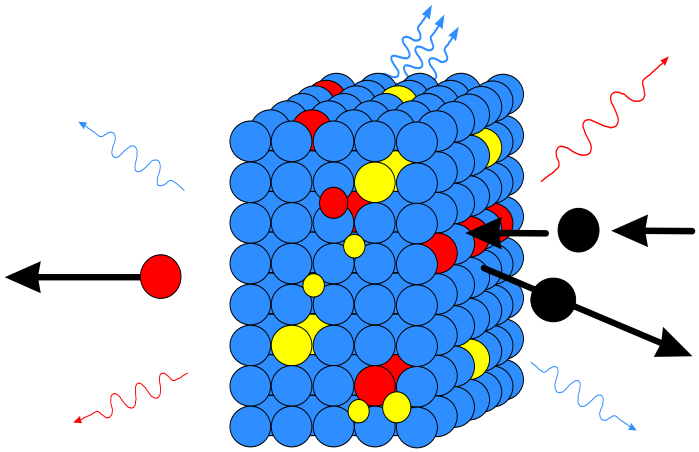
Materials Science & Engineering Research &Education at the Irradiation of Materials of Alabama A&M University

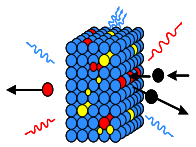
D. ILA, R. L. Zimmerman, C. Muntele, L. R. Holland, B. Chhay, S. Budak, Z. Xiao, A. Sharma, and L. Bowman



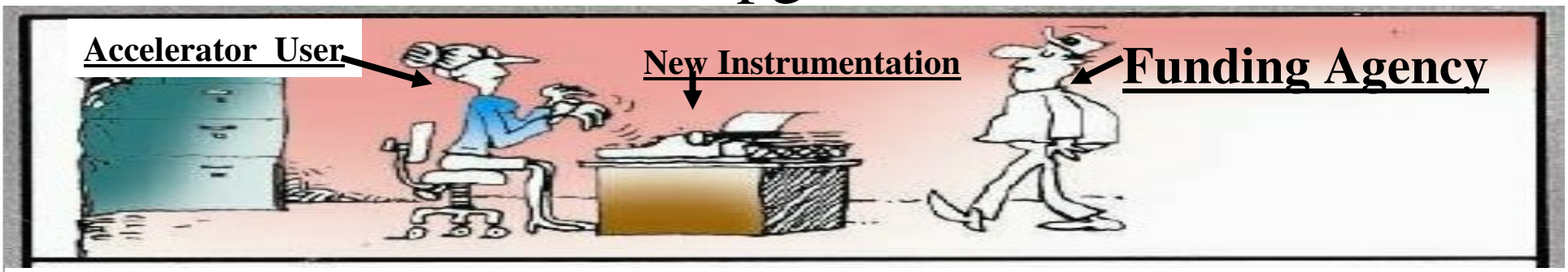
Center for Irradiation of Materials

Voice: (256) 372-5866 **FAX: (256) 372-5868**

http://cim.aamu.edu/



Upgrade the Ion Beam System, Adopt to the Nano-Era, or Upgrade the user! ☺



Who are we?

AAMU:

Faculty and staff:

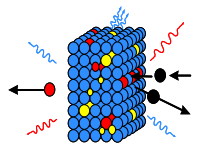
D. ILA, R. L. Zimmerman, A. L. Evelyn, L. R. Holland, C. I. Muntele, D. Nisen (R), Z. Xiao, H. L. Bowman, S. Budak, S. Guner, K. Heidary, M. Saafi, A. Sharma, R. Taylor, M. Alim, T. Kukhtareva, J. Wang, J. Campbell, H. J. Caulfield, J. Fisher (Ind), S. Celaschi (Ind), J. Williams (Ind/ORNL), B. Zheng

Students:

B. Chhay, M. Abunaemeh, I. Giron, B. Sistani, S. Sadat, D. Walker, R. Minamisawa, C. Smith, A. Kassu, F. Kalzzani, J. M. Taguenang, L. Wilkinson, R. Gray, P. Arrington & Many more.

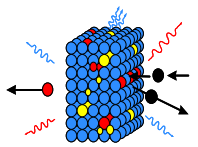
Others:

R. Mu (Fisk), A. Elsamadicy (+ UAH Students), I. Gurhan and A. Oztarhan (Ege U, Turkey + students), P. Thevenard (+ UCB Students), A. De Almeida (+USP Students), & Many more.



Partners

1. **Gov. : NRL, ARL, AMRDEC, DOE Labs, AFOSR, AFRL.**
2. **Universities:** ***UAH, UAB, UA, AU, TU, GTRI, UCB, TSU, USP, FU, EU, SU, NU, UA, DELF, UC-Davis, and few more***
3. **Industries:** ***SAIC, Jacobs Eng., BAE, MRC, Raytheon, Boeing, , NG, LM, Brontek, VLOC, II-VI, TBE, SRS, & many more (20 more SB)***



AAMURI

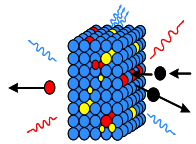
Research Institute

HQ

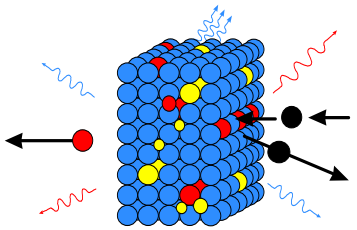
Center

for

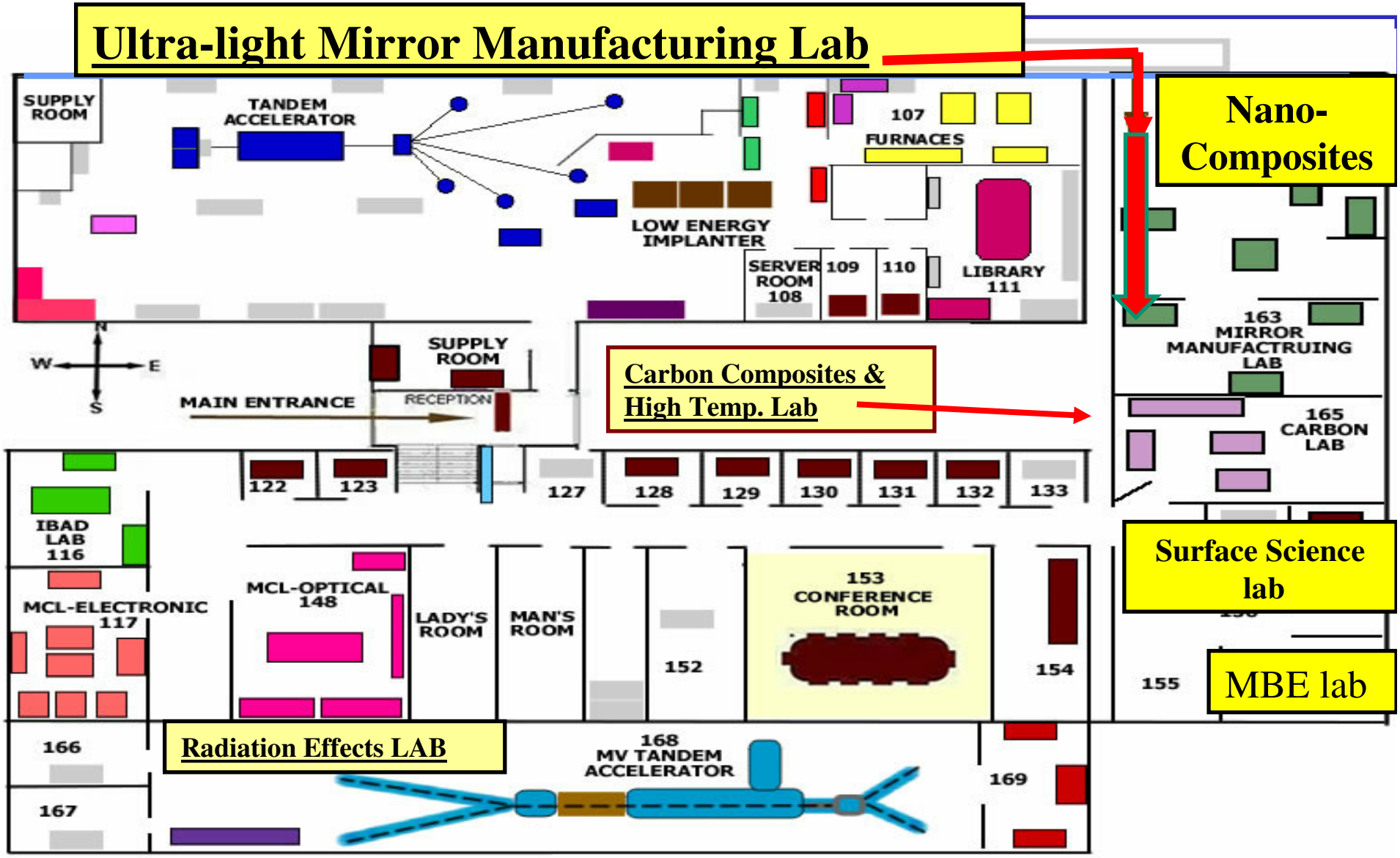
Irradiation of Materials

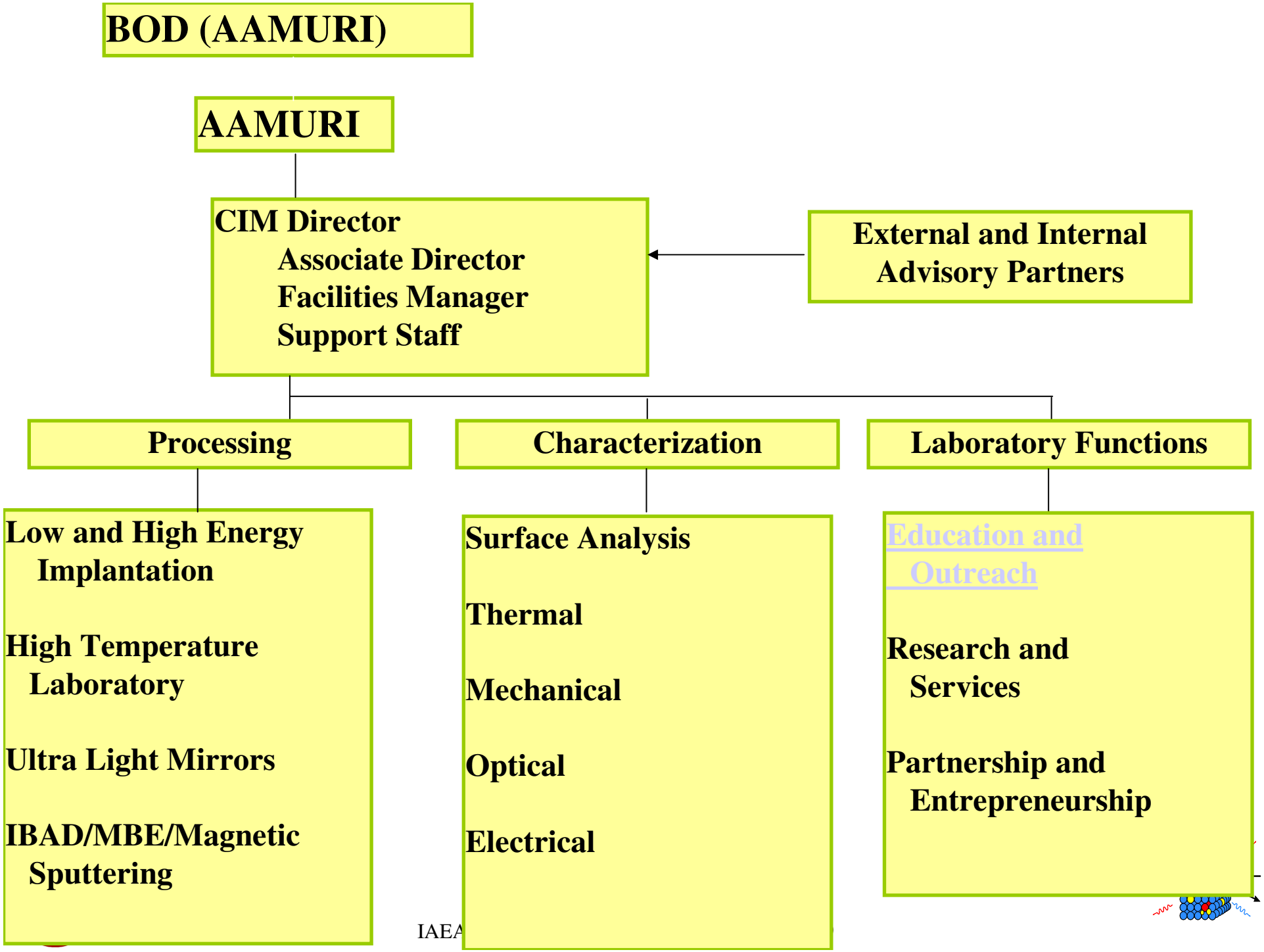


Ctr. for Irrad. of Materials



Ultra-light Mirror Manufacturing Lab




BOD (AAMURI)
AAMURI
CIM Director
Associate Director
Facilities Manager
Support Staff
External and Internal
Advisory Partners
Processing
Characterization
Laboratory Functions
Low and High Energy
Implantation
High Temperature
Laboratory
Ultra Light Mirrors
IBAD/MBE/Magnetic
Sputtering
Surface Analysis
Thermal
Mechanical
Optical
Electrical
Education and
Outreach
Research and
Services
Partnership and
Entrepreneurship

External User

Day 1

Principal Investigator
or Management Team
or Grants/Contracts

Research Partners

Management Team
for evaluation

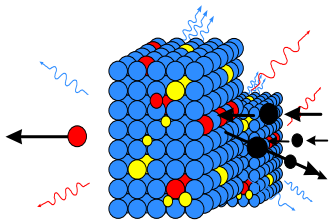
Facility Manager
for planning and safety

Facility Manager
for execution

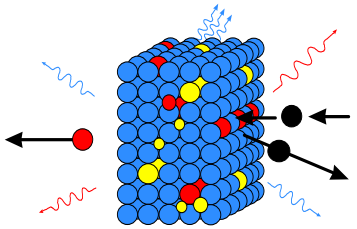
Day 2

Day 3

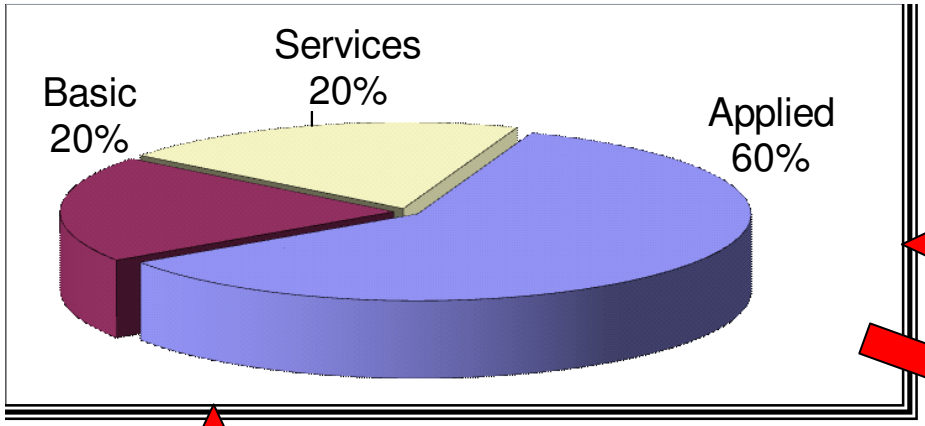
G/C office
identification of type
costing
protection of IP



Where are we?



