Microelectronics and Materials Science at COMSATS Institute of Information Technology

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Department of Physics

Layout

- History of COMSATS Institute of Information Technology
- Department of Physics
- Programs and Degrees
- Research at CIIT
- The Role of Higher Education Commission in Promoting Research: How we can benefit?
- The Virtual University of Pakistan

History of COMSATS

- **(COMSATS)** The Commission on Science and Technology for Sustainable Development in the South is an international organization. **Nobel Laureate Prof. Dr. Abdus Salam was the motivator.**
- **AIMS:** To reduce the ever-growing gap between the developed and developing world through useful applications of science and technology.
- **COMSATS Membership** currently represents 21 developing countries across three continents namely Bangladesh, China, Colombia, Egypt, Ghana, Iran, Jamaica, Jordan, Kazakhstan, Korea (DPRK), Nigeria, Pakistan, Philippines, Senegal, Srilanka, Sudan, Syria, Tanzania, Tunisia, Uganda and Zimbabwe

COMSATS Institute of Information Technology

- Within Pakistan major activities of COMSATS are:
  - **COMSATS Internet Services (CIS):** CIS has set up and is operating modern communication systems in most cities throughout the country
  - **COMSATS Institute of Information Technology (CIIT):** CIIT has been established for training professional human resource in Info Tech initially and now in all important areas of Science & Technology.
- **CIIT in Islamabad became functional in 1998.**
- **Federally Chartered** as a Public Sector University in 2000.
- **Five operational campuses** in Islamabad, Lahore, Wah, Abbotabad, Attock.
- **Two more** being established in Gujrat and Sahiwal.

Students, Faculty, Programs and Degrees

- Undergraduate Student Strength: around 7,500
- Graduate Students Strength: around 300 – 400
- PhD holding Faculty Members: just around 1/3
- BS, MS, and PhD
  - Physics
  - Mathematics
  - BioSciences
  - Electrical Engineering (Electronics, Computer and TeleCom)
  - Computer Sciences
  - Management Sciences
  - Chemical Engineering

Department of Physics
Programs and Degrees offered

- Established in **Fall 2003**
- **4 years BS in Applied Physics:** heavy emphasis on instrumentation, physical electronics, communications and system design
- **MS & PhD in Physics** with specializations in
  - **Optoelectronics**
  - **Materials Science**
  - **High Energy Physics**
  - **Quantum Computing**
  - **Environment**
- We have a total of 25 Full time Faculty members with 9 of them having PhDs and 6 Adjunct Professors.
- BS Physics to start in Fall 2006

Facilities (Existing and being developed)

- **Teaching labs at the Graduate Level**
  - Optics Lab: Fundamental optics experiments
  - Advance Optics Lab (Awaiting equipment arrival)
  - Vacuum Science & Technology Lab (Awaiting equipment arrival)
  - Quantum Optics Lab (Awaiting equipment arrival)
- **Research labs: establishment in progress**
  - Materials Lab: (XRD, DTA, DTXD, Temperature dependent Resistivity) Being shipped (will have by end of December 2005/January 2006)
  - SPM (STM/AFM) for surface analysis and study of self assembled materials
  - Electrical and optical characterization tools (Hall Effect, I-V/C-V measurements, absorption and transmission coefficients)

Research Center for Micro and Nano Devices at CIIT

- **Higher Education commission (HEC) is funding** one big project to set up Clean Room Facilities for designing and fabrication of Devices for versatile applications (> US$ 3.0 million).
- **Class 1000 Clean room:** to be the first one in Pakistan in any University.
- **Graduate Program** in Micro and Nanoelectronic Devices to start from Fall 2006
- **The facilities include:**
  - Photolithography
  - Dry Etching (RIE)
  - E-beam evaporation (metallization)
  - Sputtering and CVD (for oxidation, alloy deposition, Nitridations, etc)
  - Measurements: electrical (I-V, C-V, Hall Effect) and optical (PL, Raman and Spectrophotometer)
  - SEM to be acquired after the clean room set up.
- MEMS and sensors for single molecule detection
- Optoelectronics devices: LED, LD, Detectors
- Integration of nanoparticles/nanostructures with semiconductor electro-optic devices

