African History
- Served as Vice-Chancellor of Unilag
- Returned to the University of Ibadan as professor
- Chose to stay in Nigeria in spite of numerous offers from leading universities in the world…..

Lessons Learned From Great Nigerian Professors

- Lifetime dedicated to scholarship with some service
- Imagination and dedication are more important than knowledge
- Practical approaches to world class research using global best practices
- Make the subjects come alive by not following the crowd
- Globally recognized for their lifetime of scholarship…..

Case Studies from Cambridge University

- Observations as a student at Cambridge…..
- Simple town with dedicated teachers and students…..
- However many of the lecturers were truly world class in spite of their simplicity
- I will highlight my limited contact with 4 professors that influenced me
  - Prof. Stephen Hawkin
  - Prof. Alan Cotterell
  - Prof. John Knott
  - Prof. Mike Ashby

Prof. Stephen Hawkin

- Lucasian Professor of Mathematics at Cambridge
- Same Chair that was held by Sir Isaac Newton
- Paralyzed for almost 50 years……
- However determined to lead a normal life of scholarship….
- One of the leading minds in astrophysics
- Encounters in the graduate center at Cambridge University……
- Watching him from a distance convinced me that I can overcome any challenges

Prof. Alan Cotterell

- Goldsmith Professor of Metallurgy at Cambridge University
- Trained many world class scientists…..
- Went on to become Scientific Advisor to the UK Government
- Returned to Cambridge as an Emeritus Professor
- My encounters with him were always in the library where he reviewed the journals on a daily basis – like a student
- His 4 Lectures on the Theory of Metals showed me that I had a lot to learn……

Prof. Mike Ashby

- Son of Lord Ashby of The Ashby Commission that developed he Educational Policy for Nigeria and West Africa
- Student of Alan Cotterell at Cambridge
- Went on to Harvard University before returning to Cambridge in the 1970's
- Brilliant mind that made complex ideas appear simple – dedicated scholar, teacher & researcher
- Pioneered the development of Materials Selection Charts that gave birth to the CES Company
- Encountered him in the late 1990's and early 2000's when I worked on Metal Foams

Prof. John Knott

- Student of Alan Cotterell at Cambridge
- First class mind with a dedication to students and scholarship
- Rose through the ranks at Cambridge and later in Birmingham
- To me he was simply “John” my PhD advisor
- To the world he was the leading expert on Fracture Mechanics
- I learned this when we attended an International Conference in Virginia together
- Lessons learned - great professors breed great students

Lessons Learned From Great Cambridge Professors

- Great professors dedicate their lives to scholarship – continuous learning, teaching and research
- This continues during and after holding senior administrative positions
- Simplicity and careful focus are the keys to long term success
- Deep knowledge is a product of long term scholarship supported by the university's culture
- Great professors breed great students who in turn have the potential to emulate their mentors

US Case Studies

- The Ohio State University/Washington University
  - Prof. John Hirth (The Ohio State University)
  - Prof. Paul Paris (Washington University)
- MIT/Harvard
  - Prof. Frank McClintock (MIT)
  - Prof. John Hutchinson (Harvard)
- Princeton University
  - Prof. Sui Lam (Princeton)
  - Prof. Stephen Forrest (Princeton/Michigan)

Prof. John Hirth

- Educated at The Ohio State University and Carnegie Mellon University in the 1950's
- Wrote a classical book "Theory of Dislocations" that established his reputation
- Pioneering contributions to the theory of dislocations
- Great teacher, mentor and editor of leading international journals
- First encounter in the early 1990's……

Prof. Paul Paris

- Educated at the University of Michigan and Lehigh University
- Enterprising graduate student that became a Consultant to Boeing in the 1950's and 1960's
- Developed new theory of how cracks grow
- Theory was not initially accepted by his peers
- Went on to become one of the most highly cited authors in the field
- Successful academic (Lehigh and Washington Universities) and entrepreneur (Del Research Corporation)
- Example of commercial and academic success

Prof. Frank McClintock

- Professor of mechanical engineering at MIT
- Dedicated scholar and mentor of many generations of MIT students
- Classical book on The Mechanical Behavior of Materials
- Cared about every level of detail in his work
- Sometimes made complex problems more complicated – opposite of Paris and Ashby
- Interacted with him when I was a Visiting Martin Luther King Associate Professor at MIT in the 1990's
- Lessons learned – care about every aspect of your work but always remember the big picture……

Prof. Sui Lam

- Educated at Princeton University in the 1940's
- Stayed on at Princeton and rose through the ranks
- One of the first generation of Chinese professors in the USA
- Seminal work in fluid mechanics
- Helped many Chinese students and professors to develop into world class scholars……
- First encountered him when I went to Princeton in 1999
- Lesson learned – use your success to help others to succeed

Prof. Stephen Forrest

- Strong personality and pioneer in the field of organic electronics
- Former professor and head of electrical engineering at Princeton
- Now Vice President for Research at the University of Michigan
- Outstanding contributions to the development of organic light emitting devices (OLEDs)
- Clever funding of innovation/start-up and research
- Worked with him on the modeling of cold welding for the fabrication of OLEDs
- Lessons learned – balance your imagination and drive with careful human relations

Lessons Learned From Great US Professors

- Lifetime dedicated to entrepreneurial scholarship
- Make their subjects come alive through their approaches to teaching and research
- Can sell their ideas over many generations
- Recognize the commercial potential of emerging ideas and how to overcome obstacles
- Help many generations of students to become world class researchers
- The type(s) of success often determined by university policies e.g. Stanford vs. Princeton

The US System and The Building of World Class Professors

- The US system has many elements that promote the development of world class professors
- First is the **culture of education, research and service**
- Next is **the financial support** provided for research and teaching initiatives
- **Support for Graduate Students, Young Investigators and World Class Researchers** helps to build the **pipeline of world class professors**
- **The incentives and quality evaluation processes** also have a strong impact on productivity & quality
- **Above all is the freedom to explore ideas** beyond the boundaries of current approaches e.g**. interdisciplinary approaches and new ways of thinking…..**

The Challenges Faced By African Scholars

- Although our universities started very well e.g. University of Ibadan……Our universities have suffered from political, structural and funding issues since the 1980's
- The governance structure is highly political
- Access to funding is limited – No National Research Foundation
- The mentoring of junior, mid-level and senior faculty is limited
- The problems of survival push many scholars into multiple activities
- The opportunities for self renewal are limited especially after engaging in administration

Some Emerging Opportunities For Nigerian/African Scholars

- Within Nigeria the TERTFUND has provided significant funding for the development of infrastructure while World Bank has provided funding for training & research
- Some international organizations have also funded selected research groups e.g. NIH, USAID, DIFID, Gates Foundation
- However the funds are small compared to our local needs….
- Some companies are also begin to work with African academics although more engagement is needed…..e.g. TOTAL
- However we need transformation as has occurred in the East

Lessons From The East…

- The recent examples of emerging countries such as Brazil, India, China, Taiwan, Korea and Singapore show what is possible with a careful investment in education……..
- These countries are rapidly emerging into world class environments with high profile professors and industry
- So the real question is how can we do to engineer the transformation of Africa through new initiatives that build on existing African capacity and networks?

The Role of Networks

- The key is to use networks as catalysts for economic development **e.g. CODESRIA**
- Their potential has already been demonstrated recently by Africans in the **movie, spare parts, banking and religion industries**
- Similar networks are possible in the "knowledge" industry by forming networks that link
  - Africa to Africa
  - the international/diaspora to Africa e.g. ARIST
- However the span of activities must range from ideas to markets…

The Nelson Mandela Institutions (NMIs) of The African Institutes of Science & Technology (AISTs)

- The objective of NMIs is develop world class institutions that can use science and technology as tools to solve African problems
- The basic goal is to create world class African Institutes of Science & Technology (AISTs) in Africa
  - Similar to the Indian Institutes of Science and Technology (IITs/IIS)
  - The first of these is the African University of Science and Technology in Abuja (AUST-Abuja)
  - AUST- Abuja was established in 2007 (NUC approval) with support from the Federal government of Nigeria, PTDF, FCT, World Bank and the global scientific community
  - Goal is to establish other campuses across sub-Saharan Africa

The Pan-African NMI Flower Model

Curriculum Development for The NMIs – The African Scientific Committee

- The African Scientific Committee (ASC) was created in 2004 to develop curricula for the NMIs
- The ASC consists of 2 groups (Chair – Wole Soboyejo)
  - Members based in Africa
  - Members based in the diaspora
- 32 fields are represented – with each field having at least 2 experts (1 in Africa and 1 in the diaspora)
- The fields range from the social sciences/humanities to natural/applied sciences and engineering
- Curriculum was developed by ASC in Dar-es-Salaam followed by working group efforts over 3 month period
- This curriculum is **the basis of AUST and NM-AIST-Arusha programs today** (has the **blueprint for 10-15 year development of undergraduate & graduate programs**)

Lessons Learned from the NMI Experience

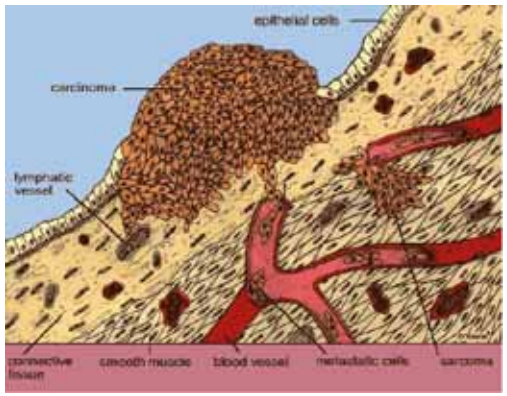
- The advisory role of the ASC and ISAB means that the curricula are not always implemented by local faculty at NMIs
- Buy-in needed by local faculty and management to ensure true implementation
- Hiring of new management can result in partial experiments that can lead to failure
- Must engage industry in curriculum development and implementation
- Centers of excellence concept can lead to sense of alienation by existing universities
- Must engage local universities and labs as partners

Joint Research Programs@ AUST

- The AUST has provided a strong platform for initiating joint research programs with other universities and national labs in Africa
- Ongoing research projects with SHESTCO, NASENI and NABDA
  - Critical mass of scientists being trained
  - Developing research-based solutions to African problems in energy, water, infrastructure, health
- Visits to Princeton University & ICTP for research experience in 2012 (15 scientists and engineers)
- Visits to universities in the USA and iThemba Labs in South Africa in 2013