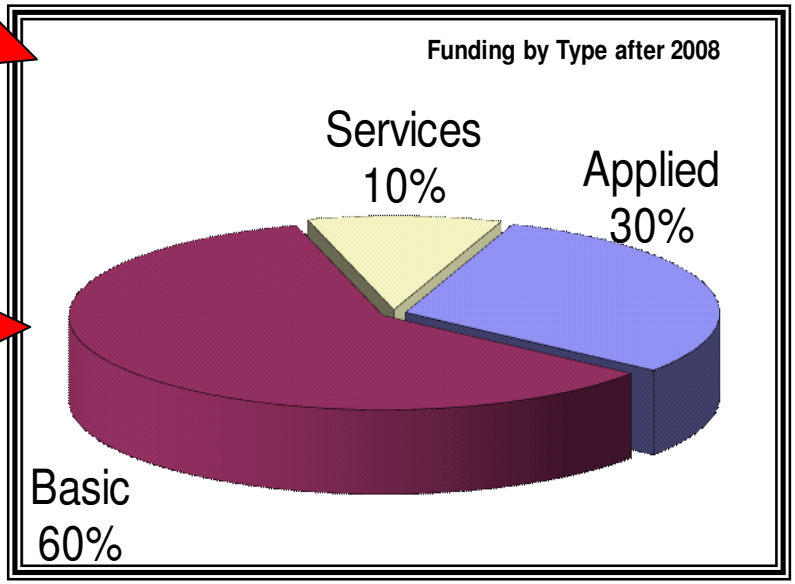
Center for Irradiation of Materials, AAMU, Huntsville, AL (http://cim.aamu.edu/)



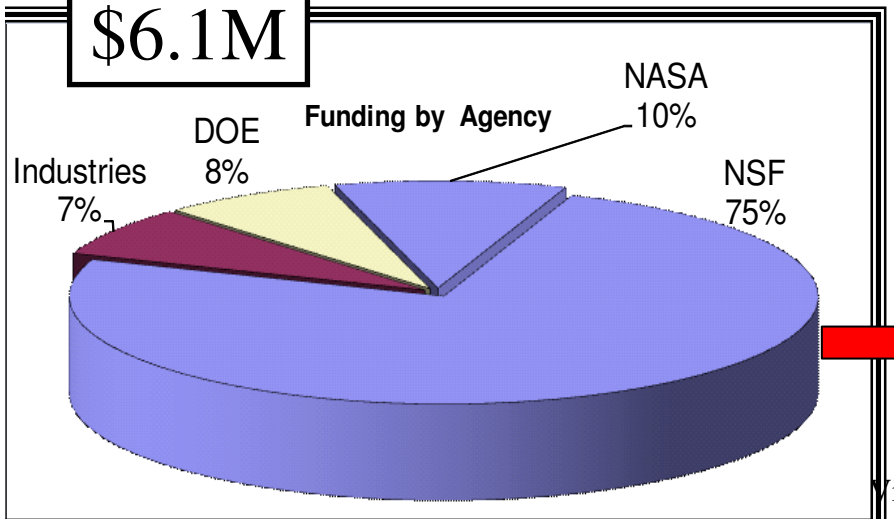
Funding Before 2008

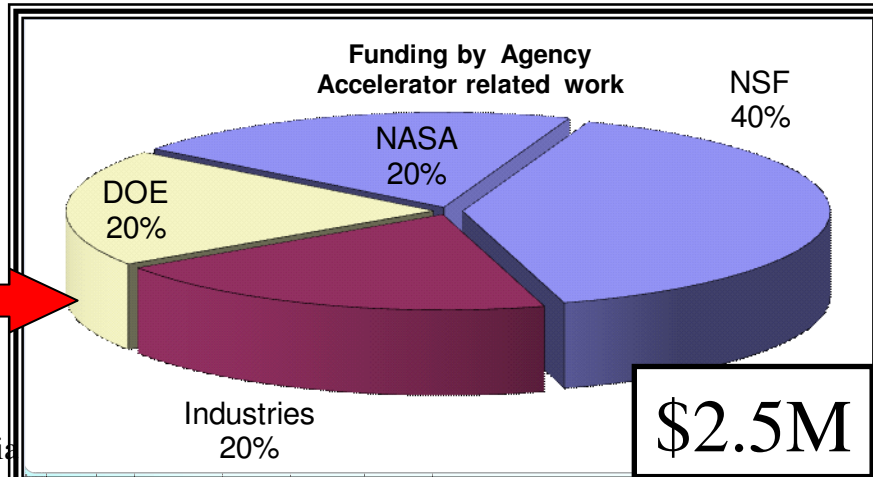
Funding After 2008

Funding by type



$6.1M





$2.5M

Types of Research and Services

1 Basic Research

Pure & Fundamental Research: Publications, Thesis, & Dissertation

2 Applied Research

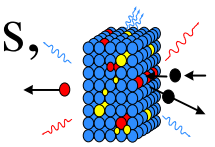
Materials Modification (ion Implantation, Radiation effects, …), Forensics, Materials Characterization (RBS, NRA, PIXE, PIGE, μ-Probe, ion channeling, Device Prototyping (Sensors, Detectors, Thermoelectric, Filters, HT C-Composites, Bio-Mat., Nano-pores, ..)

3 Education

Special Topics Courses (3-6 Credit hours), Summer Training, REU, IGART, Exchange students, and Visiting Scientists/scholar

4 Services

SBIR, STTR, IBA, IBMM, Inverse Engineering, Forensics, ….



Examples

1 **Optical & Electronics Materials**

Quantum Dots, Nano-materials, Nano-fabrications;
Properties: Wave guiding, optical absorption, electronics, electrical, NLO, SERS,

2 **Polymers**

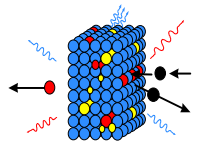
Chemical, electrical, thermal & structural changes (FTIR, μ-Raman, fracture toughness, σ, ZT, τ, & S),

3 **Forensics/IBA**

Paints (cars, old building, toys), coins, stones,
Phytoremediation, water, soil, …

4 **Bio-Materials**

Enhanced Cell adhesion, inhibit the cell adhesion, enhanced surface properties (Dental implants, hip joint implants, heart-valves, Percutaneous devices, ….



Research & Education @ the CIM

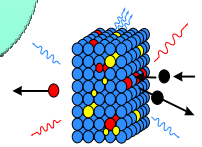
Special Topics Courses (STC)

Summer Training Program (STP)

Ctr. For Irrad. Materials Programs

Thesis (Diploma)

Dissertation (Diploma)



STC
- Ion Beam Mod. Materials
- Ion Beam Analysis

STP
- 8-12 weeks summer program
- 9 months Academics

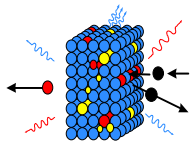
Diploma
- Thesis
- Dissertation

IBMM/IBA

Rad. Effects Implant. Instrum.	RBS, PIXE, PIGE, NRA, μ-Probe,	Forensic, Inv. Engineering, ….

Summer Traineeship (8-12 weeks)

Selection	Food, Housing, Transportation	Week 1
VISA	Project	Week …..
Insurance	Mentor	Last week



Special Topics Course

Duration: 12-14 weeks

3-6 credit hours, almost every other fall semester

1-3 hours/week for class

4-6 hours lab

Final Grade; Homework (30%), Lab work (30%), drafting acceptable abstract (20%), Final Report/accepted manuscript (10%-20%)

Prerequisites:

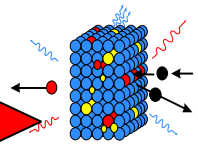
Nuc. Phys. (I), Elements of Mat. Sci., Rad. Training

Support through CIM:

Free 24/7 access to CIM, desk with computer, & CIM staff/faculty/senior grads as Mentors

Timetable (Weeks):

1, 2, 3, 4,



Special Topics Course

Timetable (Weeks):

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 ---------

Class work

Lab work

Abstract Development

Abstract Submission

Report Development

Manuscript Development

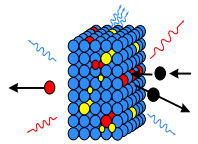
General topics:

Ion beam interactions in materials

Modification of materials

Analysis of materials

Instruments for characterization



Special Topics Course
RESEARCH PROJECT

Weekly meeting and tasks

1 Introduction to CIM staff at weekly seminar/progress report
Identify research topics and possible mentor and partners

2 Begin literature search and theory relevant to topic
10 minute .ppt progress reports at each weekly CIM seminar

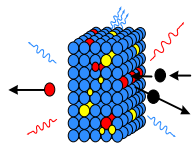
3 Experiment design

4+ Sample preparation, modification, analysis

- Data collection, processing, interpretation
- 30 minute .ppt presentation at CIM seminar
- Abstract submitted to a significant topical conference (MRS, CAARI, IBA, IBMM, SMMIB, REI, IRAP, IIT, …….)
-

Final weeks of cross checks, verifications, interpretations
Preparation of poster/manuscript (approval of co authors)
Submission on line (depending on conference deadlines)

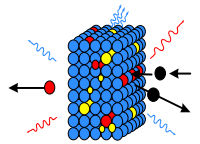
On completion, many students proceed…



Results

as of 2008

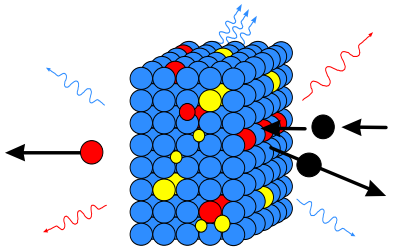
15	Ph. D. theses
12	Masters dissertations
60	Undergraduate funded research
2	High School research scholars
>100	Summer/Visiting Scholars



Partners (partial listing)

University
Claude Bernard Lyon

Alabama A&M
University



Center for Irradiation
of Materials

Ege University
Turkey

UAB, UAH, UWLA, UWGA, Stanford, TU
Kyoto, Vanderbilt, UT, Fisk U, TSU, UL, ..

University of Sao Paulo
Brazil

THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

University of the
State of São Paulo

Grissom
High School

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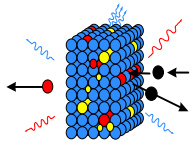
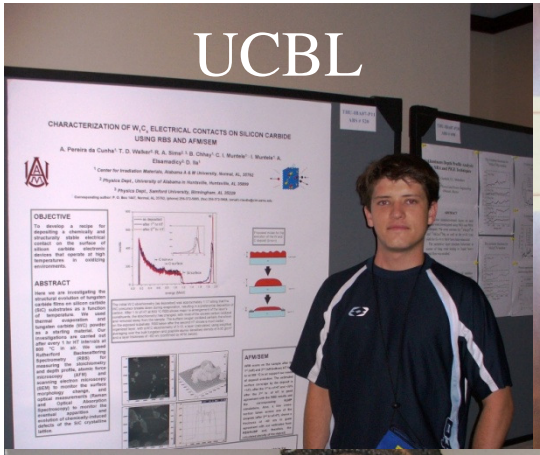
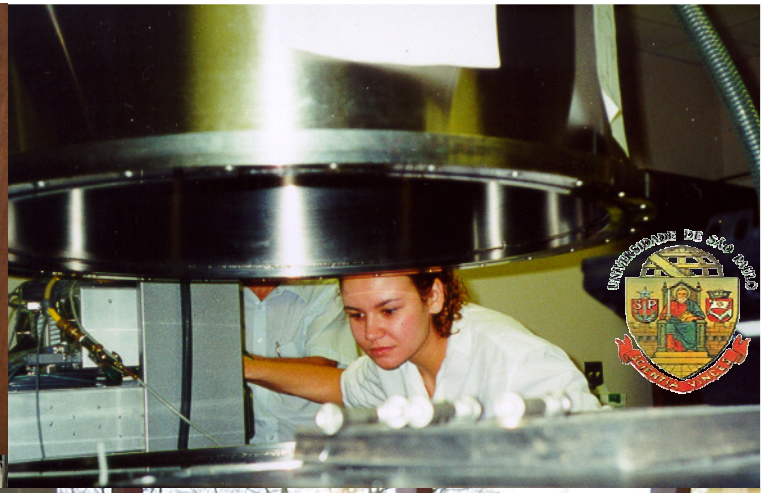