Existing International Linkages

- **Prof. John Weaver:** Department of Materials Science & Engineering, UIUC, USA.
- **Prof. Faustino Martelli:** TASC, Trieste, Italy.
- **Prof. G. Scoles:** Princeton University, USA and Elettra, Trieste, Italy.
- Department of Materials and Bio-Materials: Queen Mary College, University of London, UK
- USJ CMOS: Bell Labs (US and Ireland), Surrey, Eindhoven
- III-N-V : IBM Watson R&D, Stanford, Surrey, Manchester, Uppsala
- MNSD : Surrey, Uppsala, EU Network on Micro and Nanotechnology
- Al-Farabi Kazakh National University, Almaty, Kazakhstan.
- Pakistan Council of Renewable Energy Technologies, Islamabad, Pakistan.

The Group formed only in July 2005

- A. S. Bhatti (PhD Cambridge)
- Ahmed Shuja (PhD, Surrey)
- Ishaq Ahmed (PhD, QAU & Bonn)
- Manzar Abbas
- Aneeque Ahmed Qazi
- Ayesha Farooq
- Graduate students (MS and PhD)

Group Activity

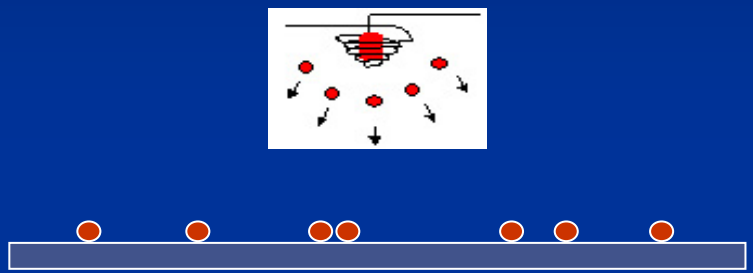
- **Synthesis and characterization of Nanostructures** (Self Assembled) : Semiconductor and Magnetic
- **Synthesis by** Buffer Layer Assisted Growth (BLAG): A technique developed by Prof. John Weaver (UIUC) being Developed at CIIT. **Characterization** by TEM, AFM, Raman, PL, MOKE.
- **Mn doped Self Assembled GaAs quantum wires:** Optical studies (PL and Raman)
- **Semiconductor micro and nano – devices** for sensor applications (using lithography)
- **Non-conventional energy resources:** Fuel Cell Technology
- **Magnetic Materials**
- **Synchrotron Radiation** for characterization of materials
- **Theory and Simulations** of Nanoparticle growth

Buffer Layer Assisted Growth

for

Nanoparticles & Nanostructures

Physical Vapor Deposition



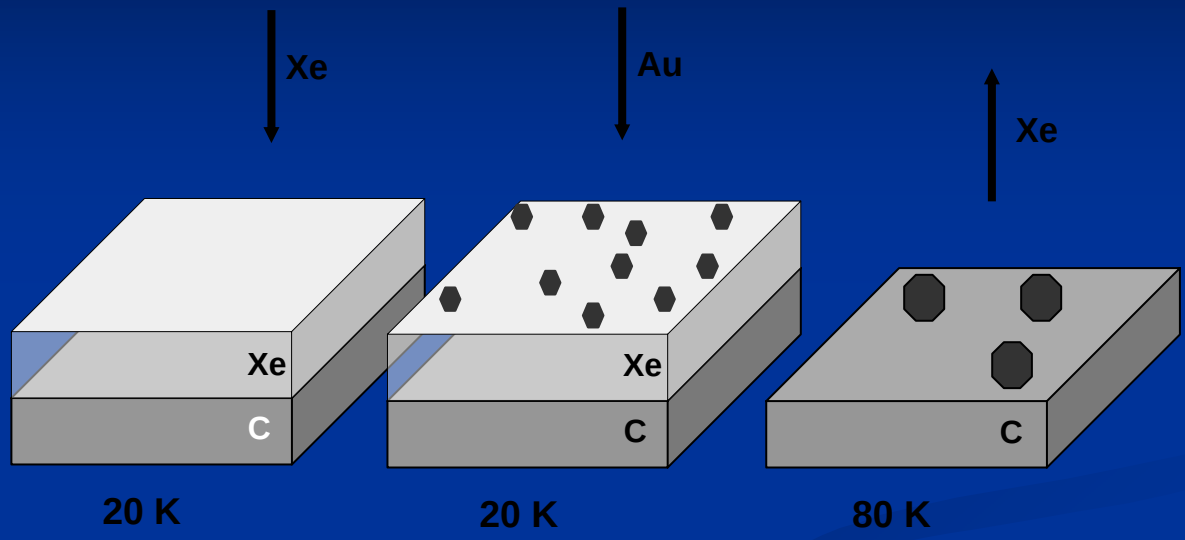
To wet or not to wet?