Systems-Based Interdisciplinary Research at AUST

- Advanced Materials (Bio and Nano)
  - Targeting of disease
  - Alternative energy
- Societal Development
  - Affordable infrastructure e.g. recycling of agricultural & industrial waste
  - Value addition to minerals and natural products (Africa's silicon)



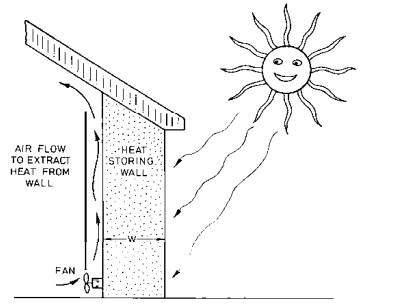
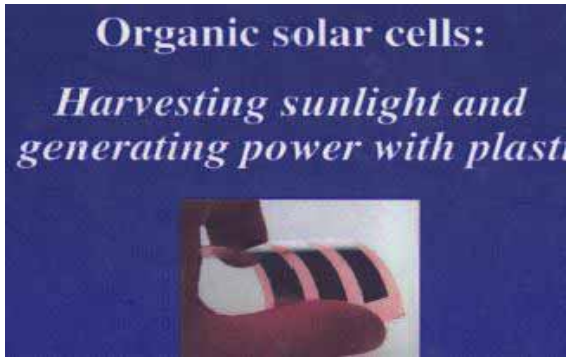


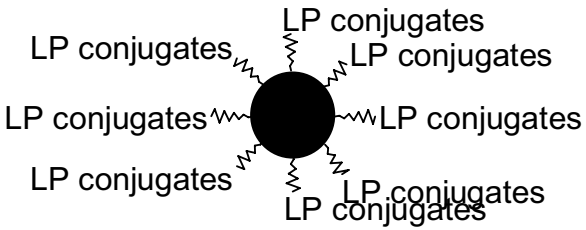
FIG. 6.32 A heat-storing wall. The sun shines on the outside during the day; heat is extracted from the inside at night. The heat diffusion time through the wall must be about 12 hours.

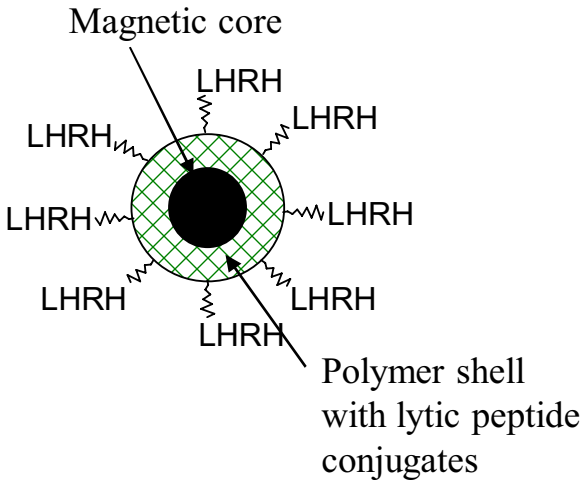


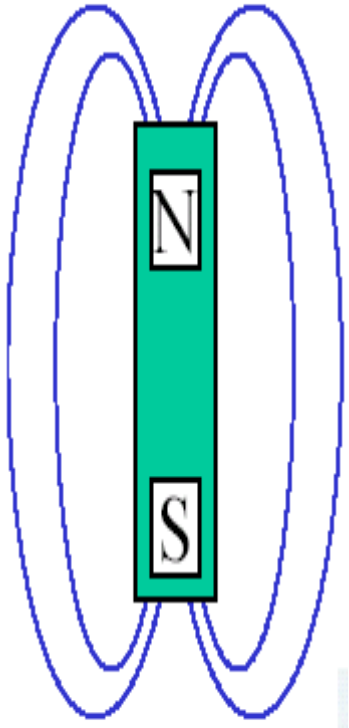
CAMD

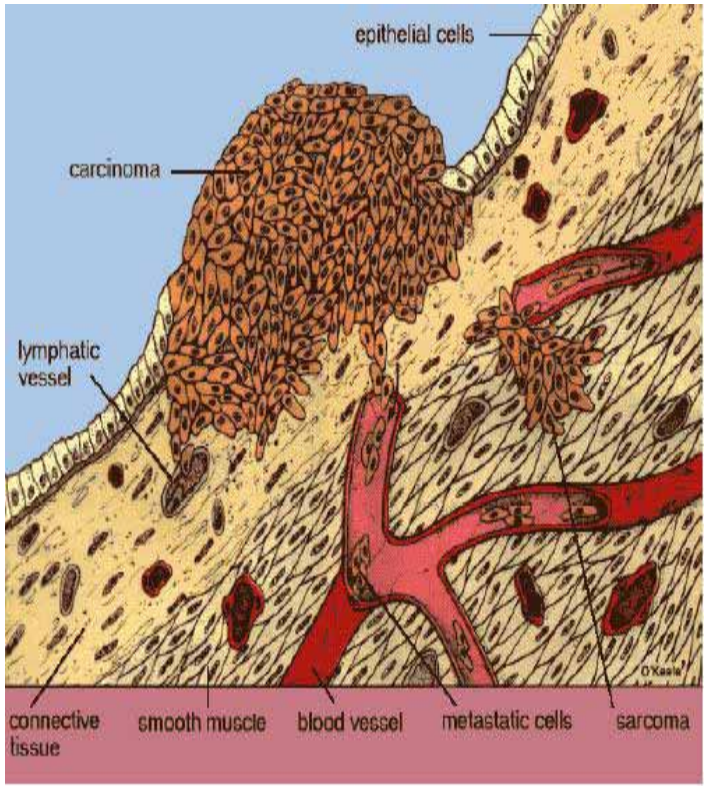
Our Approach to Early Cancer Detection and Treatment!

A novel use of magnetic fields and magnetic particles to deliver therapeutic drugs at the desired time in the correct dosage to the correct site in the human body.