UCBL
CHARACTERIZATION OF W,C, ELECTRICAL CONTACTS ON SILICON CARBIDE USING RBS AND AFM/SEM
OBJECTIVE
ABSTRACT
AFM/SEM

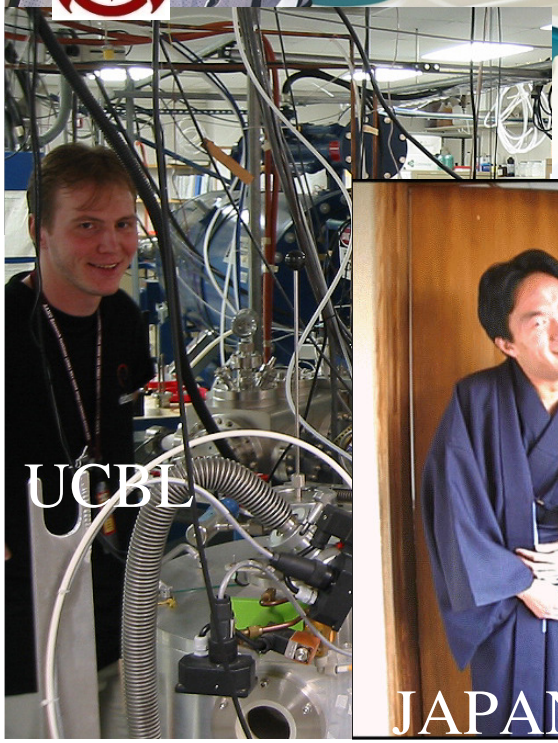

MCL
UCBL




UCBL


UCBL


Outreach Project at a Middle School
L.Wilson, E. Edwards*, and D. Ila
Center for Irradiation of Materials, Department of Physics, Alabama A&M University, Normal, AL 35762 USA
*NSROC
very Wednesday from 10am-12pm, we supervise optics laboratory experiments at the Academy for Science and
nguage, located at 3221 Mastin Lake in Huntsville, Alabama. There are two sessions of mixed students from
o eight, and they are guided through basic optics experiments. Although the experiments vary every week, the
sed generally consist of a laser and mirrors with which the students learn the fundamental principle in optics.
These students are participating in the Special Programs for Academic and Creative Excellence (SPACE), which is an enrichment pull-out program for identified gifted students. Students are given approximately 20 different offerings of classes to choose up to 3 classes each semester. Optics is one of these choices. Other class offerings include robotics and Lego robotics, traveling chemistry troupe, water quality where we test 4 sites and report to Alabama Water Watch at Auburn University, International Cooking/Cuisine, and robotics.
Acknowledgements
Research sponsored by the Center for Irradiation of Materials, Alabama A&M University, and by National Science Foundation under Grant No. EPS-0447675.
Students observing light through fibers

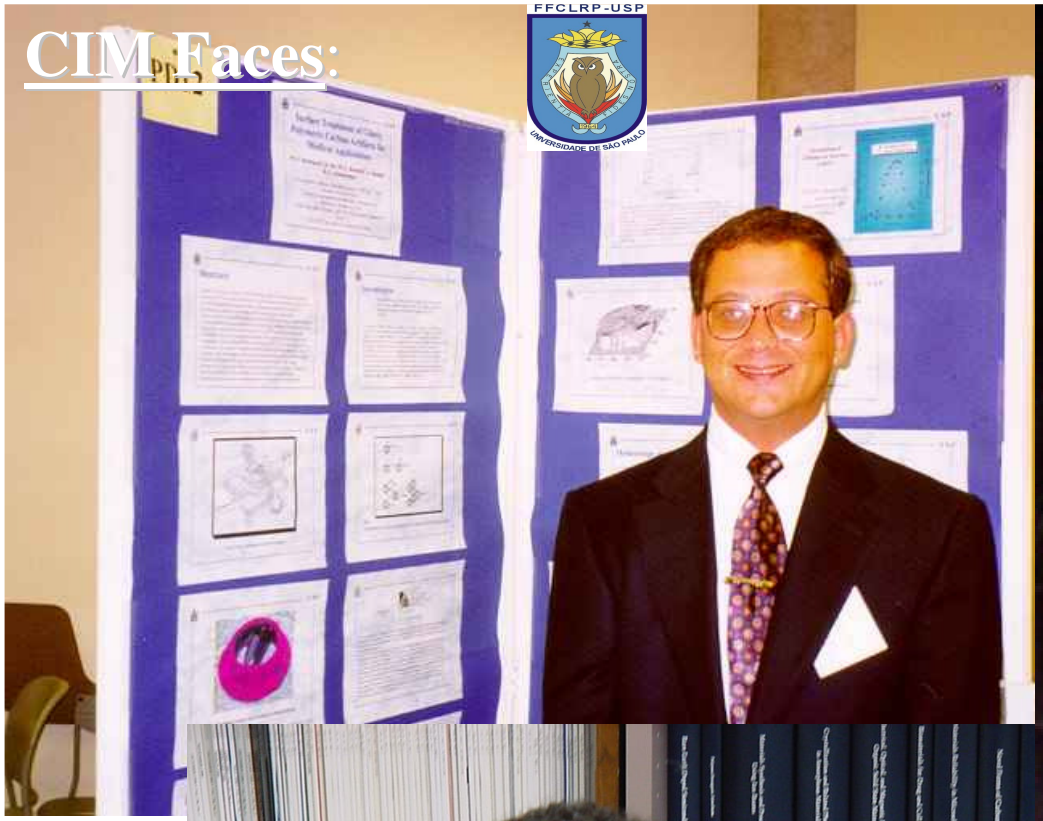

UCBL


JAPAN

UCBL


Gateway
UCBL

CIM Faces:



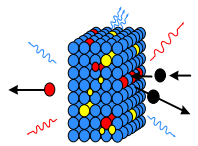
May 2009

CIM Faces:

Summer Training Program

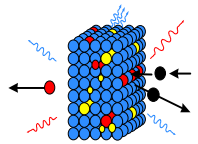
Preliminary arrangements for all students (8-12 weeks):

- Student selection
- Student visa
  (International Summer Trainee)
- Insurance
- Food, housing and transport
- Project selection
- Mentor assignment



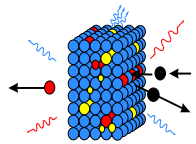
8-12 weeks summer program:

Week 1. Introduction and Background
Week 2. Theory and experimental approach
… 3. Sample preparation
… 4. Abstract 10% accomplished
30% forecast
Rest promised
… 5. Sample analysis
… 6. Posters (CAARI, IBA, IBMM…)
… 7. Final report
Week 8. Farewell excursions and parties



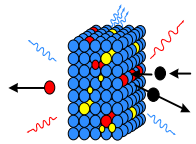
Week 1. Basic Laboratory tools:

a. Research & Education Protocols & Ethic
b. Building security and personal safety (24/7)
c. Instrument and personal research log books
d. Computer use
e. Shop practice
f. Vacuum techniques



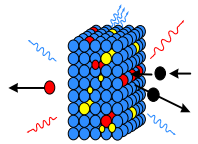
Week 2. Sample preparation

a. MBE
b. IBAD
c. Thermal treatment
d. Ultrasound
e. Labeling and storage



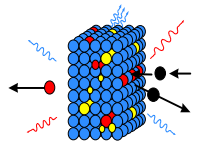
Week 3. Ion accelerator use (Modification, Analysis)

a. RBS
b. PIXE
c. Implantation
d. NRA
e. RGA
f. PIGE
g. μ-Probe
h. Rad. Effects
i. ……



Week 4. other characterization

a . UV-VIS optical spectroscopy
b. FTIR spectroscopy
c. RAMAN spectroscopy
d. AFM
e. Auger spectroscopy
f. SEM
g. Mechanical tests
h. Seebeck
i. Thermal conductivity
j. IV-CV
k. Electrical resistivity
l. Interferometric thickness
m. RUMP analysis
n. PIXE analysis , ……



Every week: Scientific reporting

a. Weekly seminar PPP

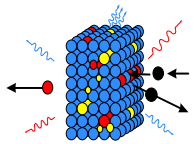
b. Weekly electronic reports

c. Conference poster contributions

d. Manuscript submission

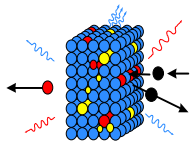
e. Revisions for publication

f. Final report (CD and HC files)

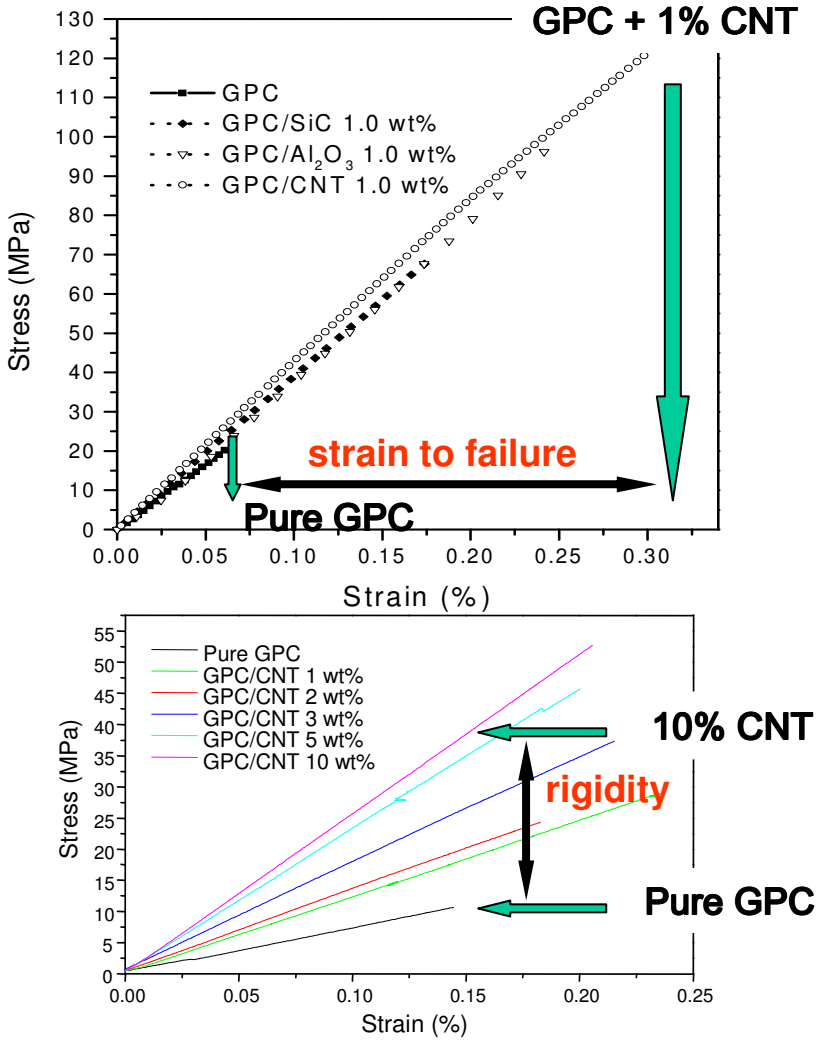


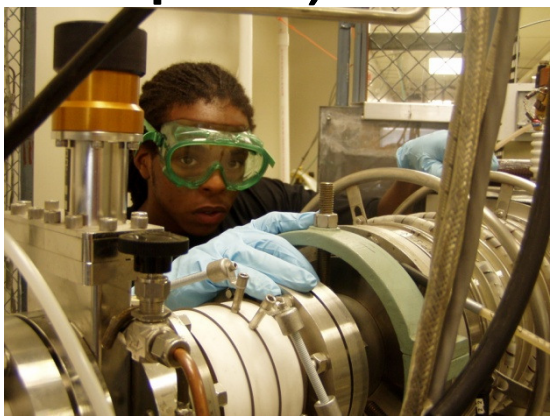
Sample Projects:

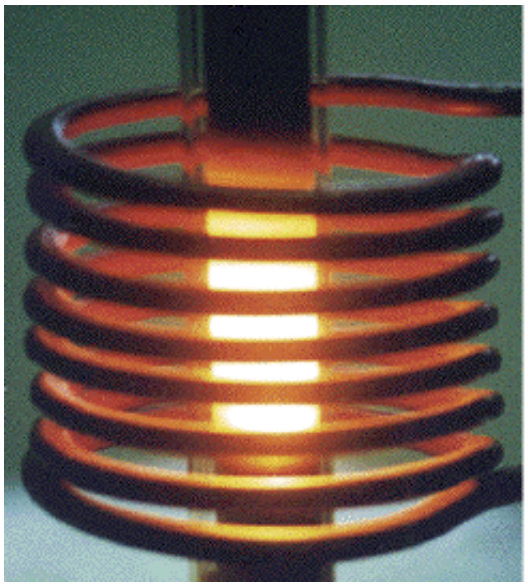
- Polymeric Carbon composites
- Cell adhesion
- Micro and nano structures in metals
- LiF simultaneous channeling (p,α) and (p,γ)
- Electrets in fluoropolymers
- Metal QD in SiC
- Radiation effects in polymers
- PIXE and RBS on coins/toys
- Pollution around Europe
- Analysis of light elements (Si and C)



CARBON COMPOSITES (Example 1.)



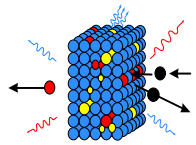




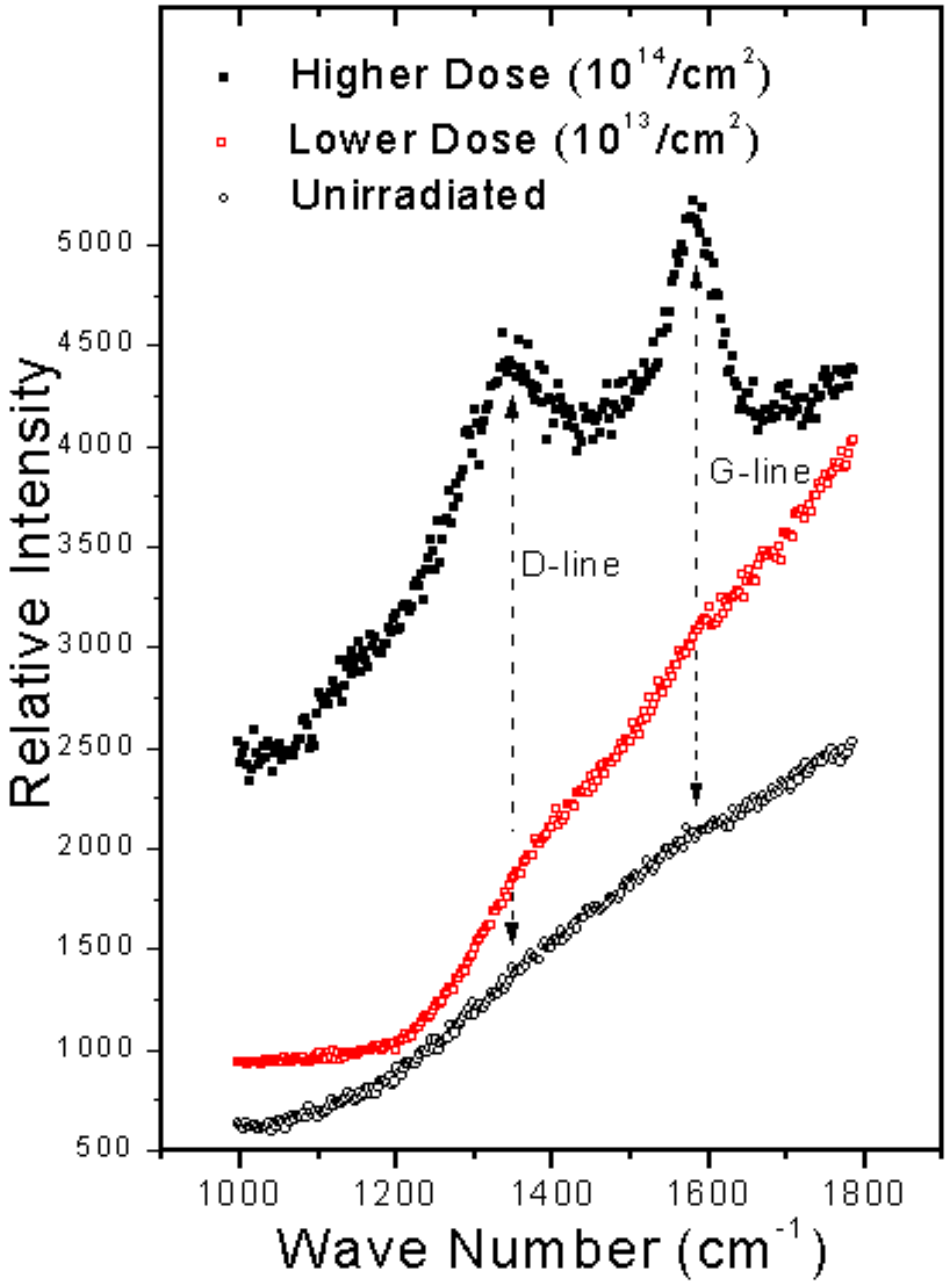
Ultra high (2500C) temperature carbon composites. Carbon nano tubes improve the strain to failure more than factor 5. And the rigidity by factor 3 !