- Frank de Merwe (FM): Layer by Layer
- Stranski – Karastanov (SK): Layer + Cluster
- Volmer – Weber (VW): Cluster formation

What is important in growth kinematics?

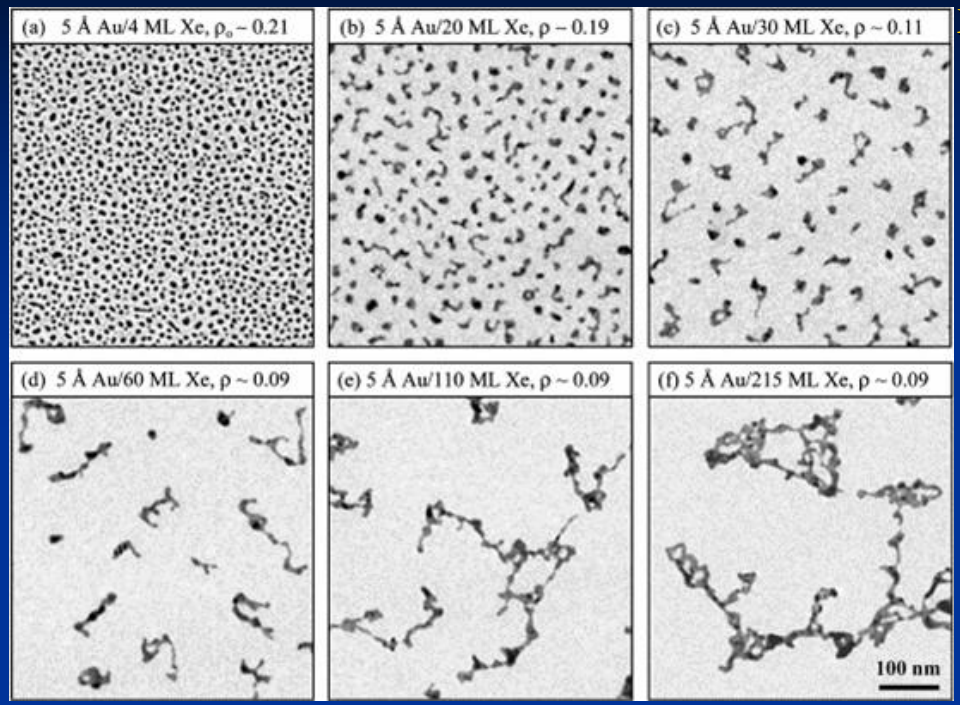
- Surface Energies of the adsorbed species, the substrate and the interface energy

BLAG Technique for Nano Cluster Growth

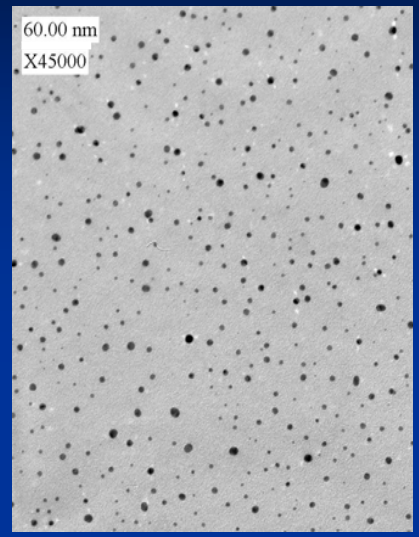


- Freedom of substrate and deposition material
- Substrate – adsorbent interaction minimum or missing
- High diffusion at low temperatures
- Study of Nano tribology
- Spherical clusters and Fractal growth