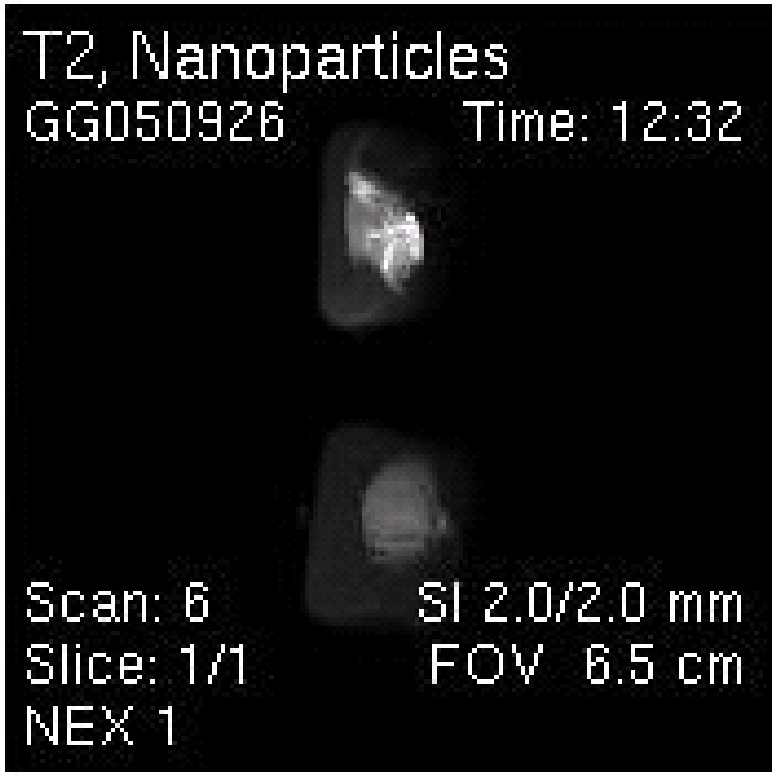


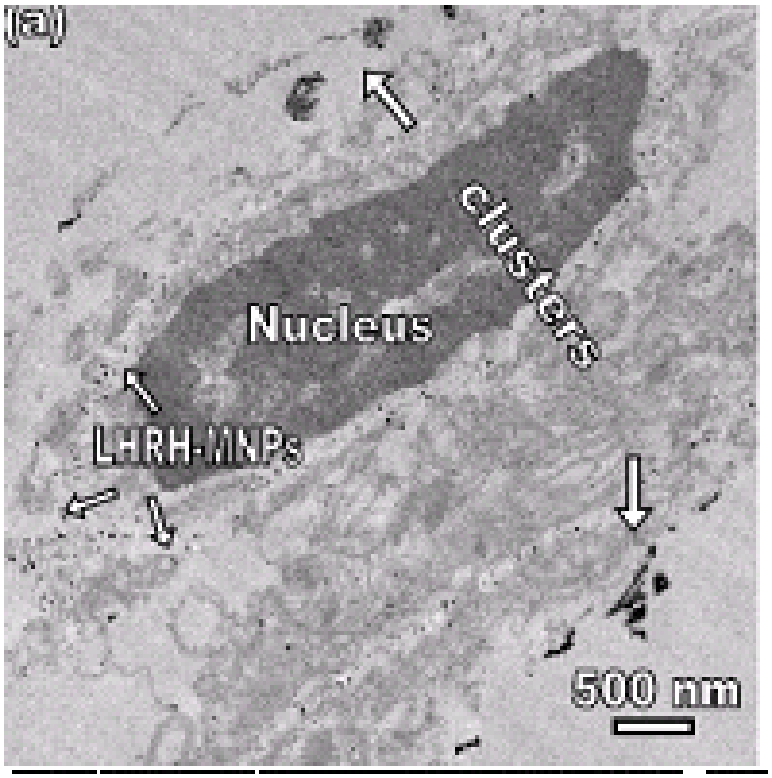


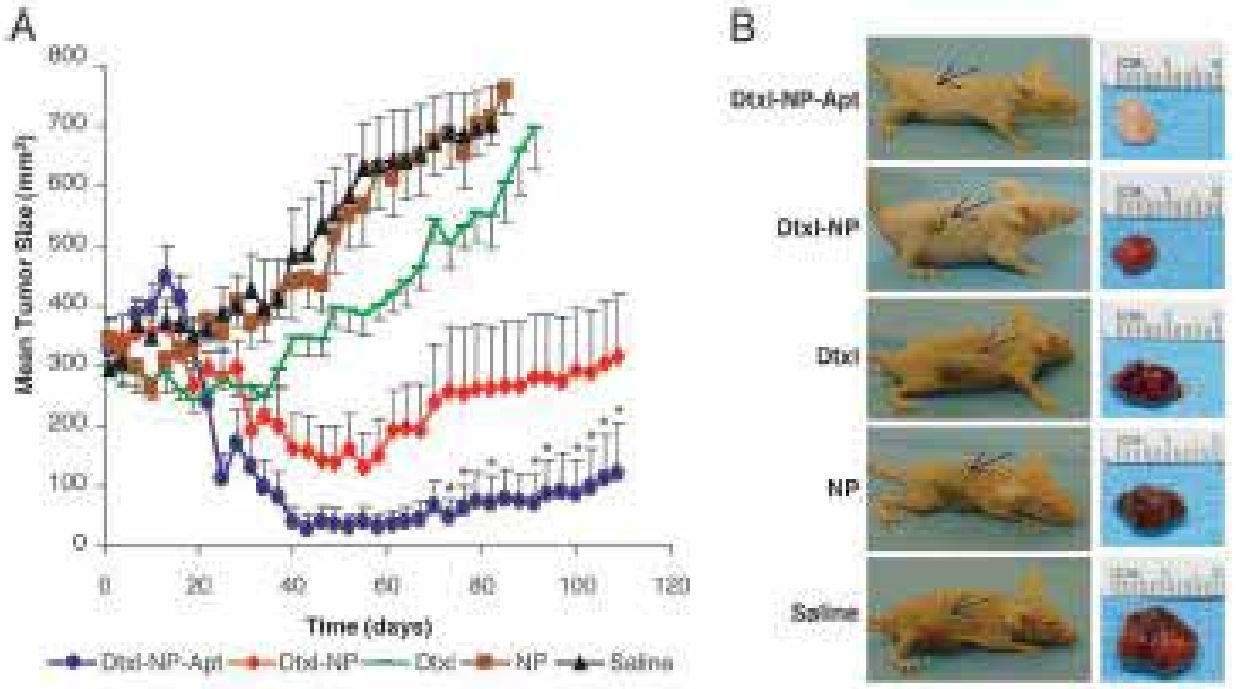
Wet Chemical Synthesis of Nano-particles

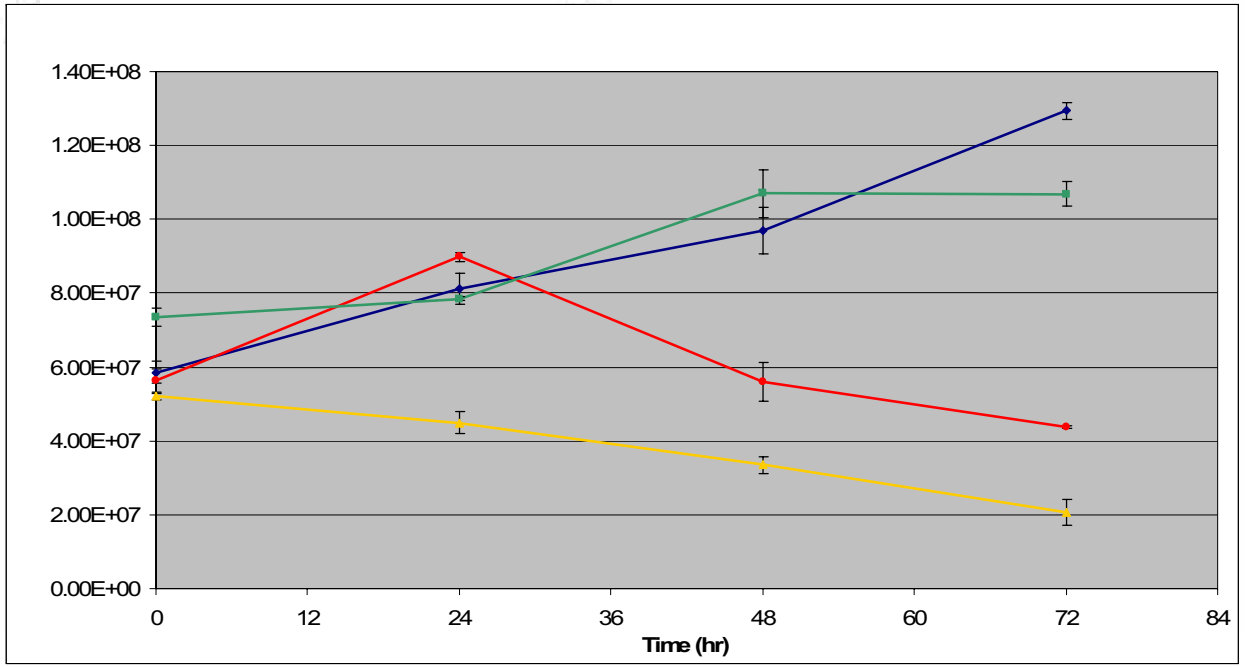
- Metallic, polymeric and metal-polymer Nano-particles using bottom-up approaches
- Novel Micro reactor technology for scale-up and controlled synthesis
- Synchrotron radiation based X-ray absorption Spectroscopic characterization
- Capability to attach bio-molecules

T2 Images of Tumors – Contrast Enhancement Due to LHRH-MNPs









Tumor Reduction Due to Localized Drug Delivery

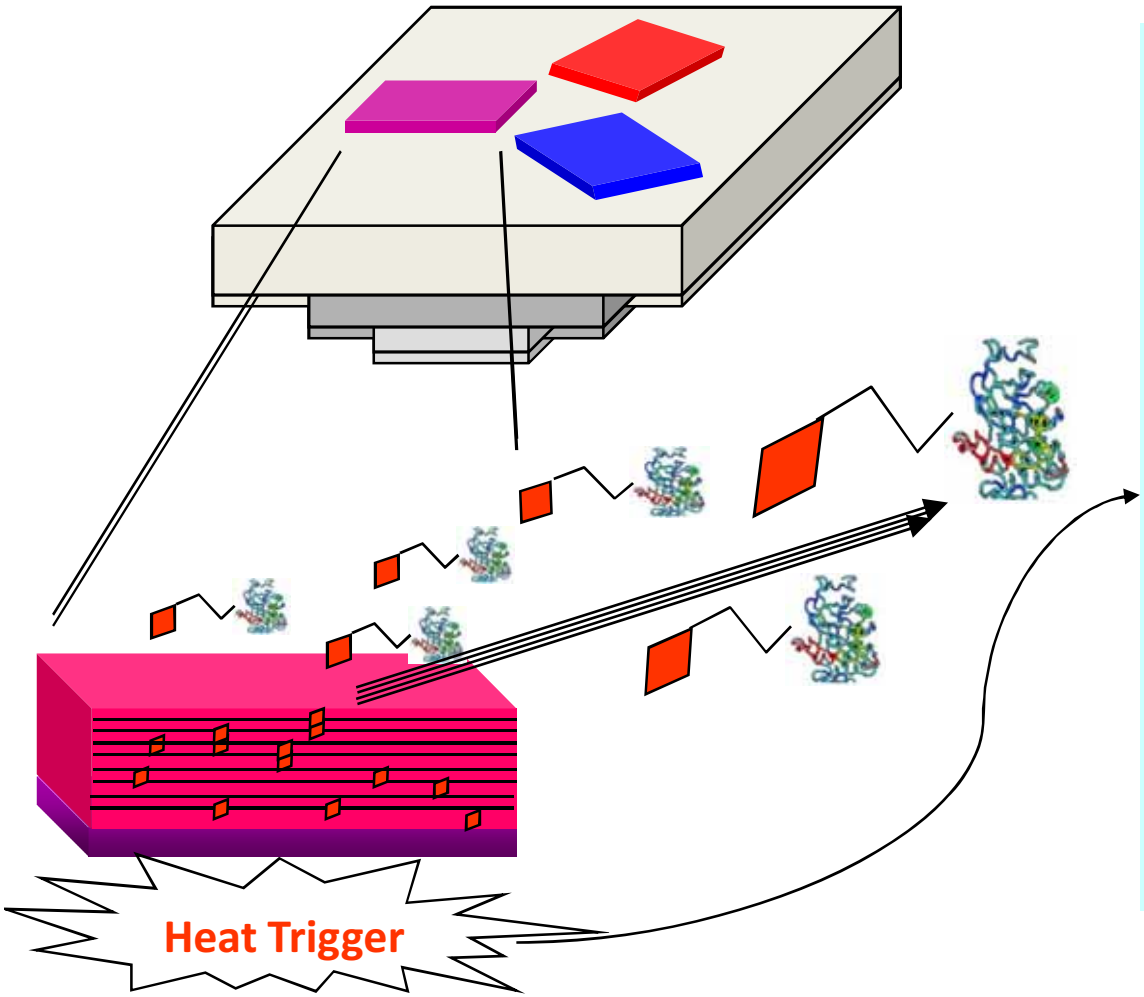
Work of Langer et al., 2006

USAMI goal is to use materials science approaches to explore ways of shrinking the tumor size to zero

The other goal is to use localized delivery to reduce the side effects of chemotherapy

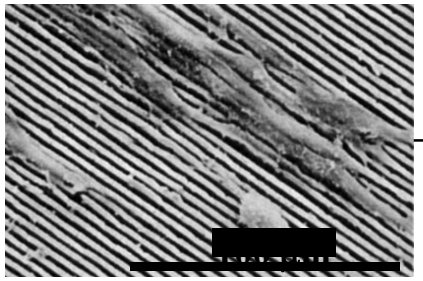
Collaboration with Prud'homme

Drug Delivery by Resistive Heating

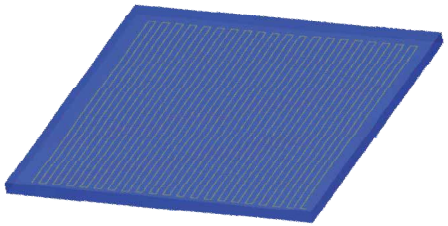


- Hydrogels sit on metallic plates
- Current running through plates heat plates
- Temperature controlled by current
- Current controlled by open/closed switch programming

