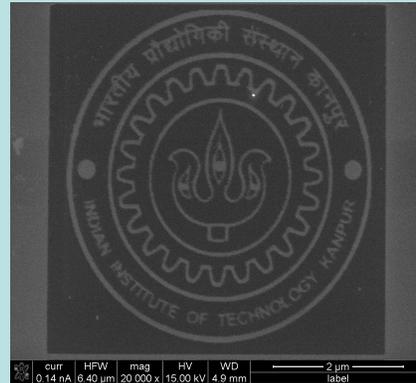


# ION BEAM CENTRE for Science and Futuristic Technologies (IBC- SFT)



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S. Dhamodaran<sup>1</sup>, J Ramkumar<sup>2</sup>, S. A. Ramakrishna<sup>1</sup>  
and G. K. Mehta<sup>1, 3</sup>**

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<sup>2</sup>Department of Mechanical Engineering, IIT Kanpur

<sup>3</sup>Inter University Accelerator Centre, New Delhi

# 2 MV, HVEC, Burlington (USA) make Van de Graaf Accelerator IIT Kanpur

Installed : 1968



## RESEARCH ( 1968-2006)

**Nuclear Physics ( 1968-82)**

Multi disciplinary Research ( 1982 -2006)

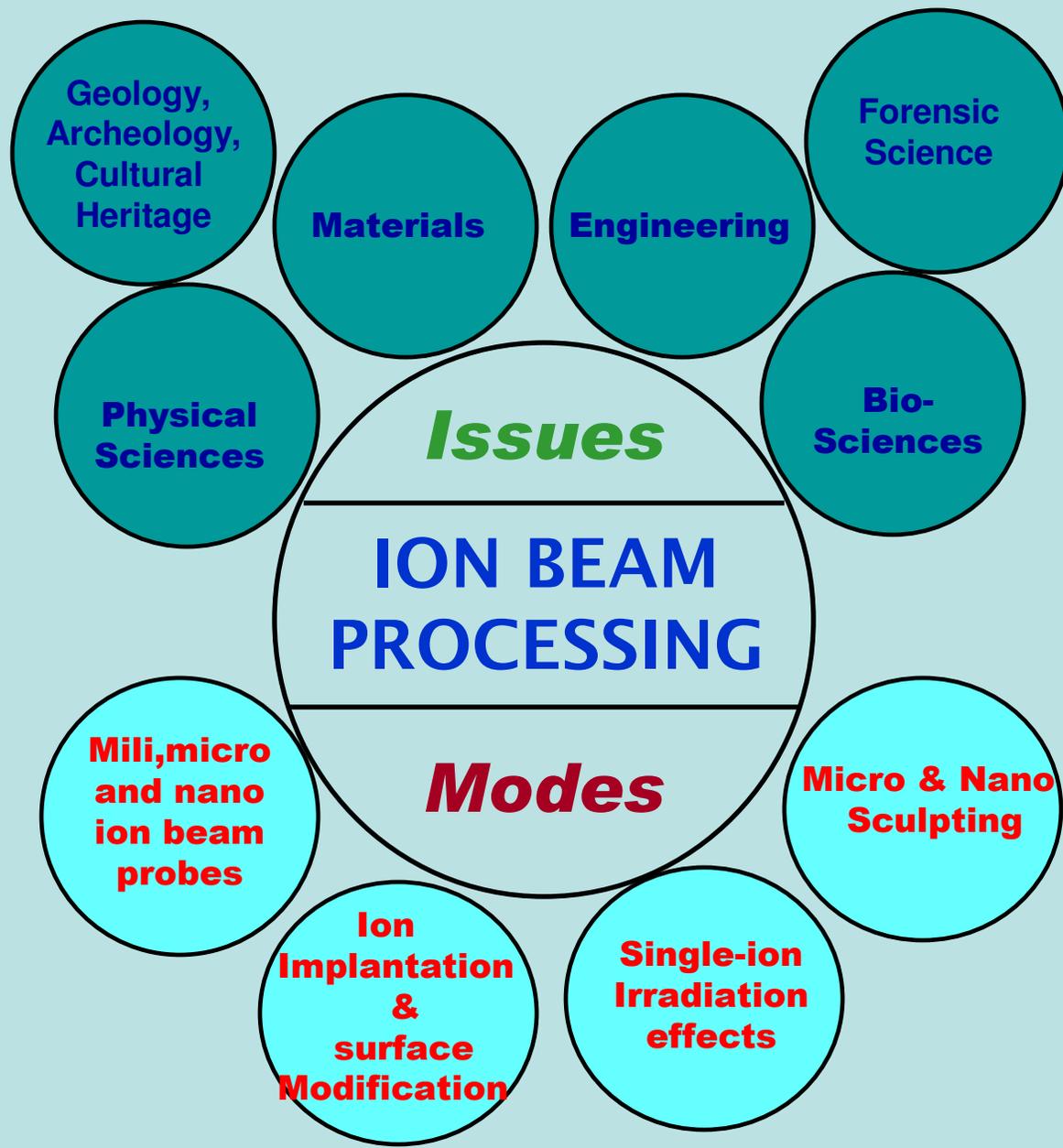
Decommissioned : 2006 (Sept)