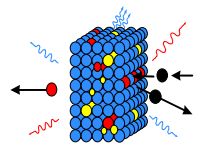
Glassy Polymeric Carbon (GPC)

- **Operates above 5000ºF**
- **Chemically stable**
- **Biocompatible**
- **Almost as hard as diamond**
- **Good electrical conductor**

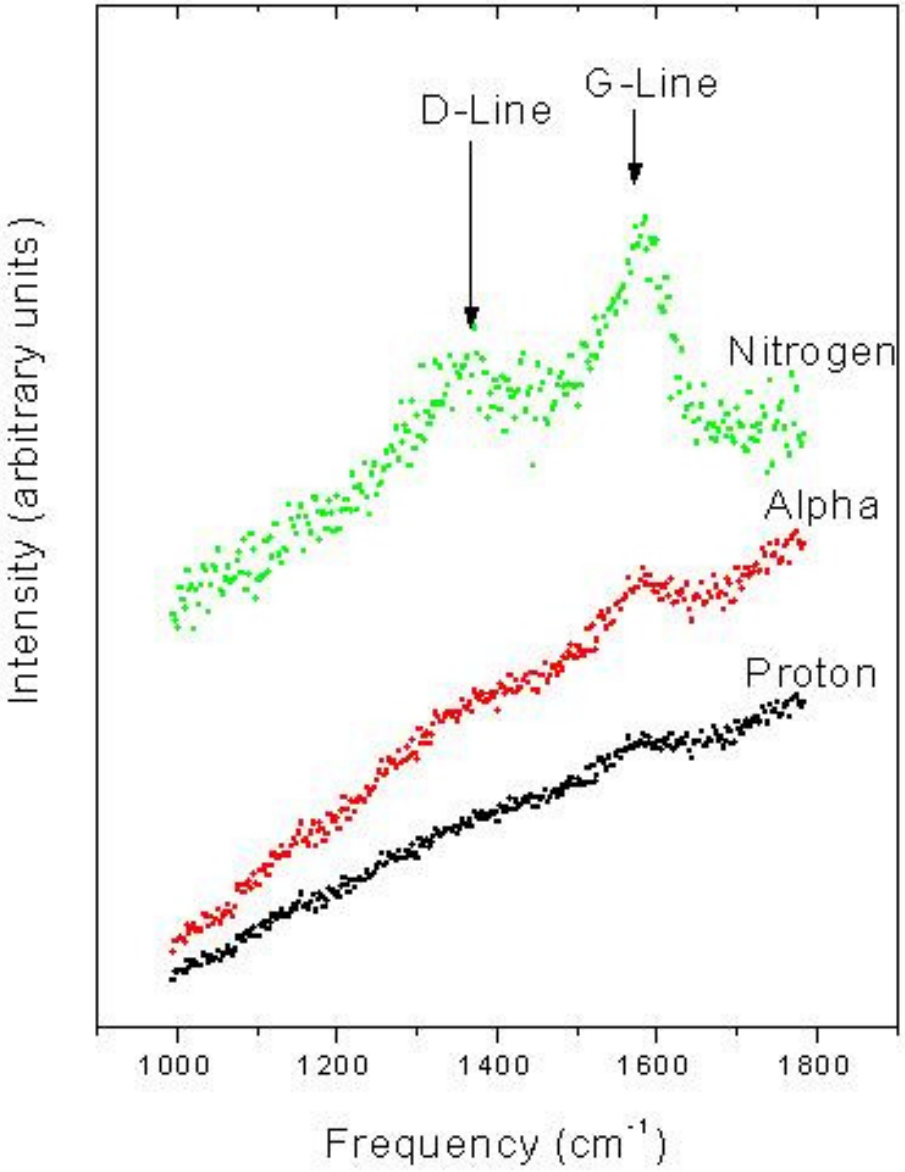


Production of polymeric carbon by ion bombardment

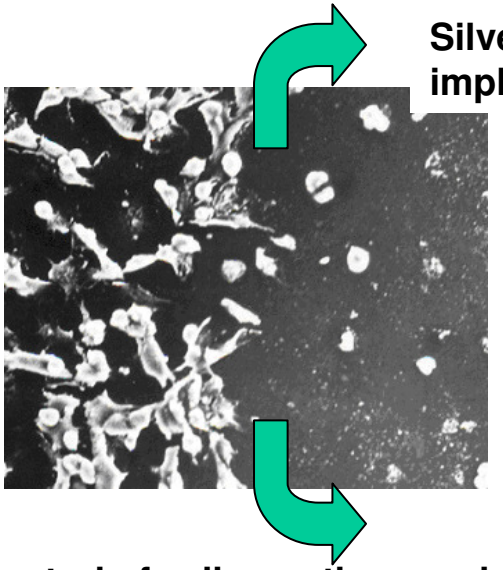




Raman from PF

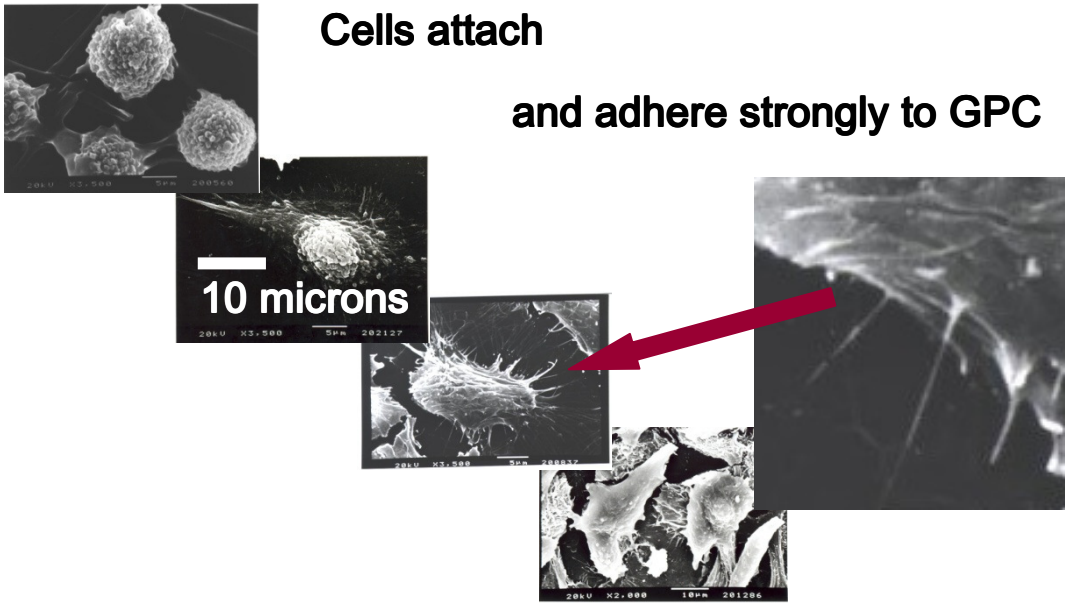


ION BEAM MODIFICATION
of materials for biomedical applications.



Silver ion implantation

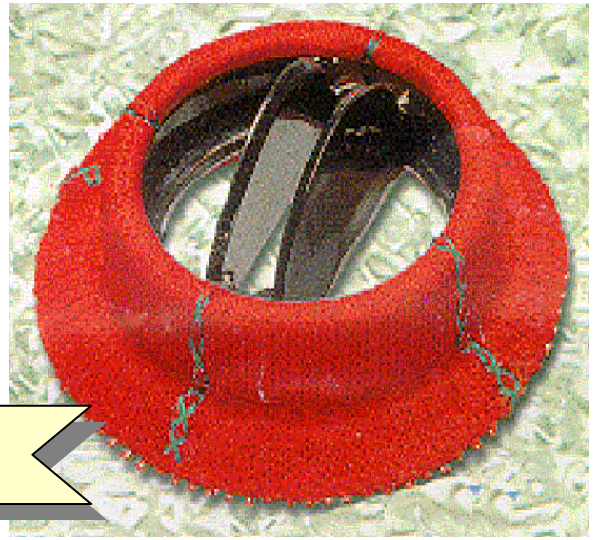
Control of cell growth on carbon for improved medical implants



Cells attach

and adhere strongly to GPC

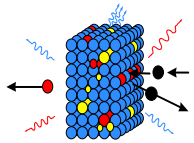
- Tenuous cell attachment (top)
- Strong adhesion (bottom)



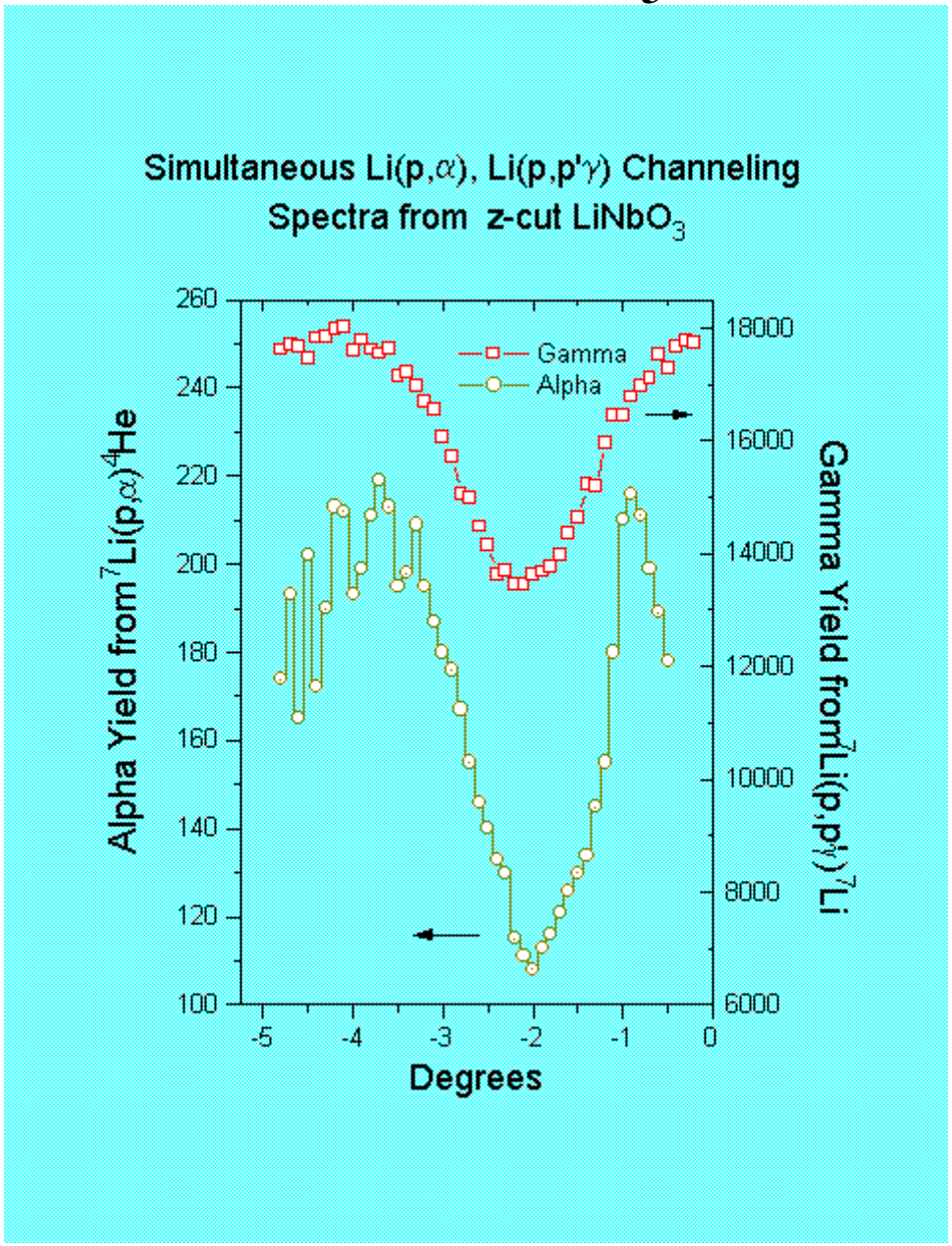
GPC heart valve
(GPC is the black material)