The Innovation

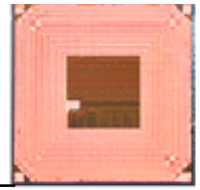


Surface Texture

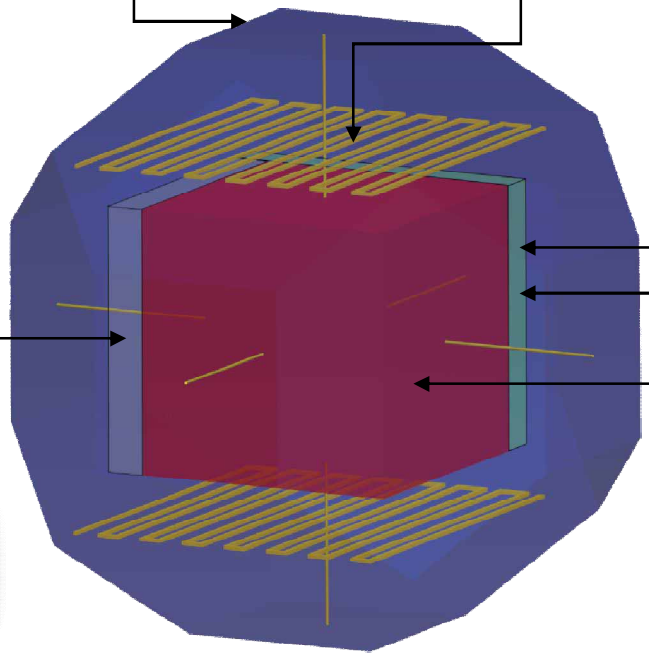


Hyperthermia Device

RFID Tag

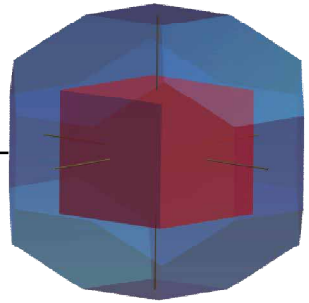


Battery



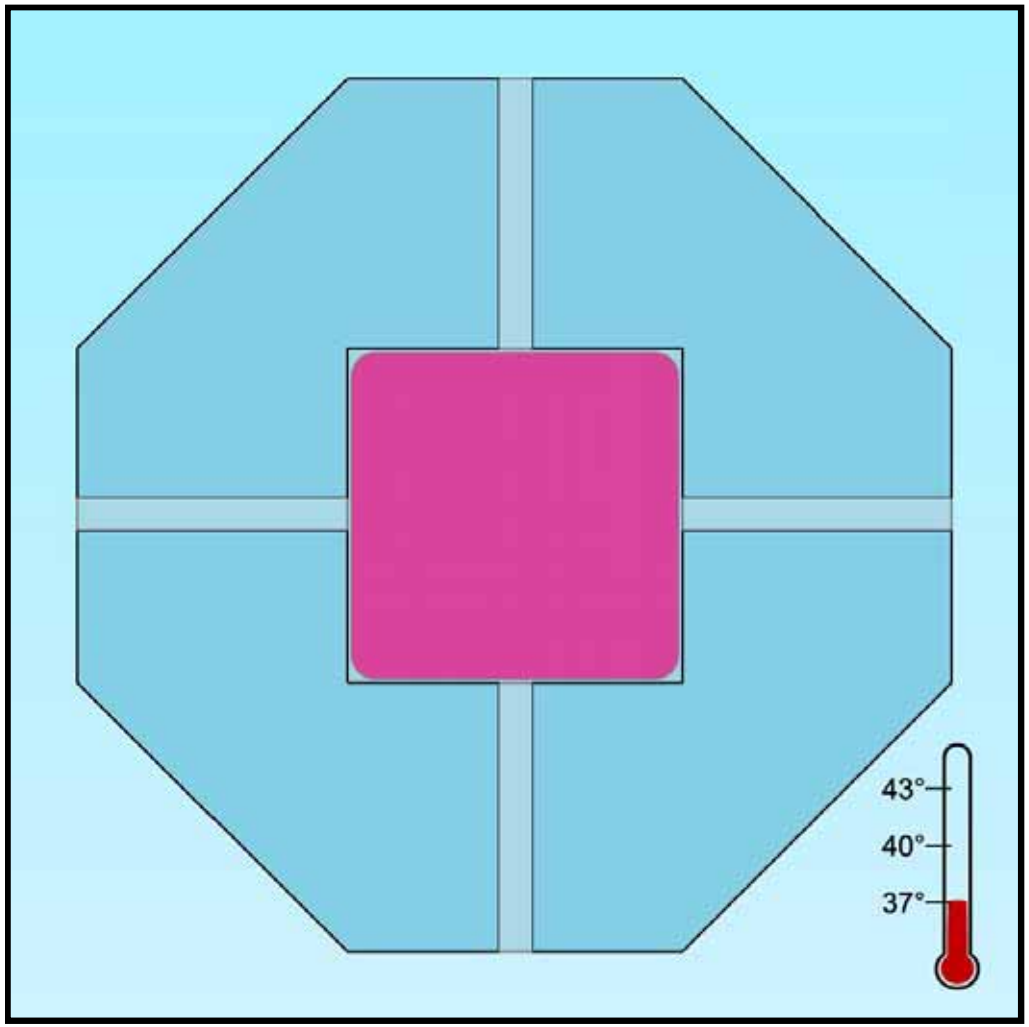
Microprocessor

Multi-Modal Implant

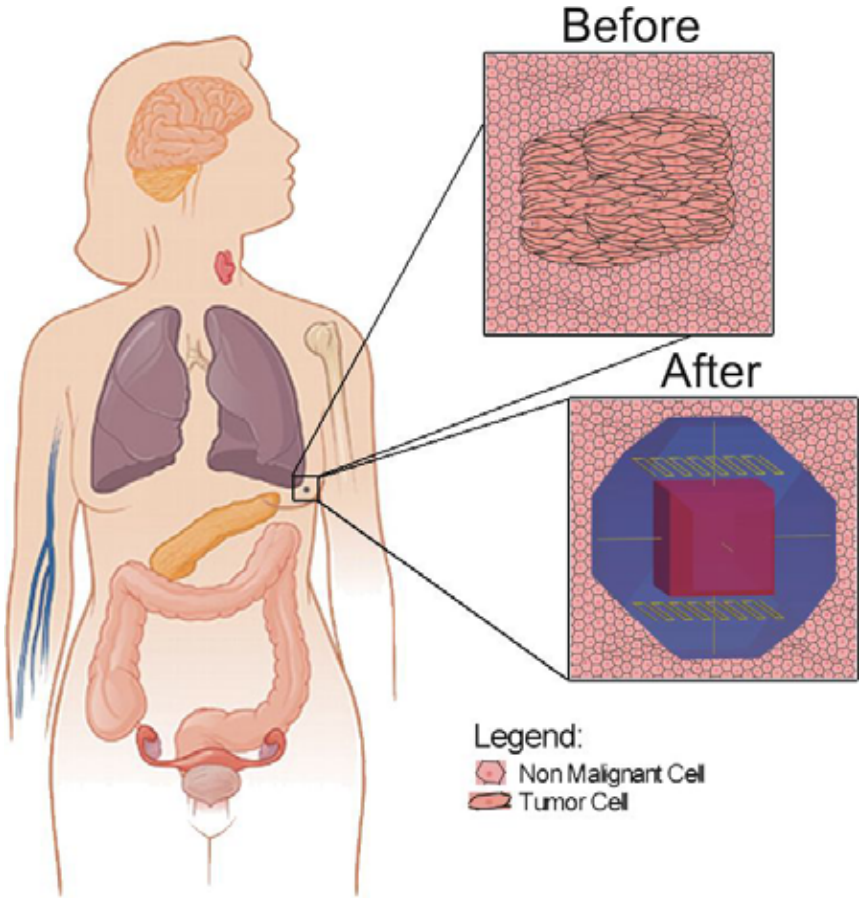


Drug Delivery Device

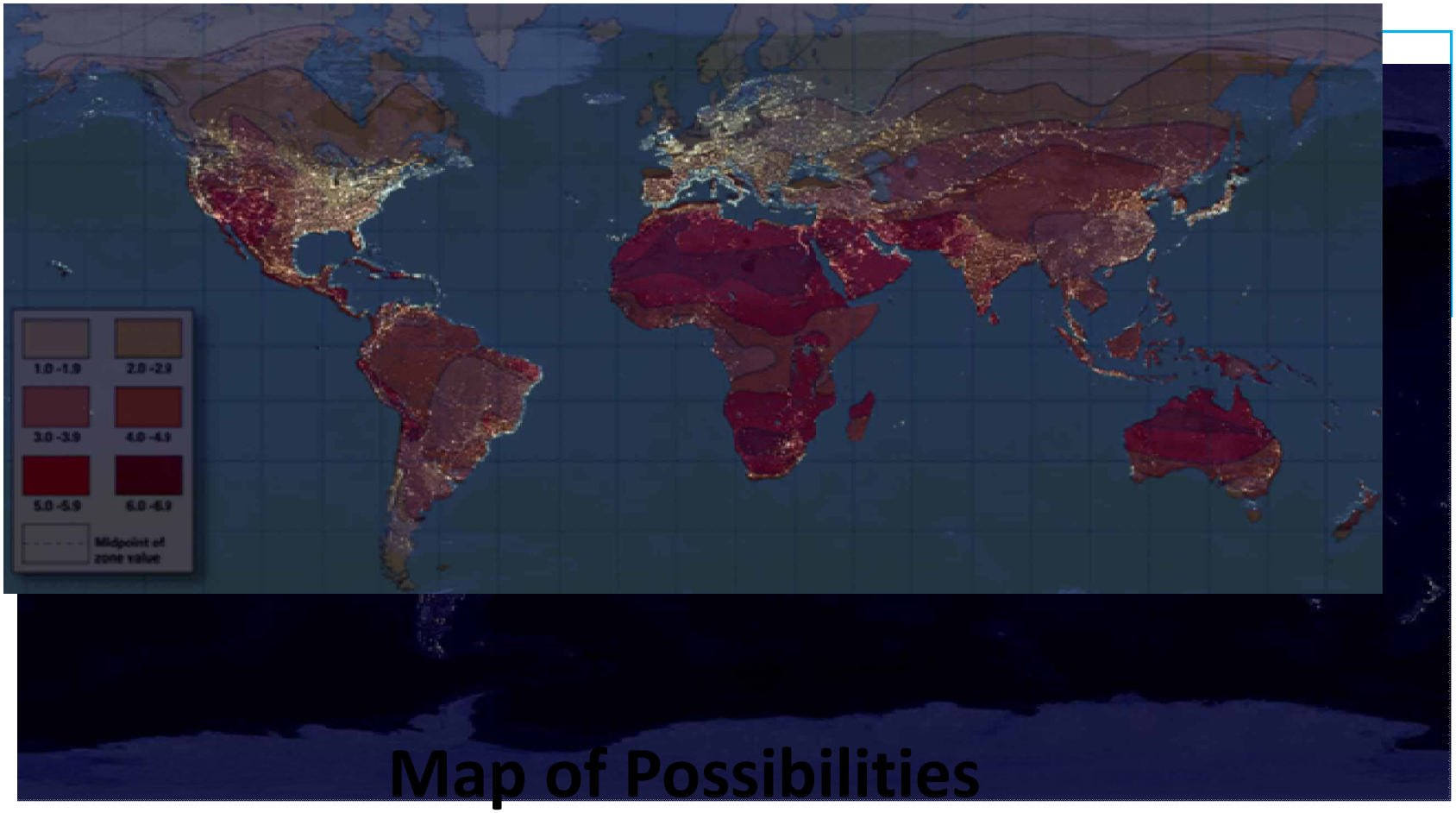
Multi-Modal Solution



The device is designed to be implanted at the site of solid tumors after removal by surgery.