Au on amorphous carbon

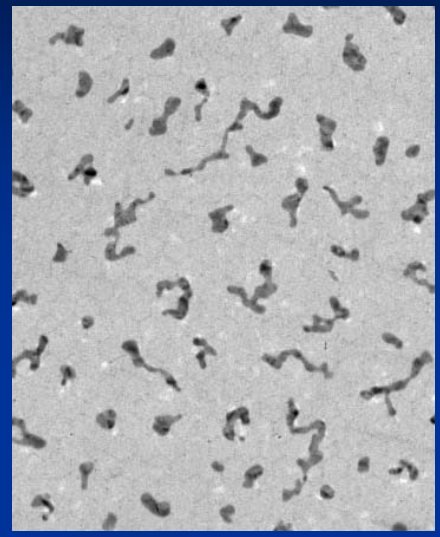


Low coverage - compact



1 Å Au / 30 ML Xe
2.6×10^{11} cm^{-2}

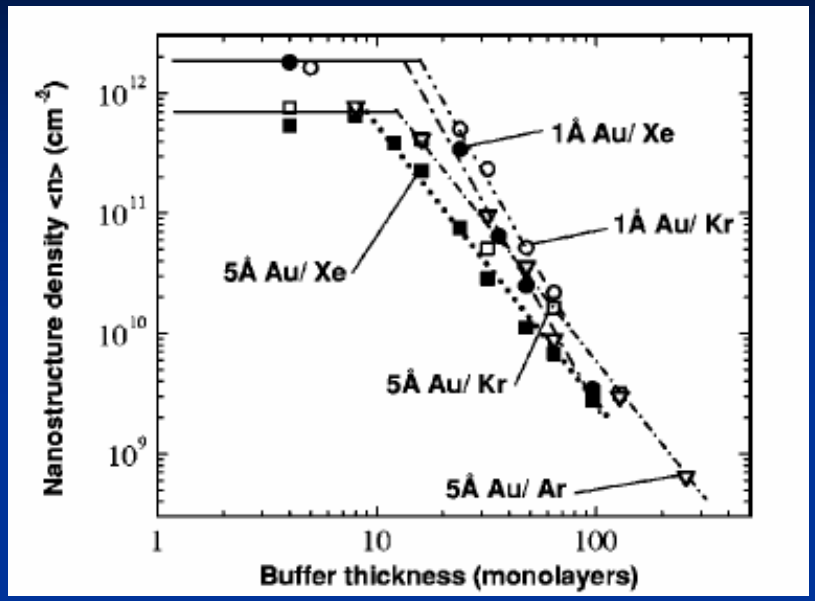
High coverage - ramified



5 Å Au / 32 ML Xe
2.9×10^{10} cm^{-2}

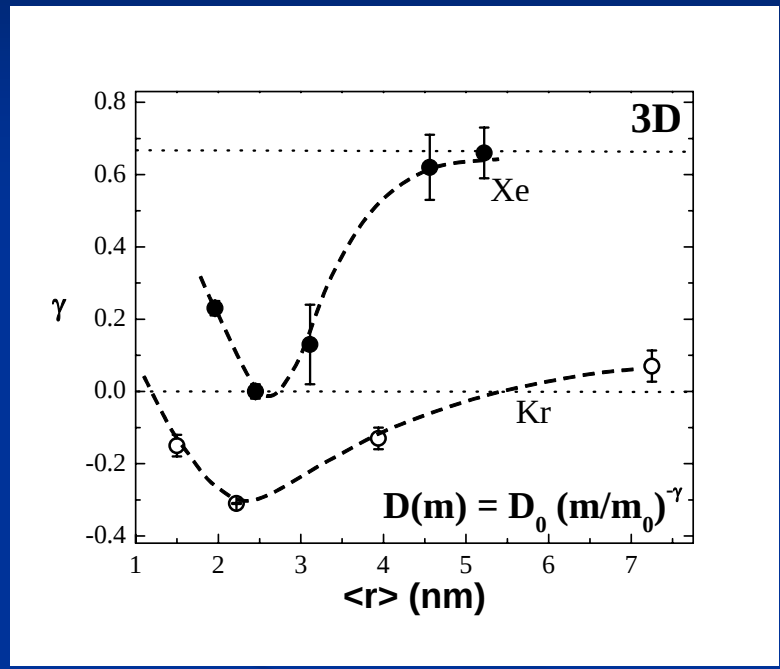
- Strong dependence of island size on Xe thickness
- Ramified islands/structures