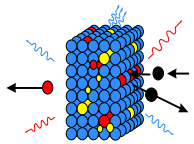
Research Partners

Brazil Turkey AAMU



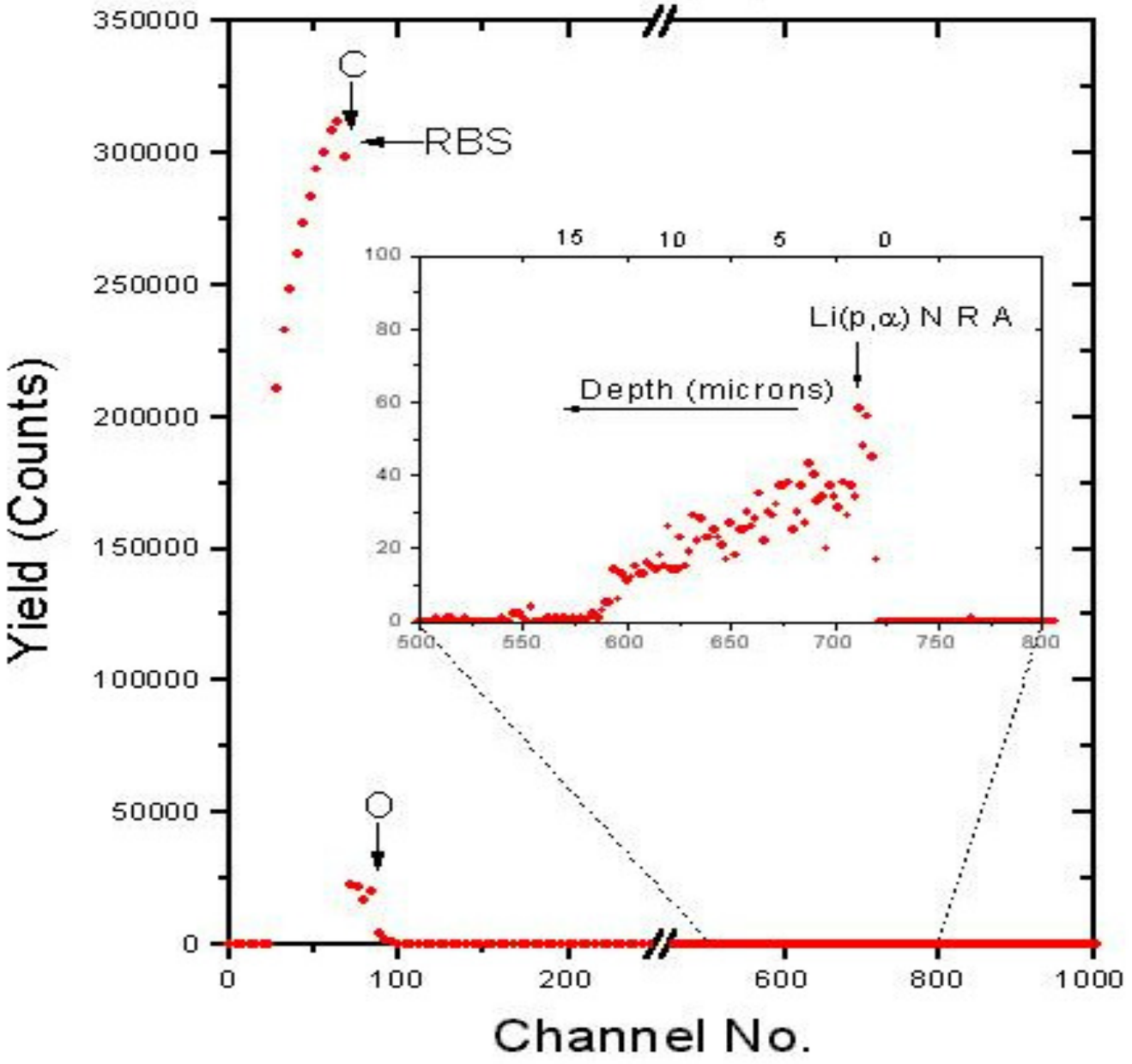
Example IBA: Ion channeling in $LiNbO_3$





RBS and NRA Spectra Produced by 1.03 MeV Protons

from 700° heat-treated polymeric carbon



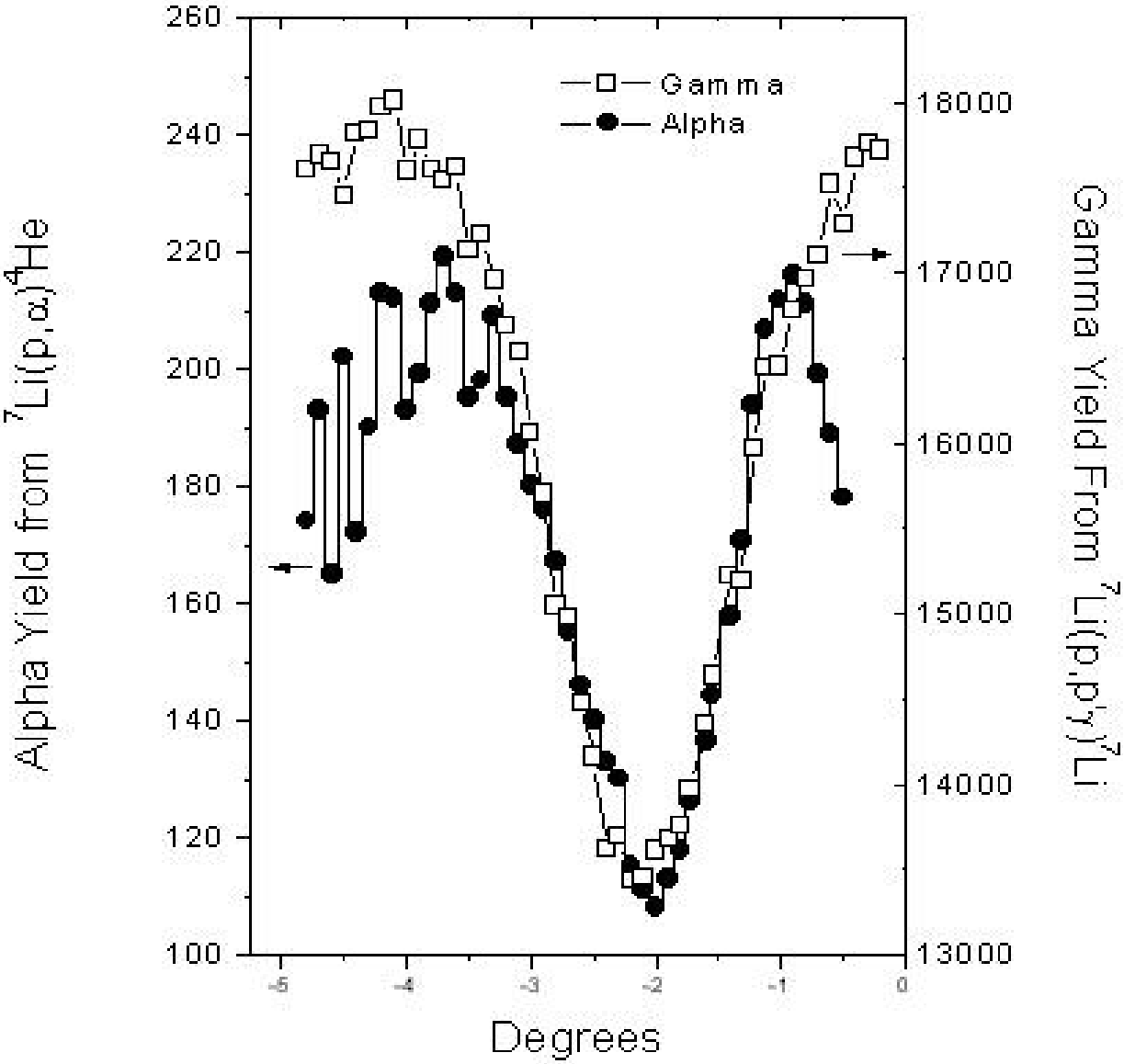
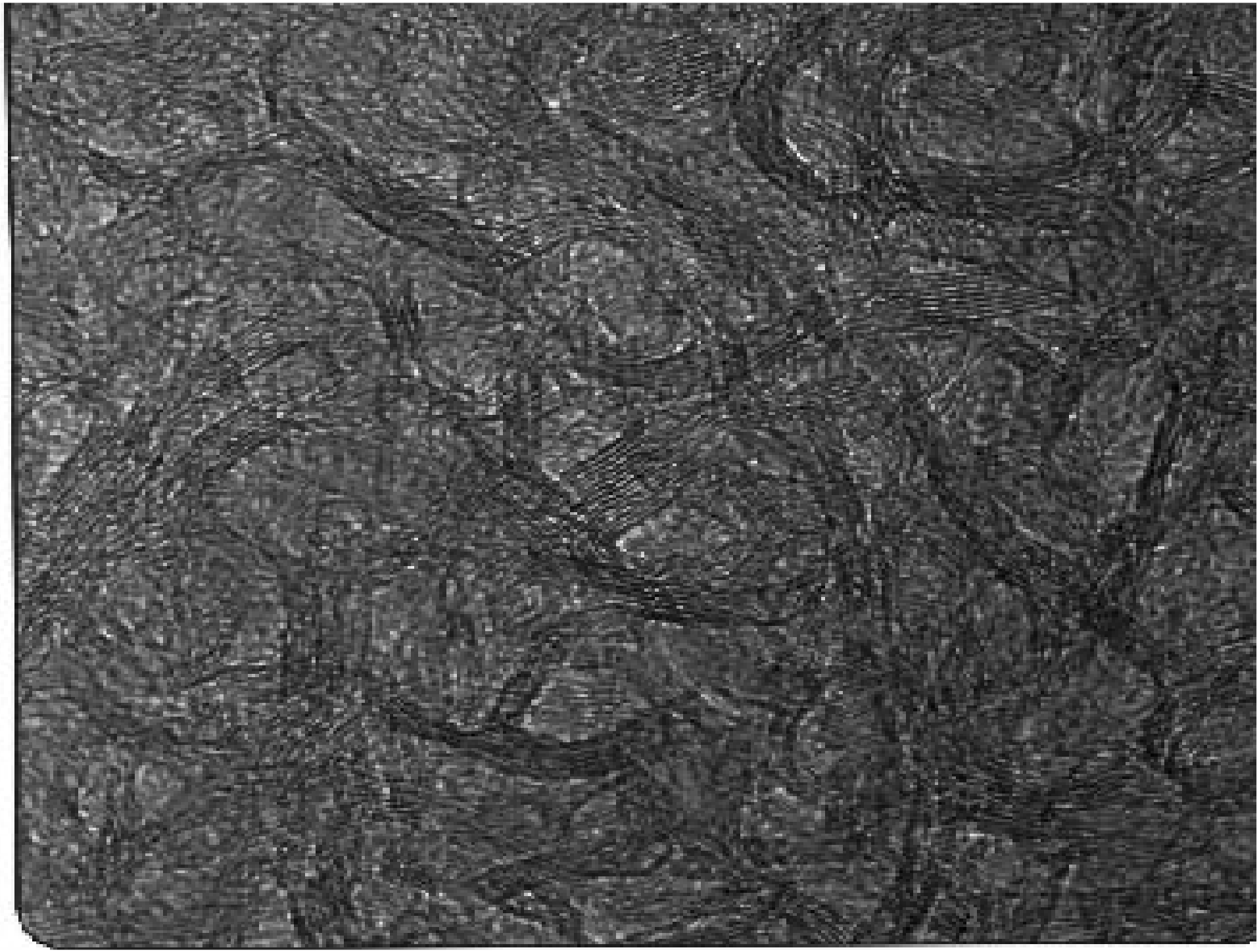
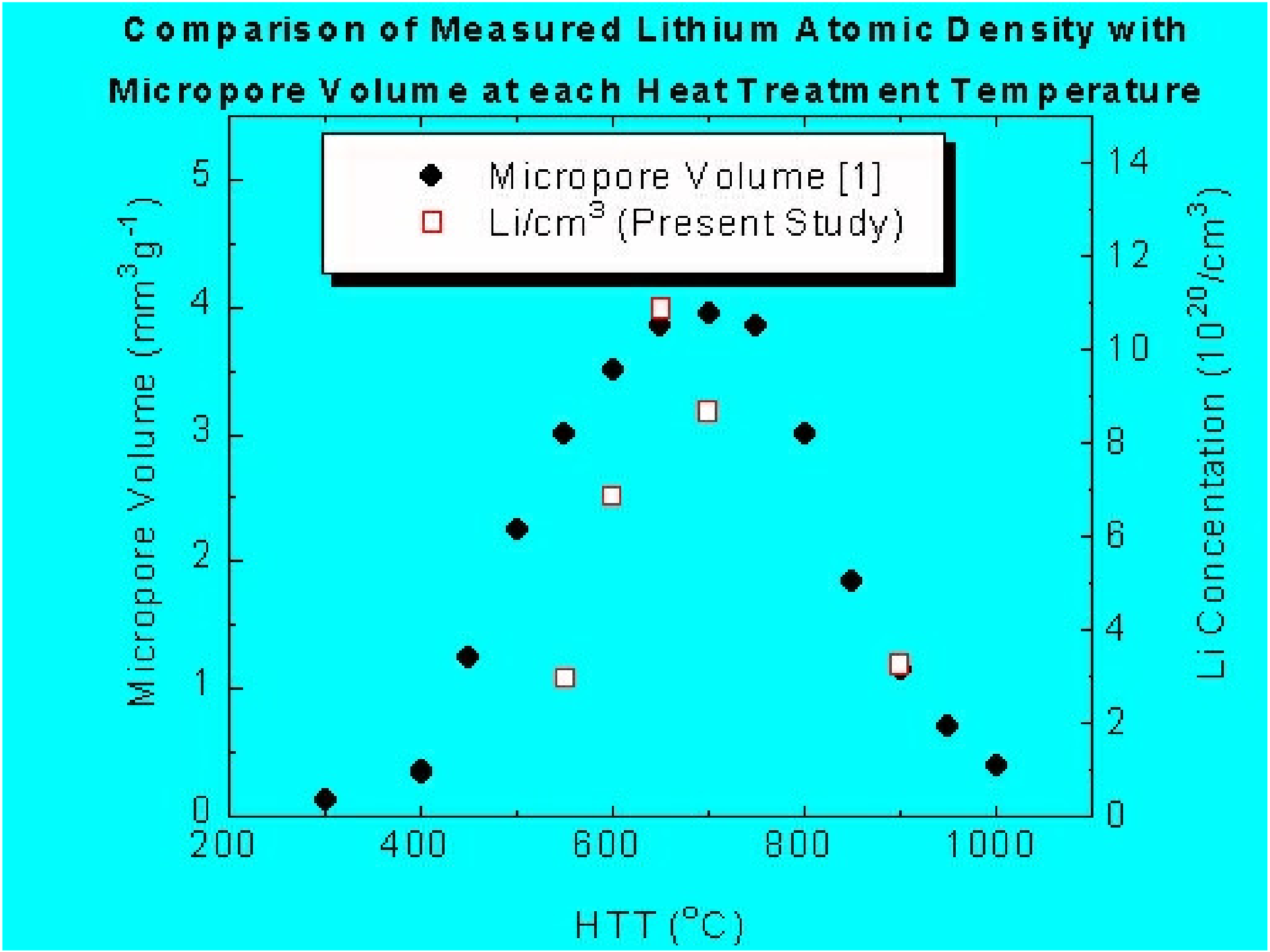
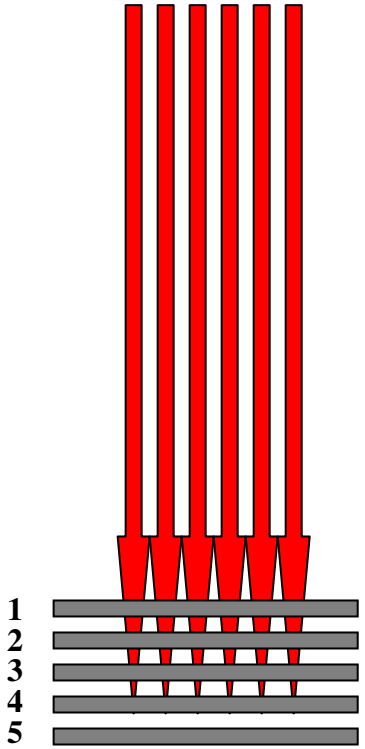