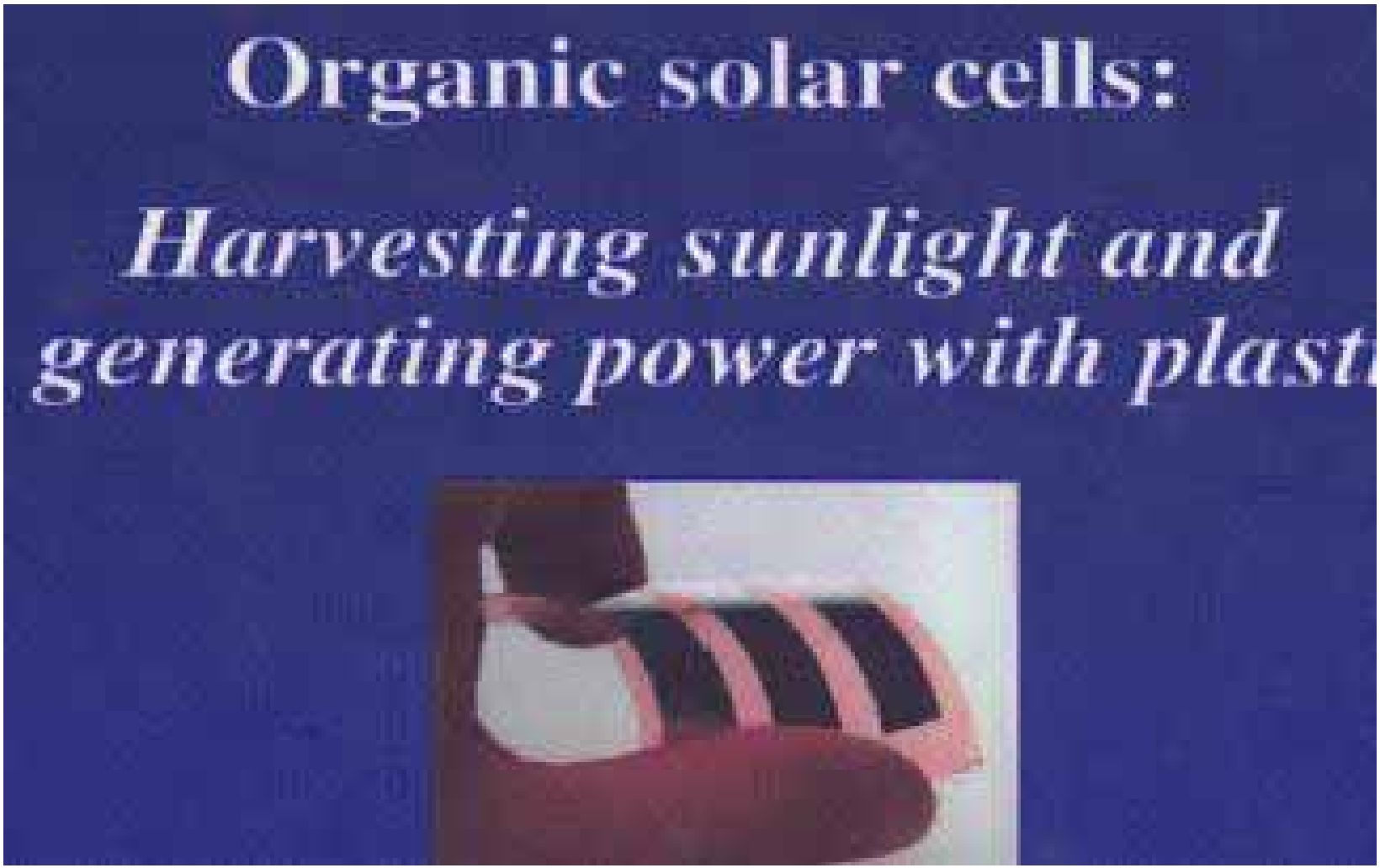
Motivating Technological Independence in Africa: Solar Energy



Map of Possibilities

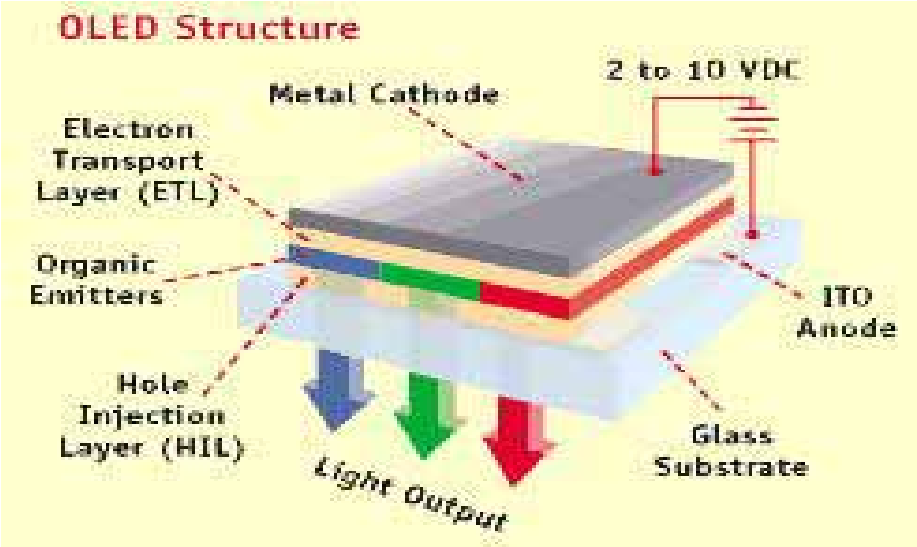
Map of the World at Night

Flexible Devices



Introduction to OLEDS

- OLED = Organic Light Emitting Device

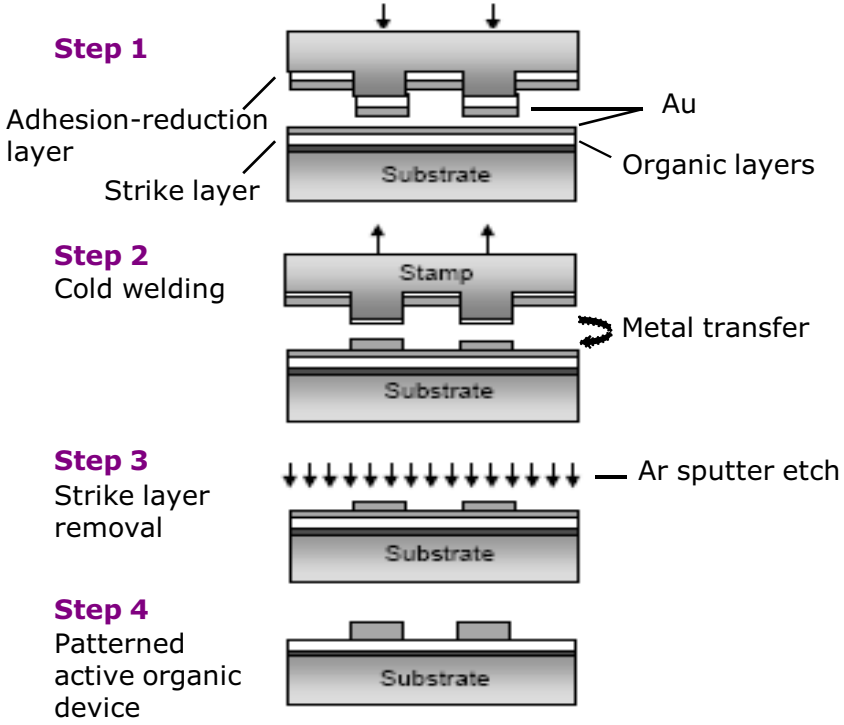


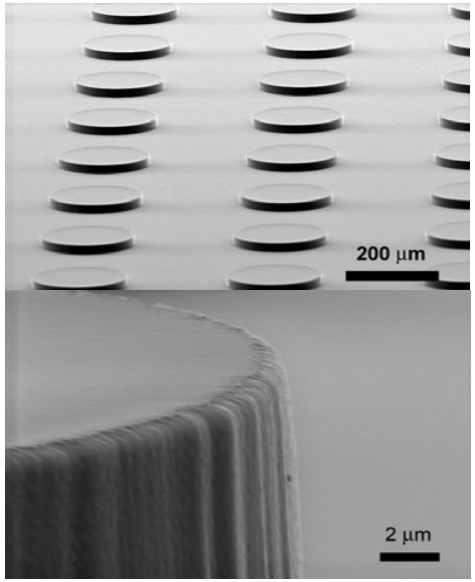
- The advantages of OLEDs:
  - Large viewing angle
  - Increased brightness and contrast
  - Low power consumption
  - …

http://www.kodak.com/

Cold Welding for OLED Fabrication

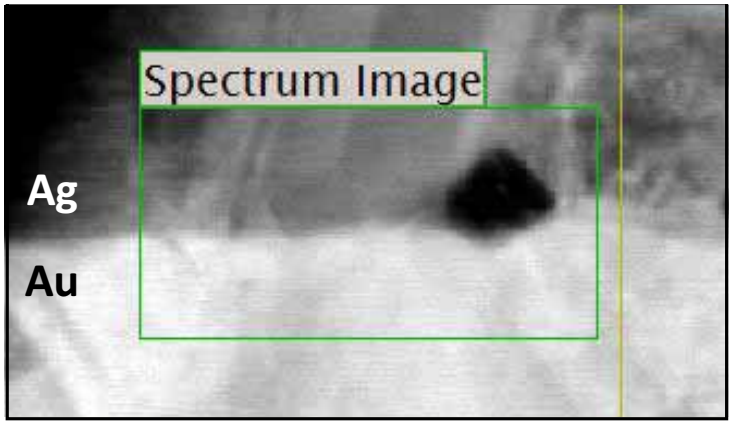
- Patterning of the OLED electrodes is difficult by photolithography since the organic material degrades in conventional solvents or high temperature
- Nano- and micro-patterning can be realized by inducing cold-welding between a metal coating on the stamp and the metal layer on the organic film