Particle Aggregation



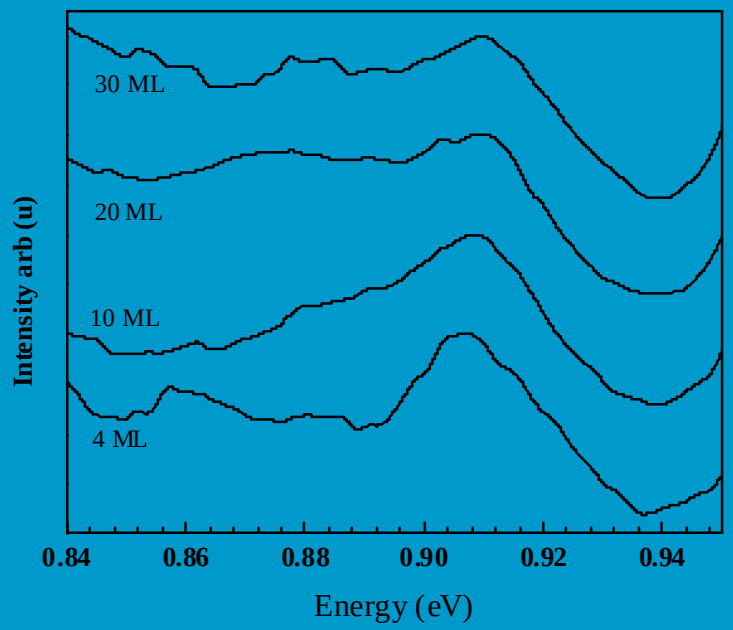
- Au / Xe / a-C: $D_f = 1.42 \pm 0.05$ at 4% surface coverage
- At higher coverage(10 – 15 %) D_f (1.7 – 1.8) also agrees with DLCA simulations.