Figure 1. Simultaneous Li(p,α), Li(p,p'γ) Channeling Spectra from z-cut $LiNbO_3$

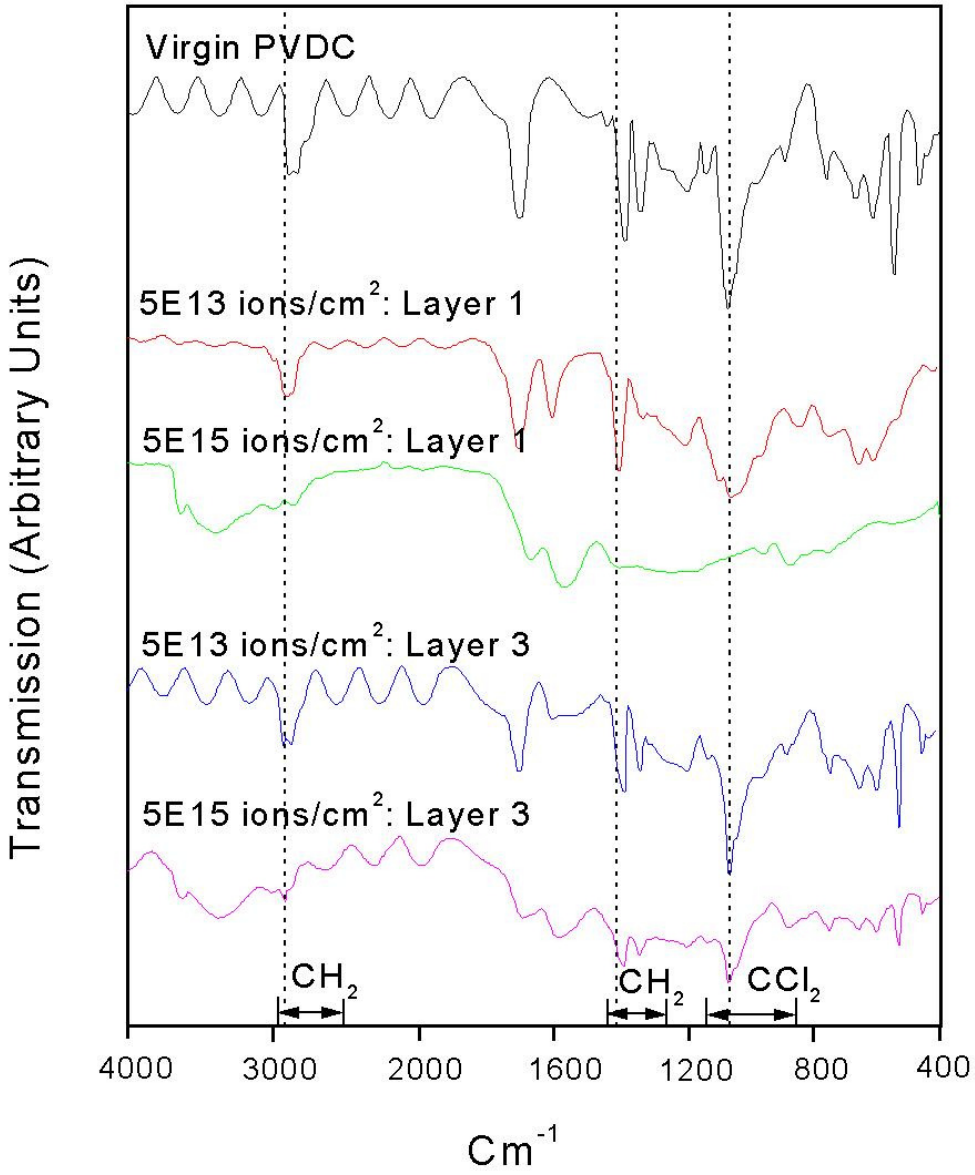


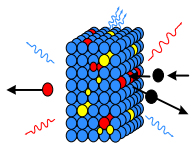

Comparison of Measured Lithium Atomic Density with
Micropore Volume at each Heat Treatment Temperature
Micropore Volume [1]
Li/cm3 (Present Study)
Micropore Volume (mm3g-1)
Li Concentation (1020/cm3)
HTT (°C)
0
1
2
3
4
5
0
2
4
6
8
10
12
14
200
400
600
800
1000

Ion beam modification of polymers; clever use of stacked films (Example 3)

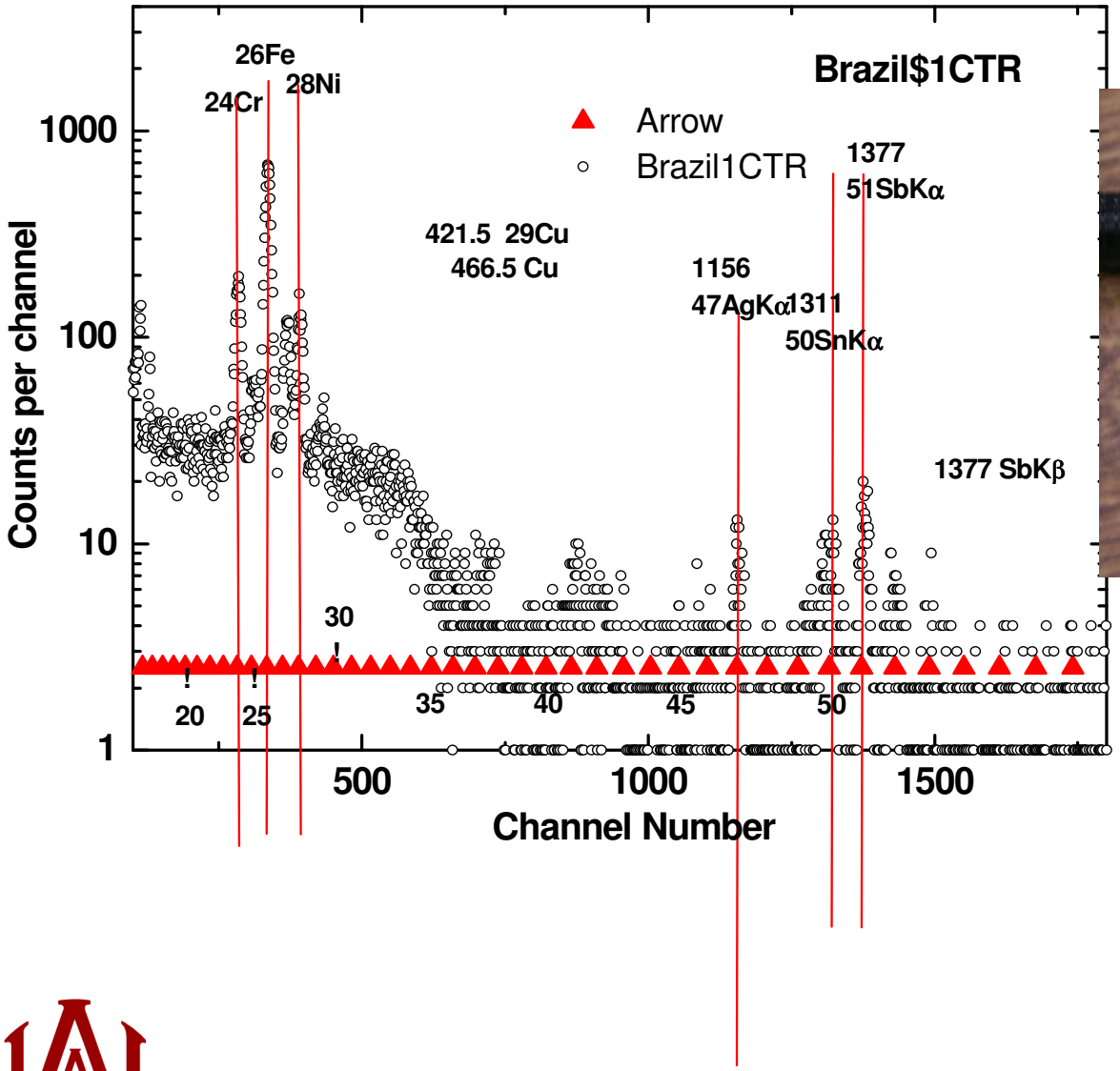


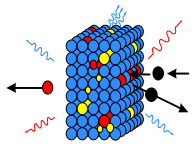
Example IBMM





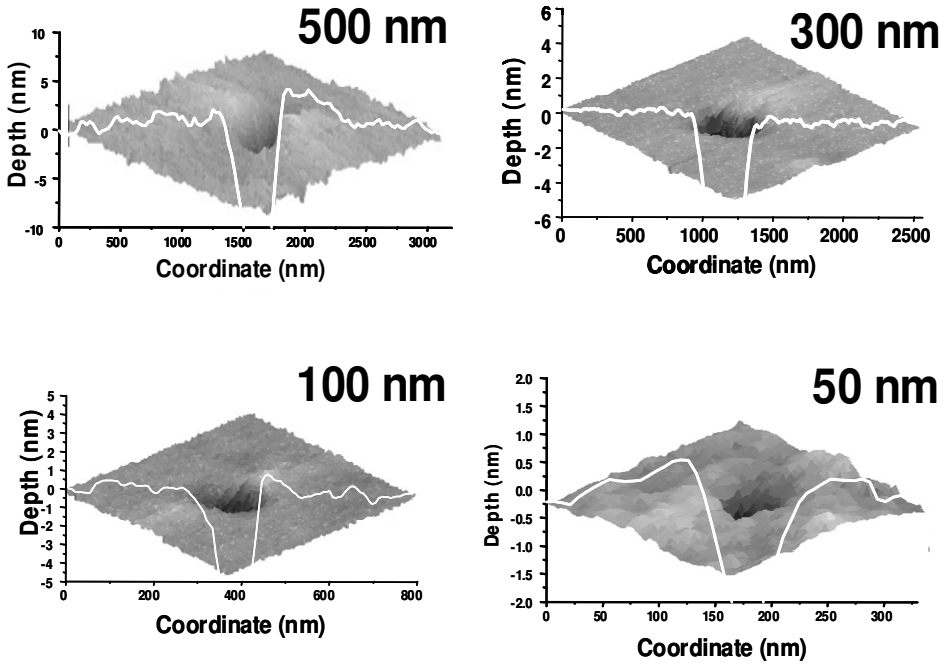
(Example IBA) PIXE analysis of ancient and modern coins

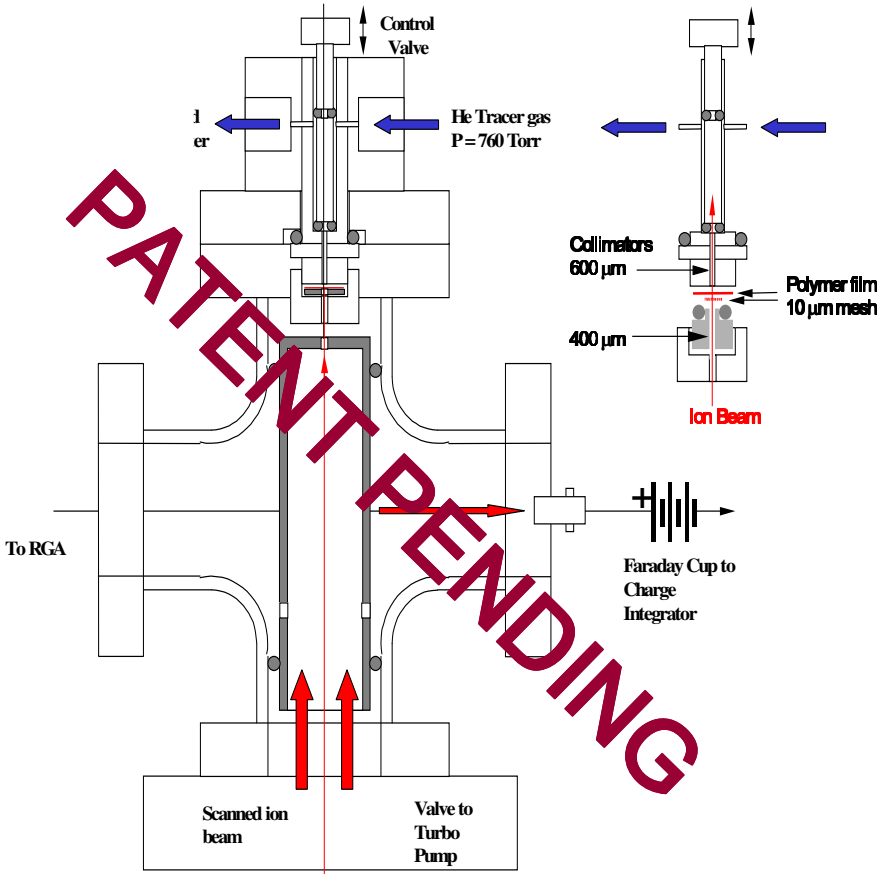




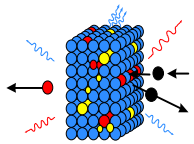
(Example IBMM) : Bio medical applications.