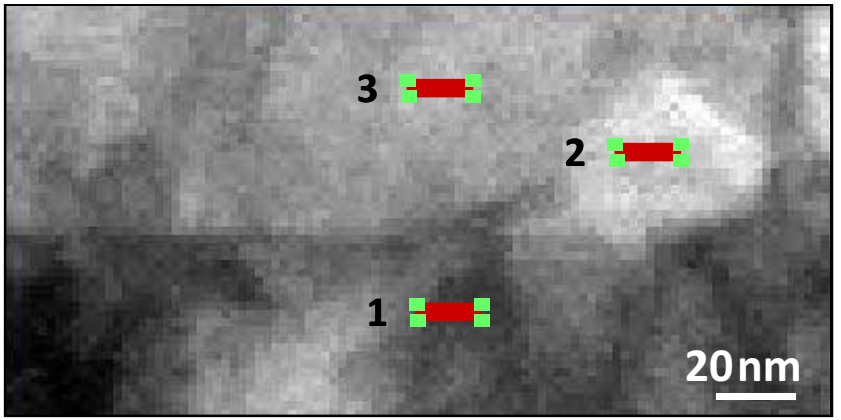


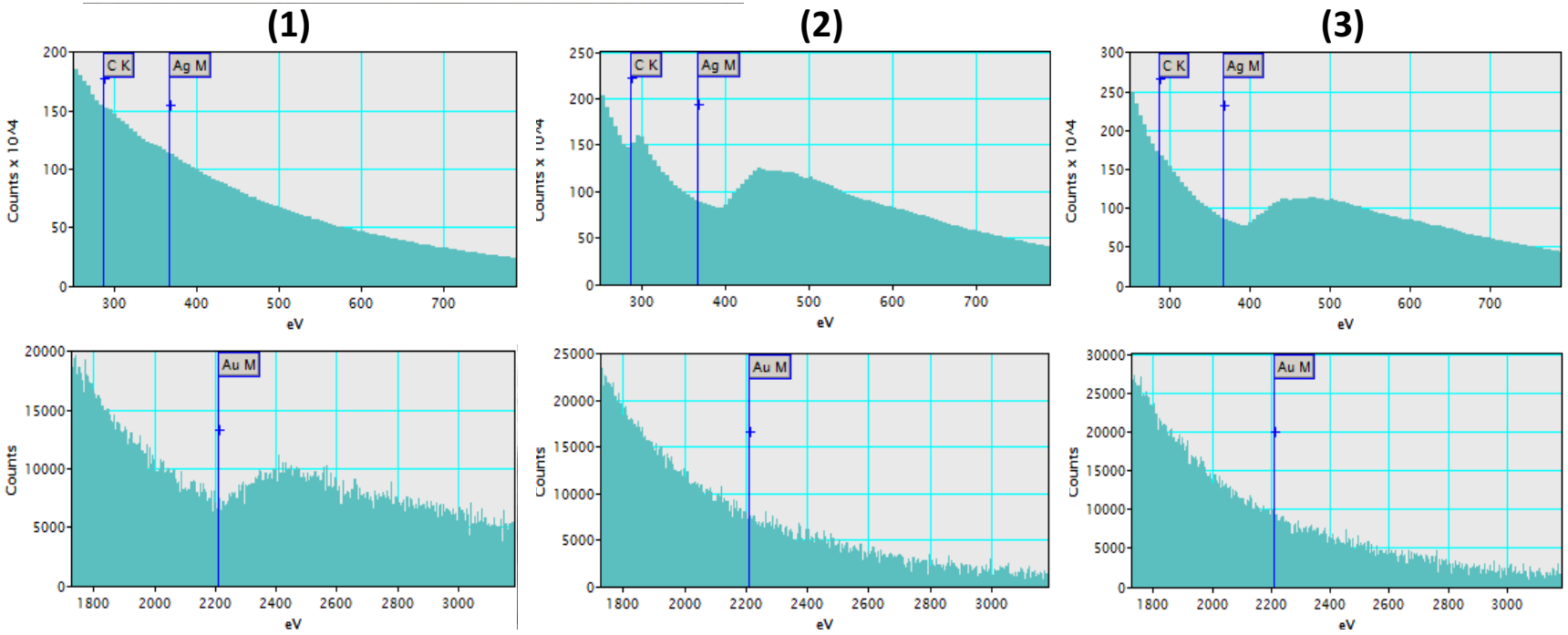


--- Kim, Forrest, *Adv. Mater.* (2003)

Electron Energy Loss Spectra of Au-Ag Interface

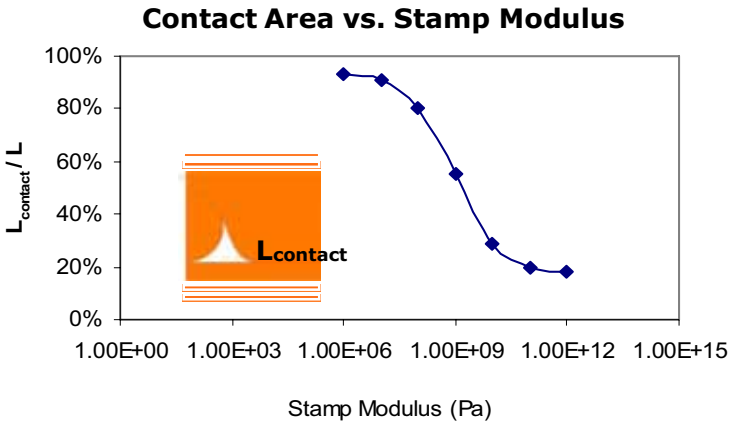


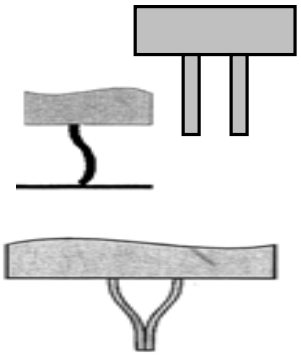




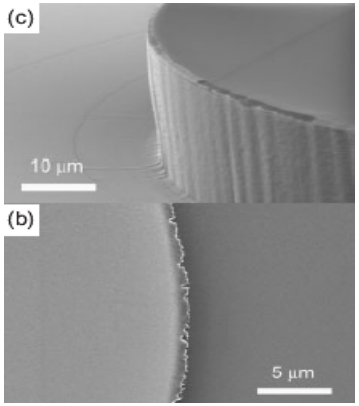
Comparison of EELS collected from various locations across the Au-Ag cold-welded interface. It shows there is a clear increase in both carbon and Ag peaks in position 2.

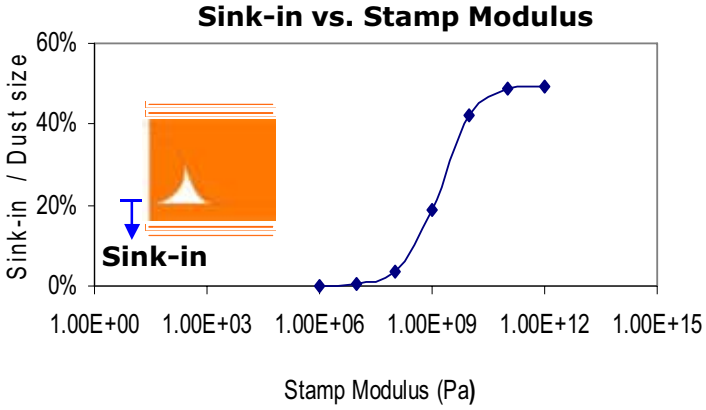
Stamp Modulus Design





---C. Hui, et al. (2002)

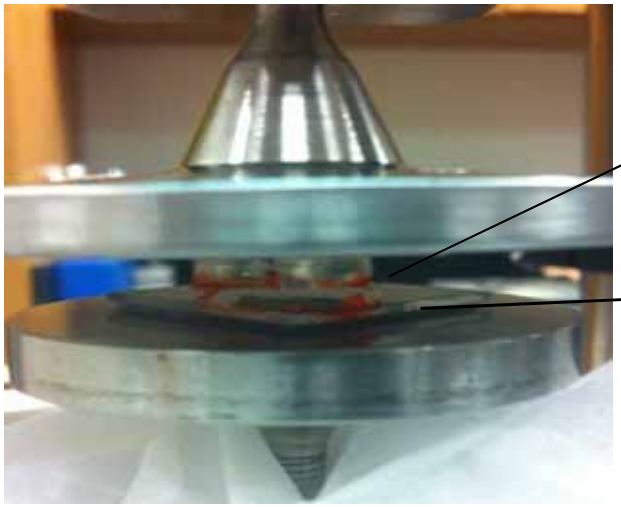




---400KN, 1µm dust

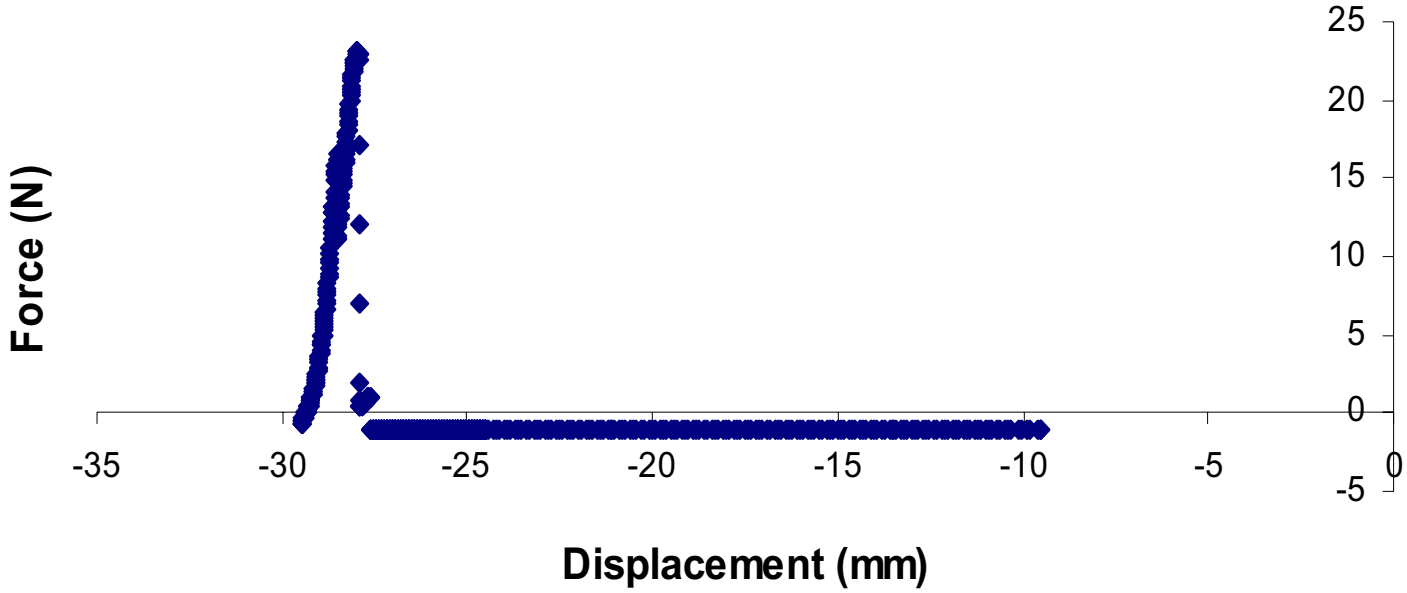
- Advantages of soft stamps: flexibility & low damage
- Disadvantages of soft stamps:
  - Dimensional instability problems
  - Stamp edge rounding
- Trade-off in design:
  - Low modulus vs. high modulus stamp