Enhancement of Diffusivity for smaller nanoparticles

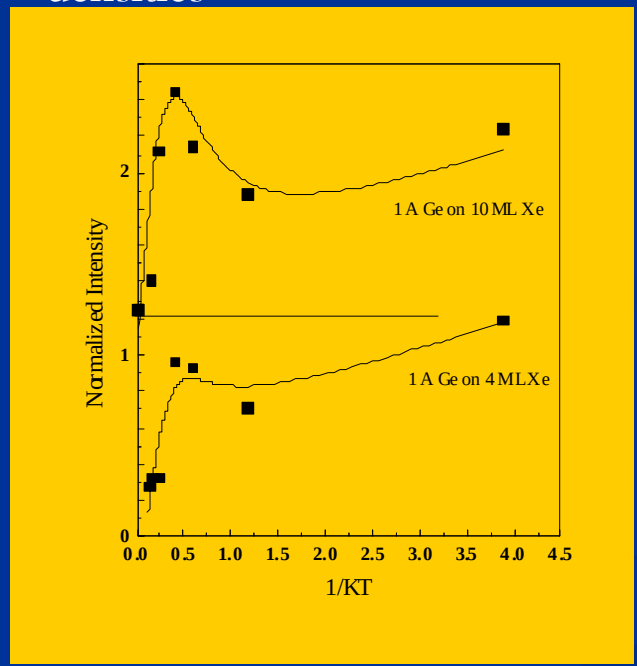


V. N. Antonov, J. S. Palmer, A. S. Bhatti, J. H. Weaver, Phys Rev B 68, 205418 (2003).

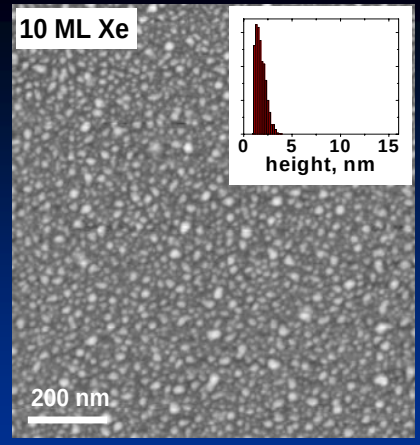
Ge Nanoparticles grown by BLAG

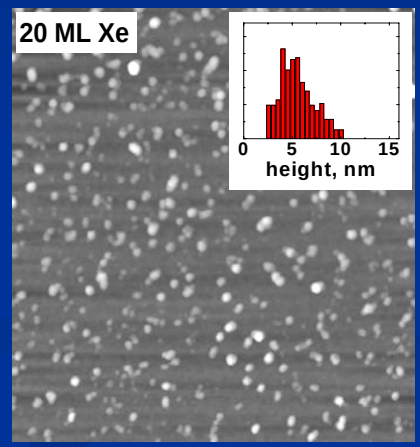


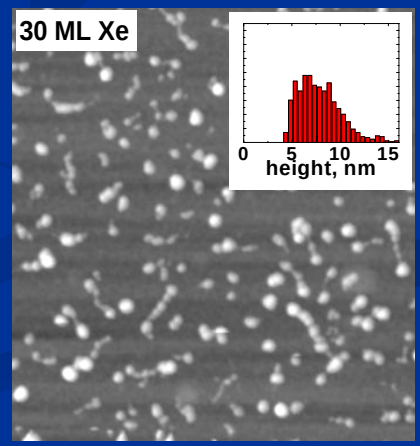
PL spectra at 3 K for different dot sizes and densities



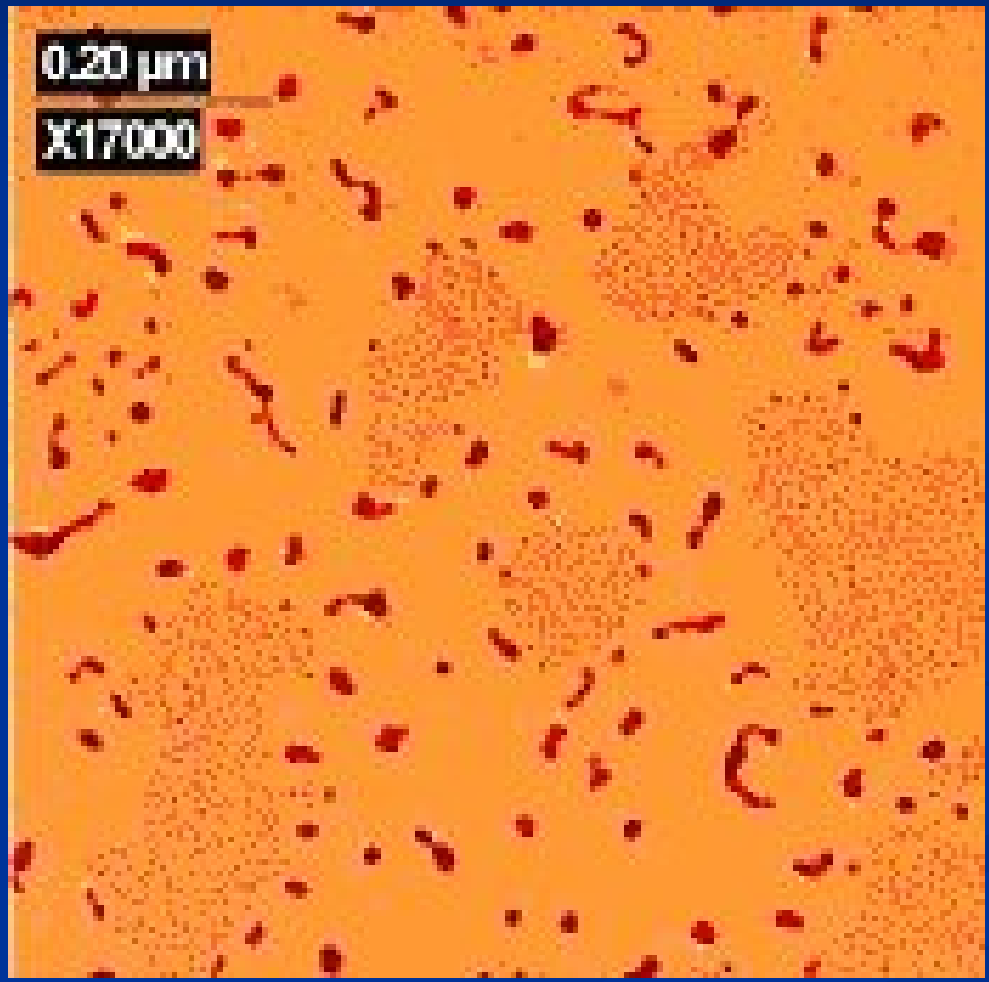
Berthelot behavior of BLAGrown amorphous Ge dots