Nano pore production for single molecule biochemistry
DNA and Protein characterization





Perfluoroalkoxyethylene (PFA) $[CF_2CF_2]_{0.99}[CF_2COF_3]_{0.01}$



Mie Theory $a<r<\lambda$

$$\alpha = \frac{18\pi Q n_o^3 \varepsilon_2}{\lambda\left[(\varepsilon_1+2n_o^2)^2+\varepsilon_2^2\right]}$$

cm^{-1}

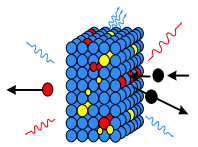
$$\varepsilon_1 + 2n_o^2 = 0$$

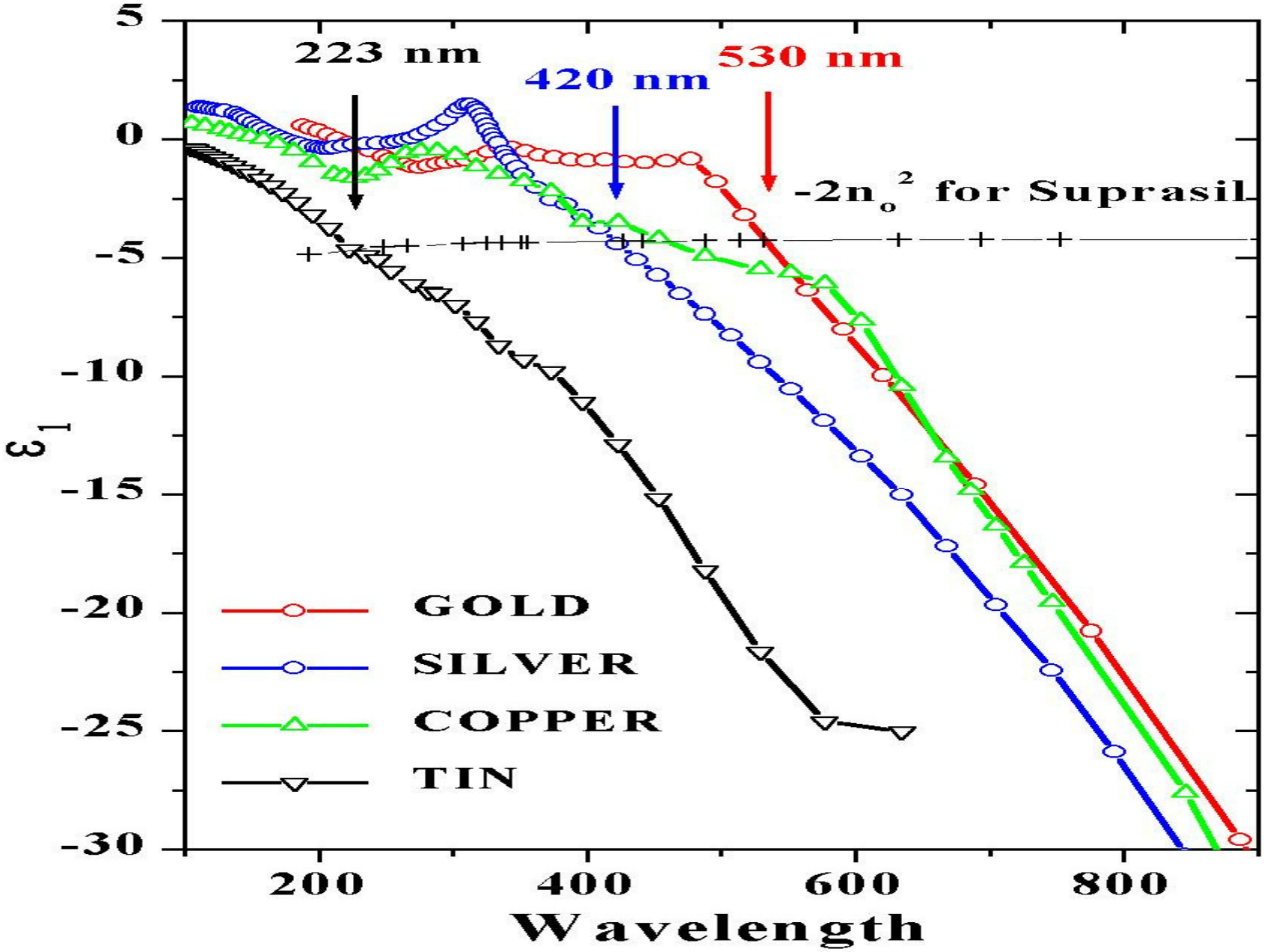
Maximum when

α	**Linear coefficient of absorption**
Q	**Volume fraction of metal in insulator host**
N_0	**Index of refraction of insulator host**
$\varepsilon_1 + j\varepsilon_2$	**Complex dielectric constant of bulk metal**
r	**Radius of metal nanocrystal**
λ	**Vacuum wavelength of incident light**
a	**Electron mean free path in bulk metal**

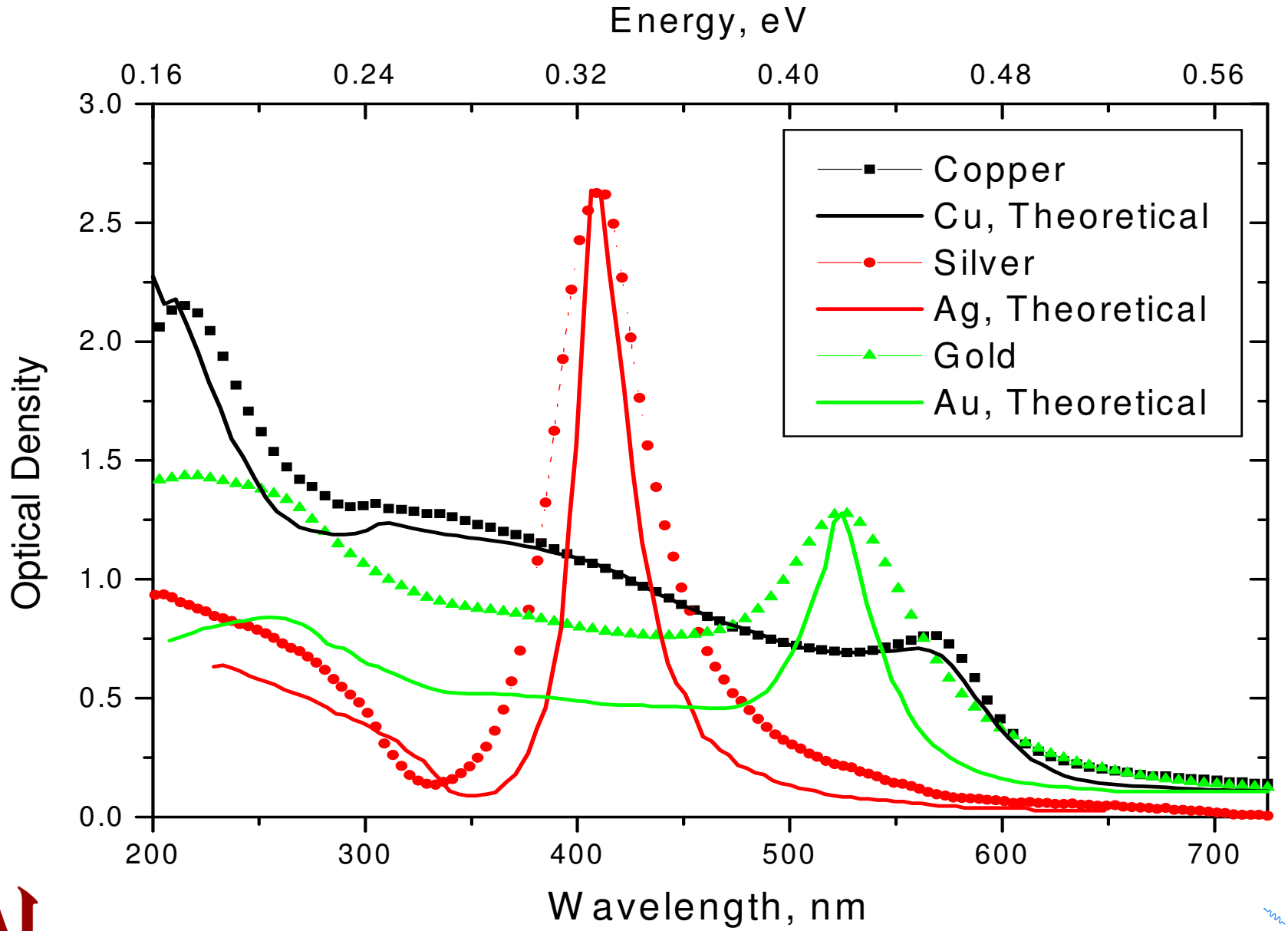
Gustav Mie, *Ann. Physik*, 25, 377 (1908)