Adhesion test for pre-laminated sample

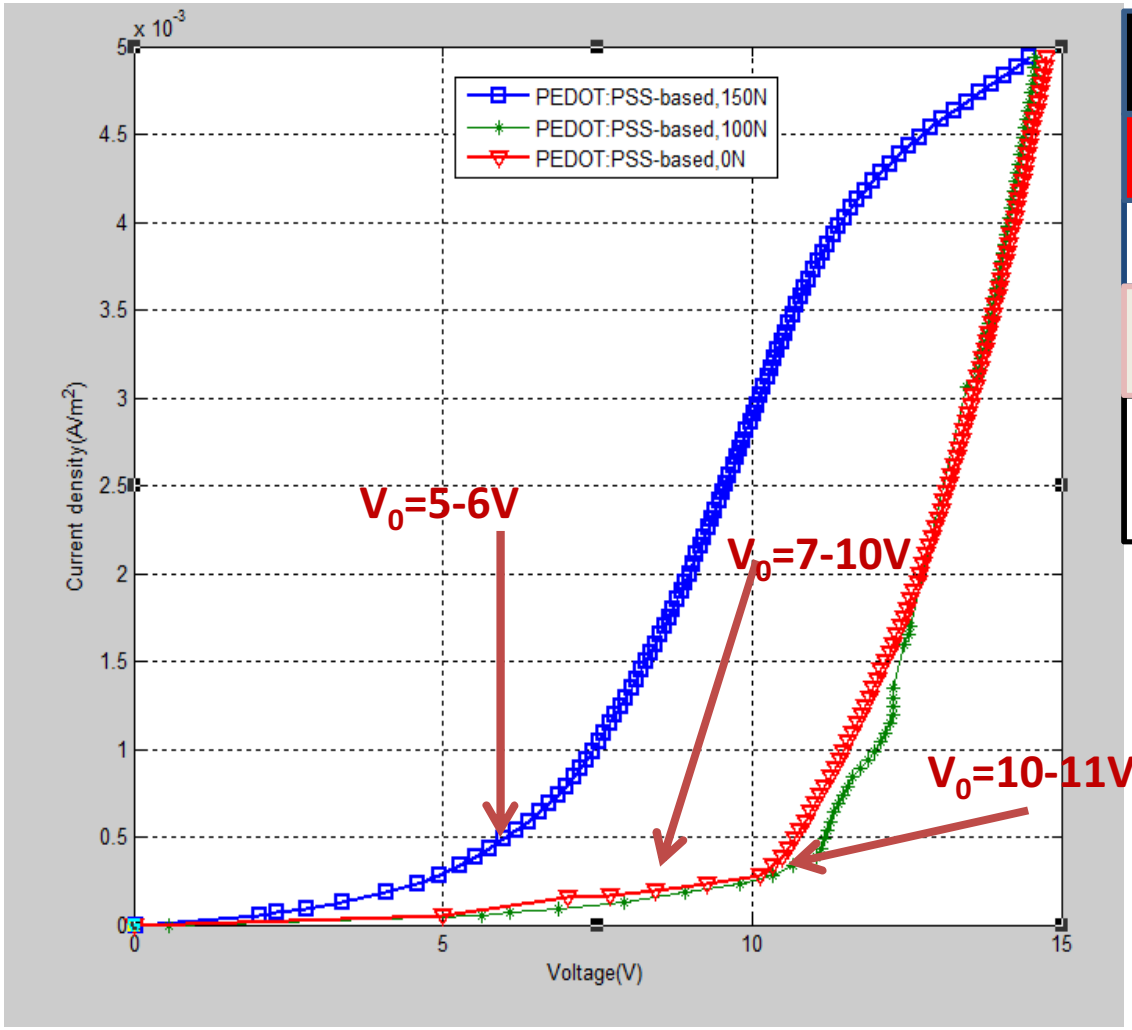


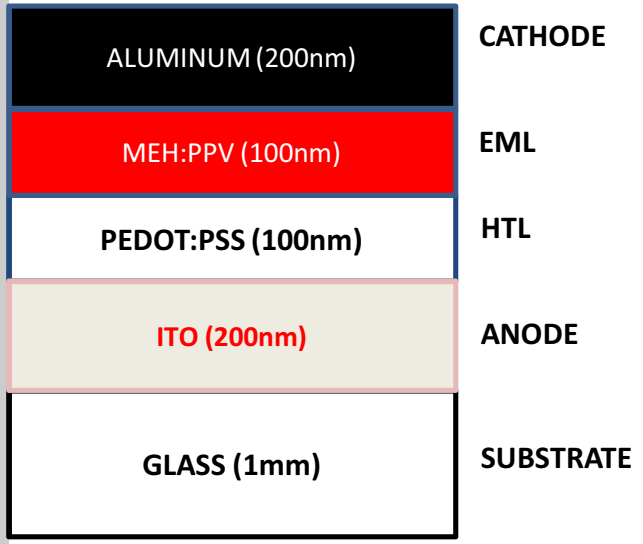
Double-sided tape on the upper mold

MEH-PPV pre-laminated onto PEDOT:PSS



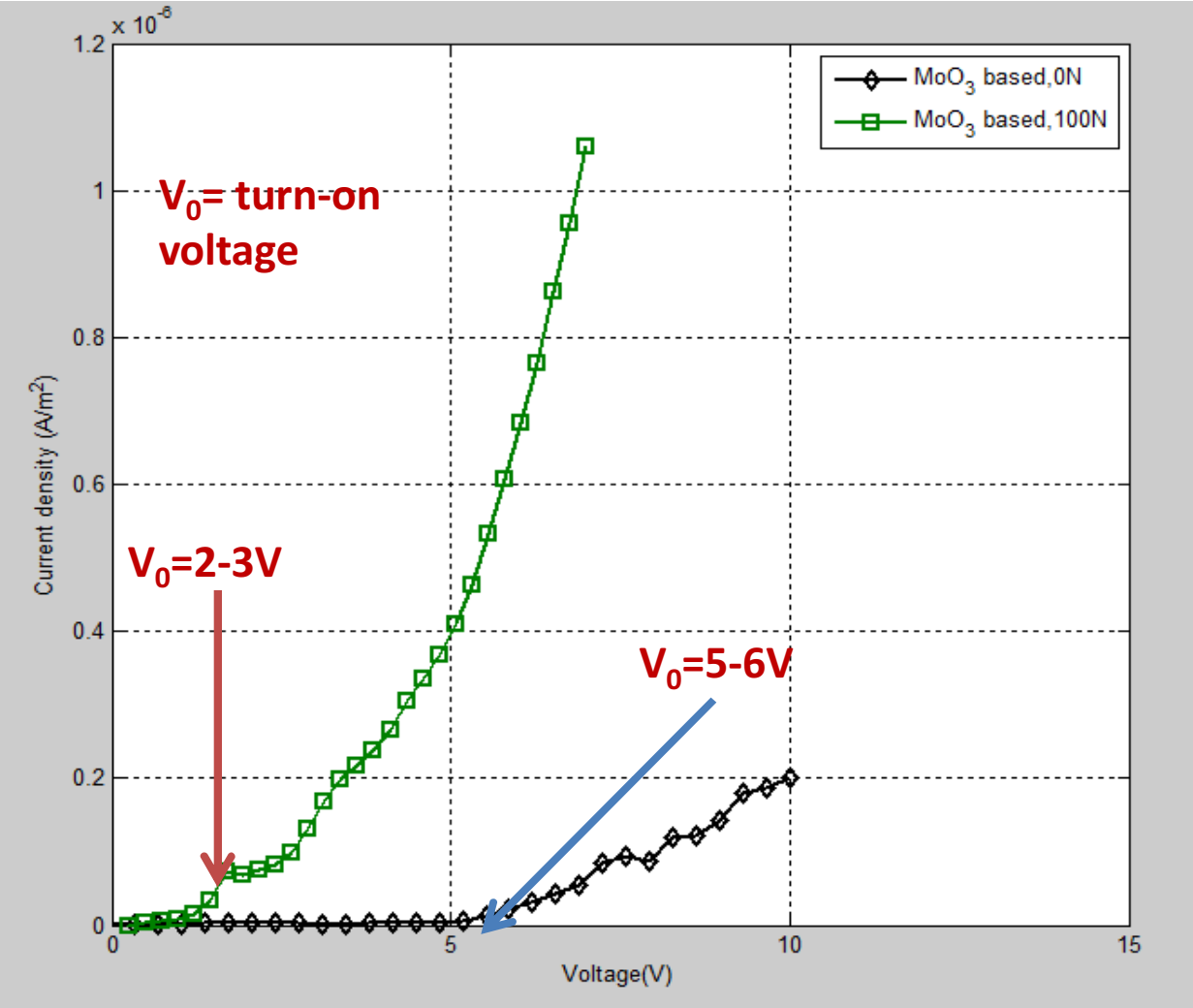
J-V CHARACTERISTICS

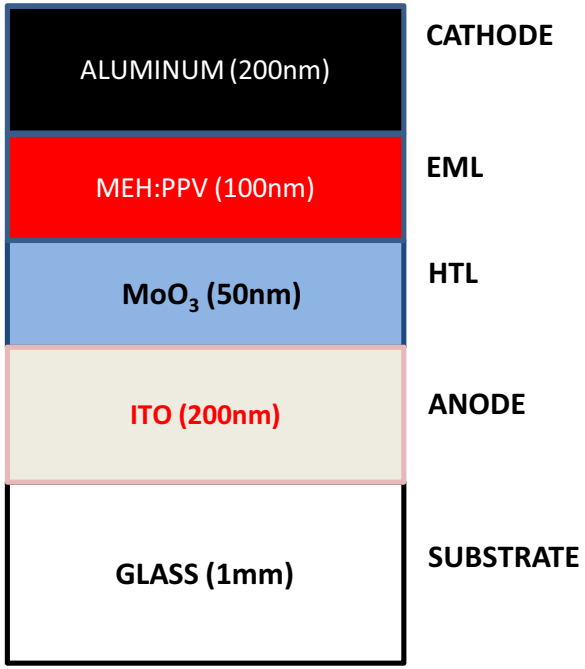


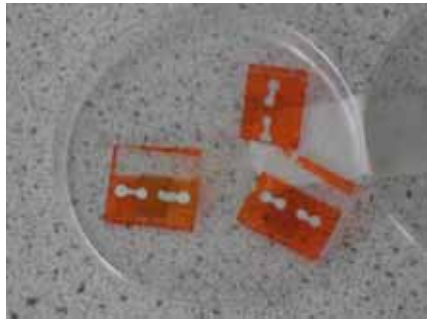


J-V plots for PEDOT:PSS -based device treated with 0N ,100Nand 150N loads compared

J-V CHARACTERISTICS



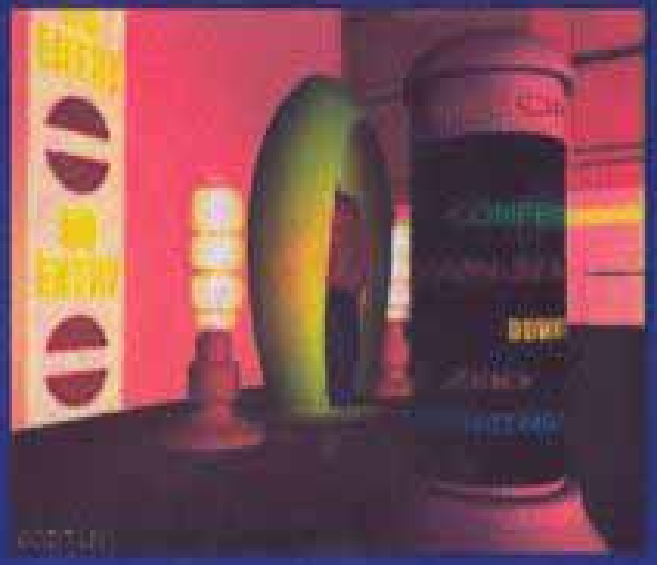




J-V plots for MoO_3 -based device treated with 0N and 100N loads compared

Integrated Systems and E-Textiles …

- Consumer applications (smartcards) will pave the way for large area PV systems (industrial coating technologies)
- Full plastic integrated systems containing solar cells, transistors and LEDs



The Need For a Manufacturing Initiative

- Quite clearly manufacturing issues are not too far ahead….e.g. NASENI plant in Abuja
- Africa's goal should be to develop low cost manufacturing capability
- However strategy should not wait for organic electronics to mature
- The sandwich structure for solar cells and OLEDs is the same
- The only real difference is what is in the sandwich
- Should start with silicon and grow to organic and carbon-based electronics

Accomplishments of NMI and AUST-Abuja

- Three campuses of the NMI established (AUST-Abuja, NM-AIST-Arusha, 2iE)
- AIST Abuja has had students from **19 countries** while graduating 4 batches of MSc students + 1 PhD in 2013
- This current batch includes **43 PhD students and 68 MSc** students from **16 African countries**
- Training students to go and teach in African Universities - **U. Ghana, U Mines in Tarkwa, U. Gambia, KWASU**
- Students finding good industrial jobs in Africa and industry is being engaged e.g. TOTAL & PIAB
- Innovation program leading to start-ups on campus

African Renaissance Institutes of Science and Technology (ARISTs)

- ARISTs are interdisciplinary centers of excellence (partnerships and networks) that are being created at existing African universities, research institutes and companies
- Initial focus on training the next generation of teachers and innovators e.g. 2iE, NASENI, KWASU etc
- The goal is to promote economic development through interdisciplinary research and education within networks (www.arist-edu.org)
- Networks are building bridges and developing solutions to Africa's problems
  - Health
  - Agriculture
  - Water
  - Energy
  - Value addition (materials and natural resources)