Motivation for BLAG



What we can offer

- Hosting for a scientist/students to work in laboratories, although that would be possible from Fall 2006.
- Once the clean room facility in place, we would like to host regional trainings on device designing and fabrication offer short courses in microelectronics and optoelectronics
- Initiation of joint degree programs
- Grow samples using BLAG or other techniques for our partners.
- Characterization techniques will be open to all partners
- Will have access to SESAME, Jordon.

What we need?

- **Experts in a specific areas:** to deliver a semester long course in a short time, e.g., conducting polymers, plastic electronics, Bio – compatible materials, etc.
- **Develop collaborative research projects:** at the moment we can contribute in term of human resource
- **Student's Exchange** at the graduate and undergraduate level. We have a set up with MatSE, UIUC for 3 of our top students to do summer research projects at UIUC. Travel to be paid by CIIT and local expenses by UIUC.
- **Exposure of young faculty members** to work in advanced laboratories of the region
- **Specialized trainings of some specific equipment: A pool of maintenance experts**, like growth or some characterization, or general maintenance of equipment.

Some Suggestions

- Initiation of Regional School/Workshops for Graduate students: Let CIIT hold first one in Fall 2007.
- Strong undergraduate internship program among collaborating institutions
- Establishment of databank for resources like
  - Equipment (labs & vendors)
  - Expertise
  - Video library of lectures/conferences/workshops, etc
  - Availability of trainings
- Facilities to do Video conferencing among institutions to telecast important lectures/conferences/workshops to the member institutions
- Develop a website for research papers (Archive) just like HEP.
- **We need to develop some kind of mechanism for supporting the visits and the running costs of the equipment use (very important)**

How it can be done?
The Role of Higher Education Commission

- Higher Education Commission has initiated many programs to enhance the quality of higher education and research in the country, e.g.,
- International Collaboration grants
- Foreign Faculty professorship: short term and long term
- Funding for split PhD programs
- Funding for exchange visits

The role Virtual University of Pakistan

- Virtual University is an Electronic Distance Learning Institution in Pakistan
- It has fully state of the art studio and equipment to develop and produce lectures
- We can use the studio to record the lectures and get them developed at actual.
- Lectures via video conference: more than 25 universities are on the PERN (Pakistan Educational and Research Network)

State of Materials Science & Engineering

- Department of materials Science & Engineering in real sense does not exists in Pakistan.
- Materials Science is being done either under the umbrella of Physics, or Metallurgy.
- A strong need to have a strong and functional Department of Materials Science & Engineering in Pakistan to take care of present needs of industry, e.g., bio-compatible materials.
- Recently Institute of Advanced Materials being established in Baha-uddin Zakariya University, Multan.
  - Contact: Prof. Dr. Tahir Abbas (e-mail: tahir_abbas@hotmail.com)

IUVSTA International School on Surfaces, Thin Films, Nanostructures and Applications
Lahore October 26 – 30, 2006
(for Graduate Students)
Followed by

2 day Symposium in Islamabad
(for Faculty Members and Scientists)

Confirmed Speakers

- **J. H. Weaver, UIUC, USA**
- **Celso Aldao,** Argentina
- **Rashid Bashir, Purdue, USA**
- **Peter Varga,** Austria
- **Richard W.Siegel,** RPI, USA
- **Ismat Shah** UDel, USA
- **Talat Rahman** Kensas, USA
- **Mats Erik Pistol,** Lund University, Sweden
- **Lars Hultman** Linköping University, Sweden
- **Xue Qikun,** Institute of Physics, Chinese Academy of Sciences, Beijing, China
- **Arshad Saleem Bhatti, Pakistan**

Thank you for your attention

- We need to develop a Word Class Research Center in Materials Science & Engineering at the earliest and would require help and assistance in terms of training, expertise, equipment.
- Under present circumstances (Earthquake), we badly need on war footing to set up the bio-materials research center.