(Example IBMM) QD/NC formation

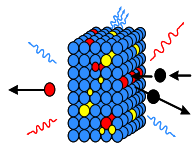


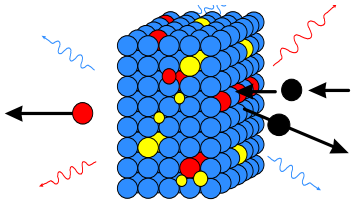


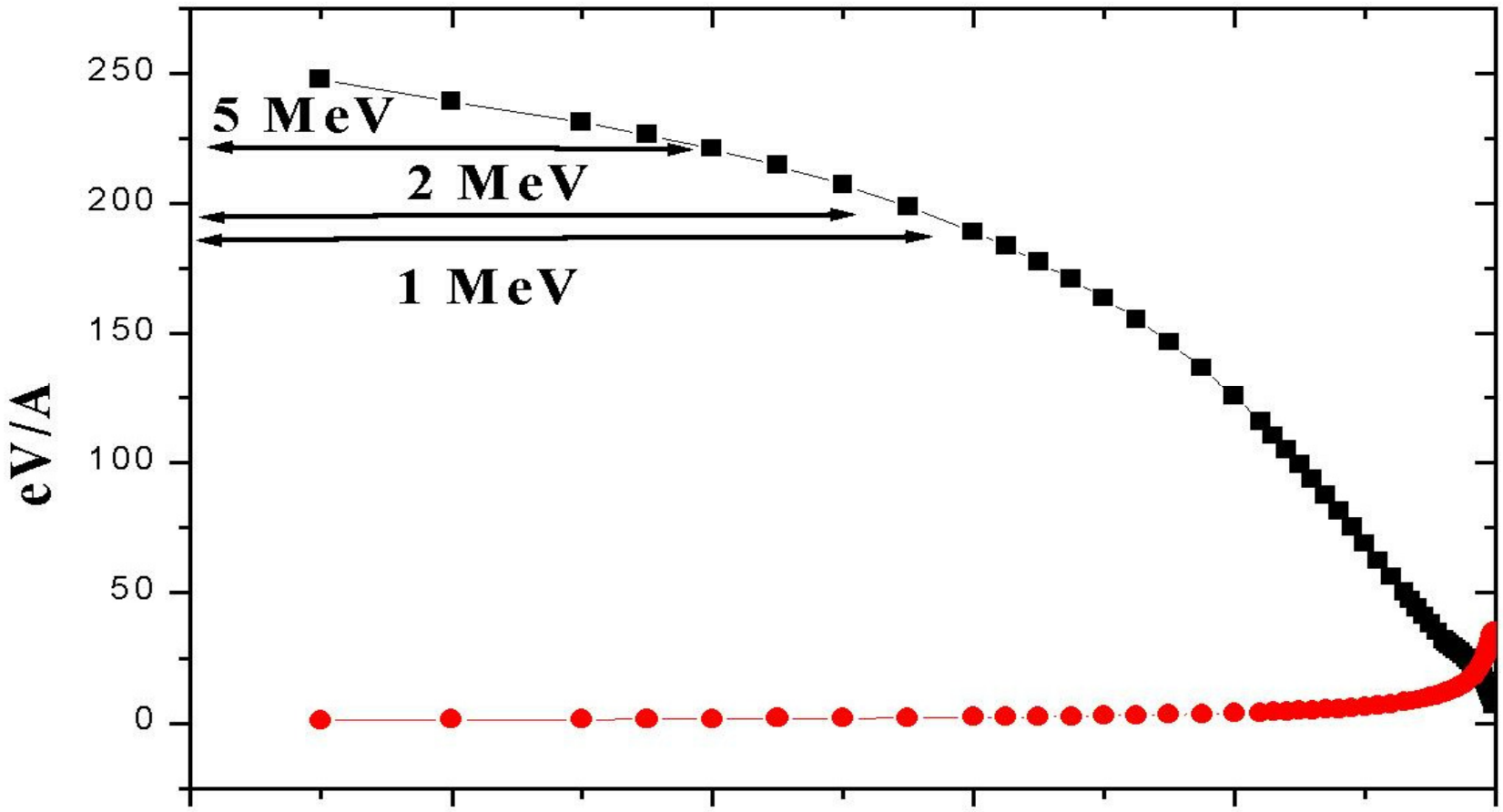
(Example IBMM) QD/NC formation



(Example IBMM) QD/NC formation



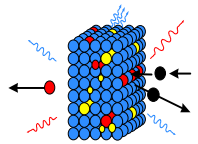




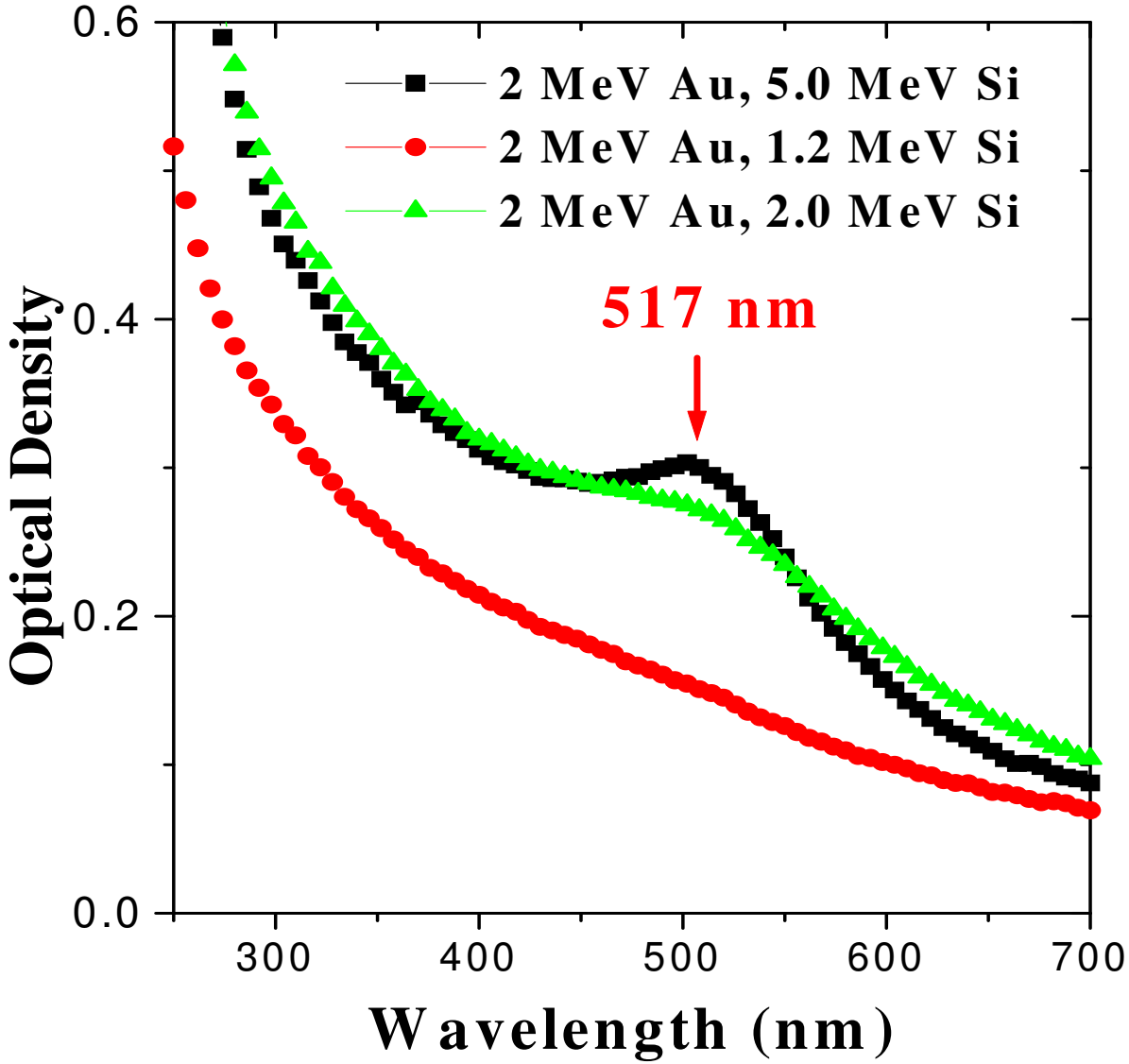
(Example IBMM) QD/NC formation

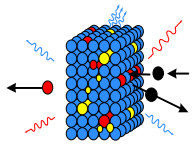
Si (MeV)	ΔE (keV) due to ε_ε	ΔE (keV) due to ε_ν	$\alpha . \lambda$ (nm)
1.2	107	7	4
2	176	5	9
5	373	3	27

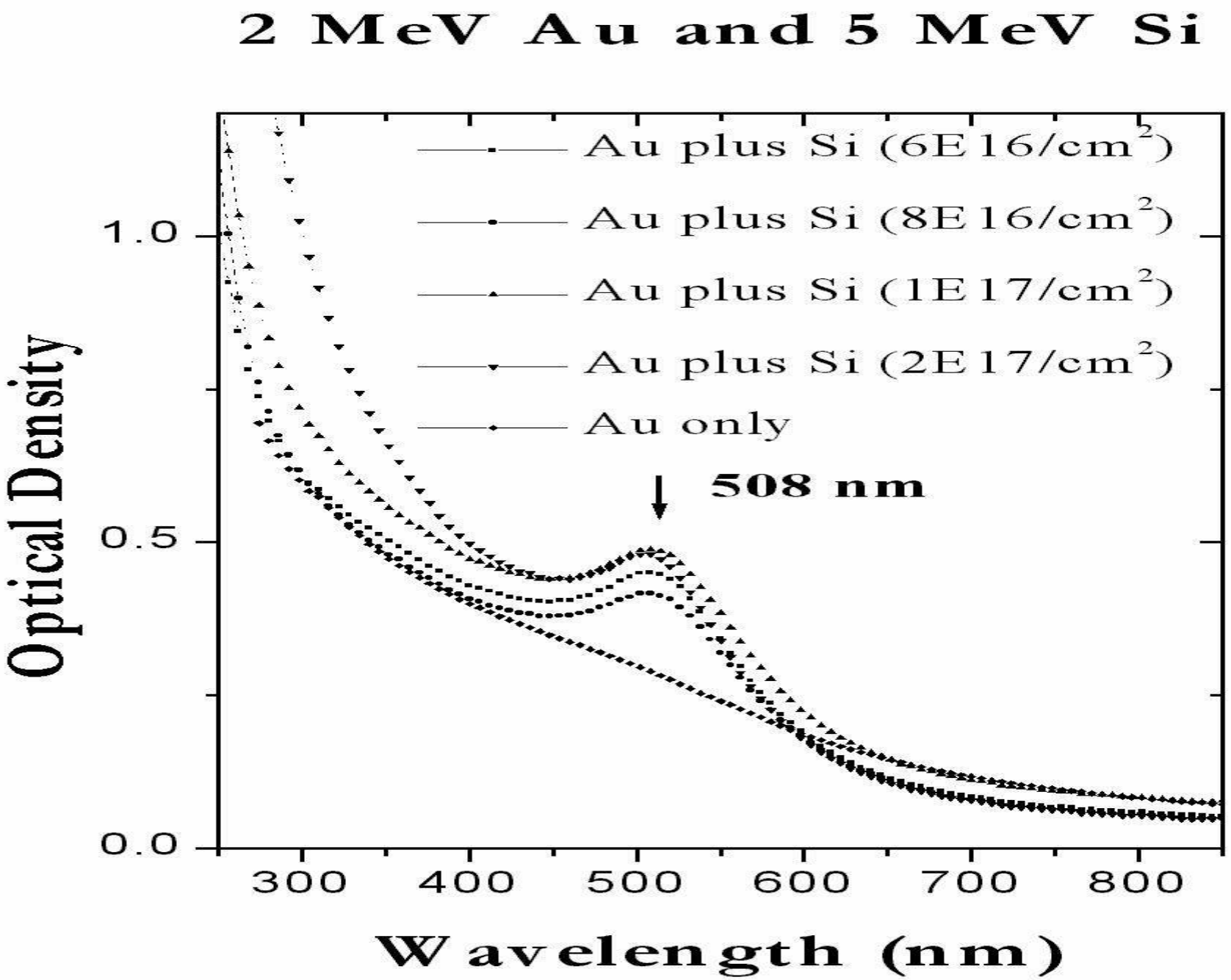
(Example IBMM) QD/NC formation



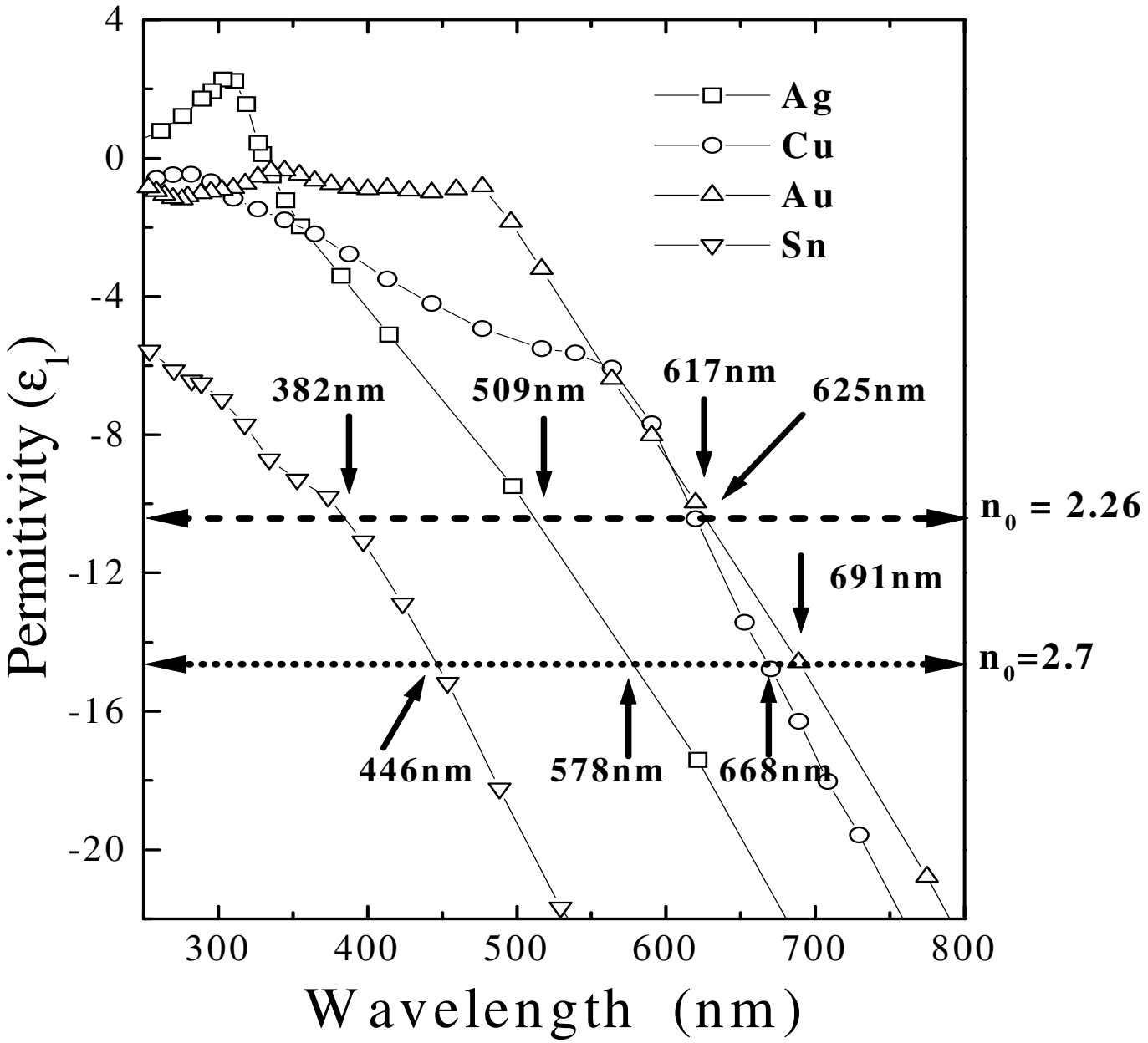
(Example IBMM) QD/NC formation

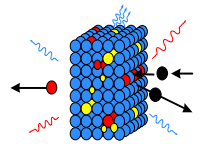


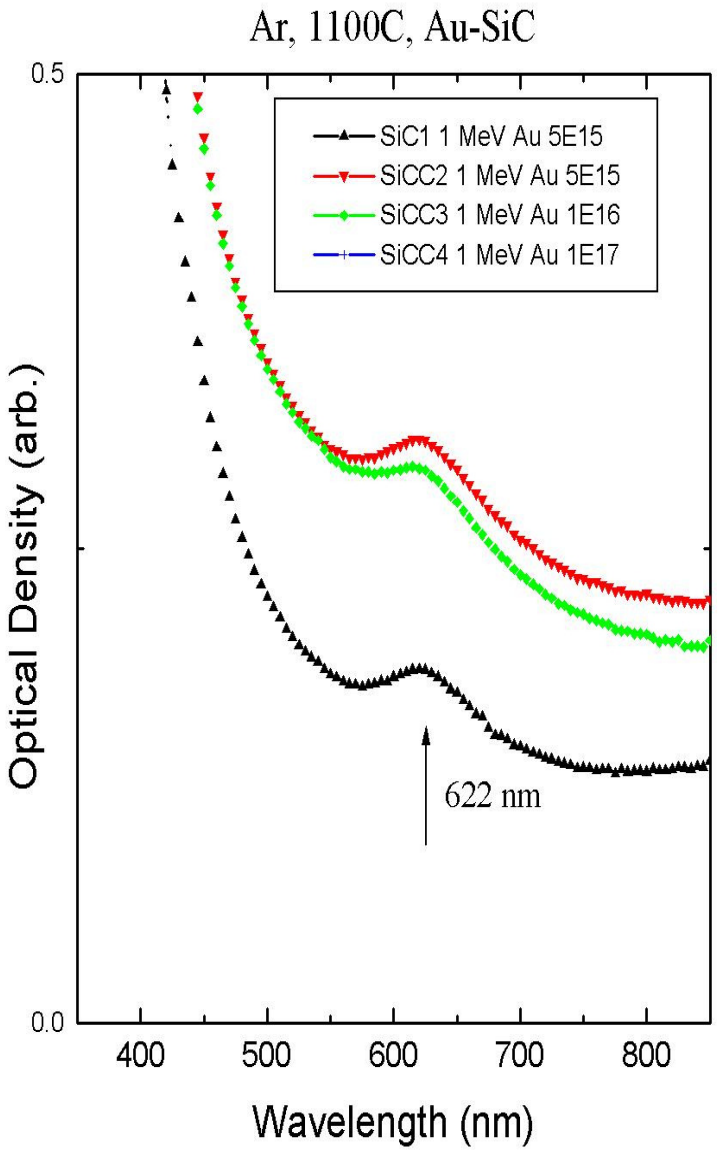



2 MeV Au and 5 MeV Si
Au plus Si (6E16/cm^2)
Au plus Si (8E16/cm^2)
Au plus Si (1E17/cm^2)
Au plus Si (2E17/cm^2)
Au only
508 nm
Optical Density
1.0
0.5
0.0
300
400
500
600
700
800
Wavelength (nm)

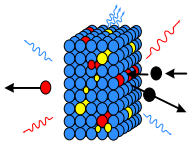
(Example IBMM) Formation of metal QD in SiC;







(Example IBMM) Formation of metal QD in SiC; Characterization with optical spectroscopy



(Example IBA) Ion Channeling in LiNbO3