- Potential to link RISE, AMSEN and AIST initiatives

KWASU ARIST Program

- Assisted with curriculum development for the new College of Engineering
- Assisted with the hiring of diaspora leadership for the new College of Engineering
- Training the trainers program – junior faculty training
  - Diaspora training in selected fields
  - Exchange visits for research experience
- Assistance with the development of research and teaching labs
- Collaborative workshops to develop capacity and interdisciplinary efforts – entrepreneurship and the environment

University of Ghana Program

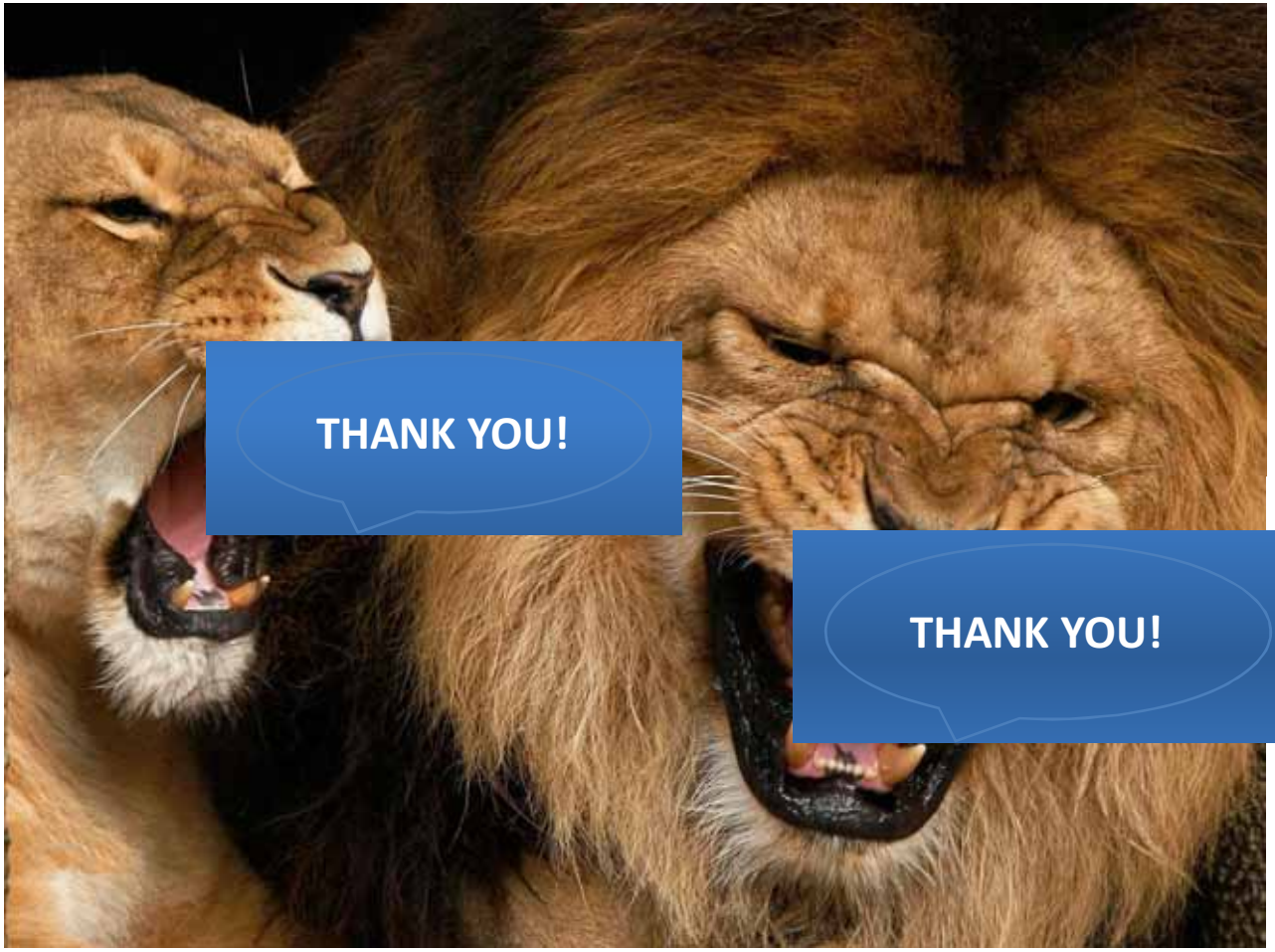
- Program developed by Prof. Yaa Ntiamoah-Baidu with support from Carnegie
- Collaboration with University of Ghana – Legon in curriculum & faculty development
  - Computer science
  - Materials science and engineering
  - Biomedical engineering
- Curriculum development at the University of Ghana – engaging ARIST & local faculty
- Introduction of graduate program – co-taught by ARIST and local faculty (staged transition)
- Exchange visits by U Ghana faculty to work with ARIST faculty in the USA and Europe

Lessons Learned From ARIST Program

- Many of the vocal diaspora scientists and engineers are not reliable at the point of implementation – need reliable teachers and researchers + builders
- Volunteer work-force alone is not sufficient
- Need reliable funding to support secretariat beyond the cost of the teaching and research visits
- Serious African partners must be willing to contribute airfare, lodging and stipend
- Integrated programs needed – curriculum, teaching, research and exchange visits (holistic approach needed)
- Must build pipeline and self reliance of faculty

Lessons Learned

- **Great professors are the product of a lifetime that is dedicated to scholarship**
- Vision, imagination, hard work and creativity are essential ingredients for success in spite of the challenges
- By their fruits you shall know them…… – hence great professors must produce great students
- **Mentoring is needed along with a system that produces a pipeline of academics** at different levels within a clearly defined university culture
- These can be complemented with access to new networks and African centers that provide the space for sabbaticals and research visits e.g. NMIs, ARIST
- We welcome your involvement in these efforts to build African capacity in science and technology in an effort to develop a new generation of African Lions……..


THANK YOU!
THANK YOU!