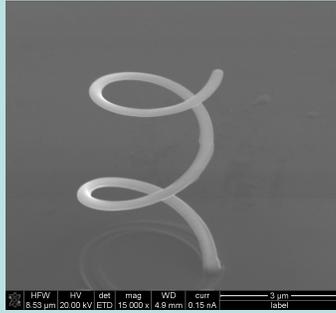
**Nuclear structure with low energy reactions**  
**P- wave neutron research**

**PIXE , RBS, Channeling, ERDA and  
Heavy Ion Irradiation Set up**

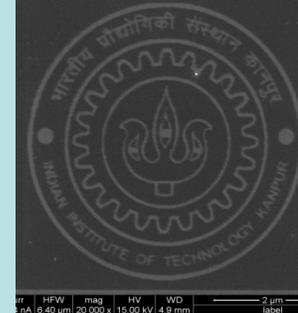
**Diffusion, Interface phenomena, ion mixing  
H and D in materials, Ion Beam induced Epitaxy  
Damage in Semiconductors, Materials  
Characterization**







•Deposition by cracking of molecules under Focused Ga ion Beam (FIB) impact e.g. nano fabrication  
 •Ion beam Lithography  
 •Multi Elemental FIB,



•Smart Cut Technology

•Scanning Ion Microscopy

Plasma Sputtering (DC sputtering) & Plasma nitridation by Ion Beams

•Nuclear Reaction Analysis  
 •Resonant Scattering

•Micro beam (Proton) beam writing and MICRO RBS /PIXE  
 •Ion Beam Induced Charge Microscopy

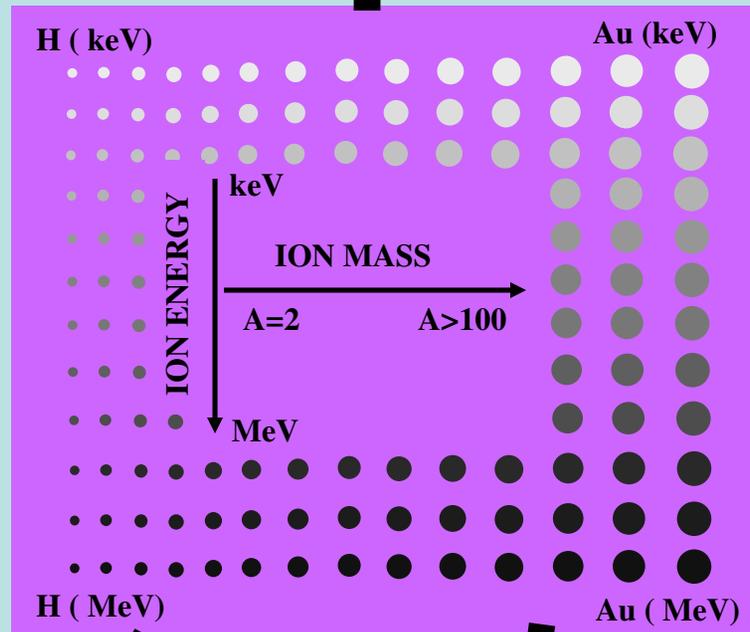
• Channeling  
 • Implantation

•Forward Scattering (Elastic Recoil)  
 •Heavy ion induced X-ray emission

•Coarse Sputtering by Broad Ion Beam  
 •Ion Beam Sculpting

•Ion Implantation  
 •Tribology  
 •Ion Beam Mixing  
 •Ion Beam Induced Epitaxy

•Radiation bystander effects (single ion irradiation effects in biological cells)



## *International Scenario*

Recently several laboratories across the world have started centers based on ion beams and accelerators to tackle issues in science and technology. Most prominent among these are i) Surrey Ion Beam Centre, UK, ii) Institute of Ion Beam Physics and Materials Research, Dresden, Germany, iii) Center for ION Beam Applications (CIBA) , NUS Singapore , iv) Ion Beam Centre for Quantum Computer Technology under Australian Research Council, and v) CHARPAN Project ( Charged Particle Nanotech ) under the co-ordination of IMS Nanofabrication Vienna, Austria. The proposed centre at IITK will operate along similar lines keeping in view the needs at national level. One of the advantages for the proposed centre at IITK is that, several researchers across the different science and engineering departments would like to explore and utilize the ion beam technology in their research program.

### *Mission Along this Direction*

To establish a Centre with state of the art systems providing ion beams for multidisciplinary research in exciting new areas in basic and applied sciences as well as engineering disciplines, developing prototypes of micro and nano devices using ion beams, and delivering methodologies to answer key issues in manufacturing at micro and nano-scale using ion beam based approach.

## *Tandetron – Characteristics*

**Terminal voltage:** 100 KV-1.7 MV (Generated by means of SF6 insulated Cockroft-Walton type solid state power supply).

**Voltage Stability:** 30V

**Terminal voltage ripple:** 25 Vpp.

**Ion Sources:** Duoplasmatron and Negative Sputter ion source.

**Currents ( after analyzing magnet):** H<sup>+</sup> : 25 μA; He<sup>+</sup> : 2 μA;

**Heavy Ions :** 10-50 μA

**Beam Brightness:** 3 A(rad)<sup>-2</sup>m<sup>-2</sup>eV<sup>-2</sup>

**Switching Magnet:** 9 ports (-45° to +45°), Mass Energy Product 175 amu-MeV

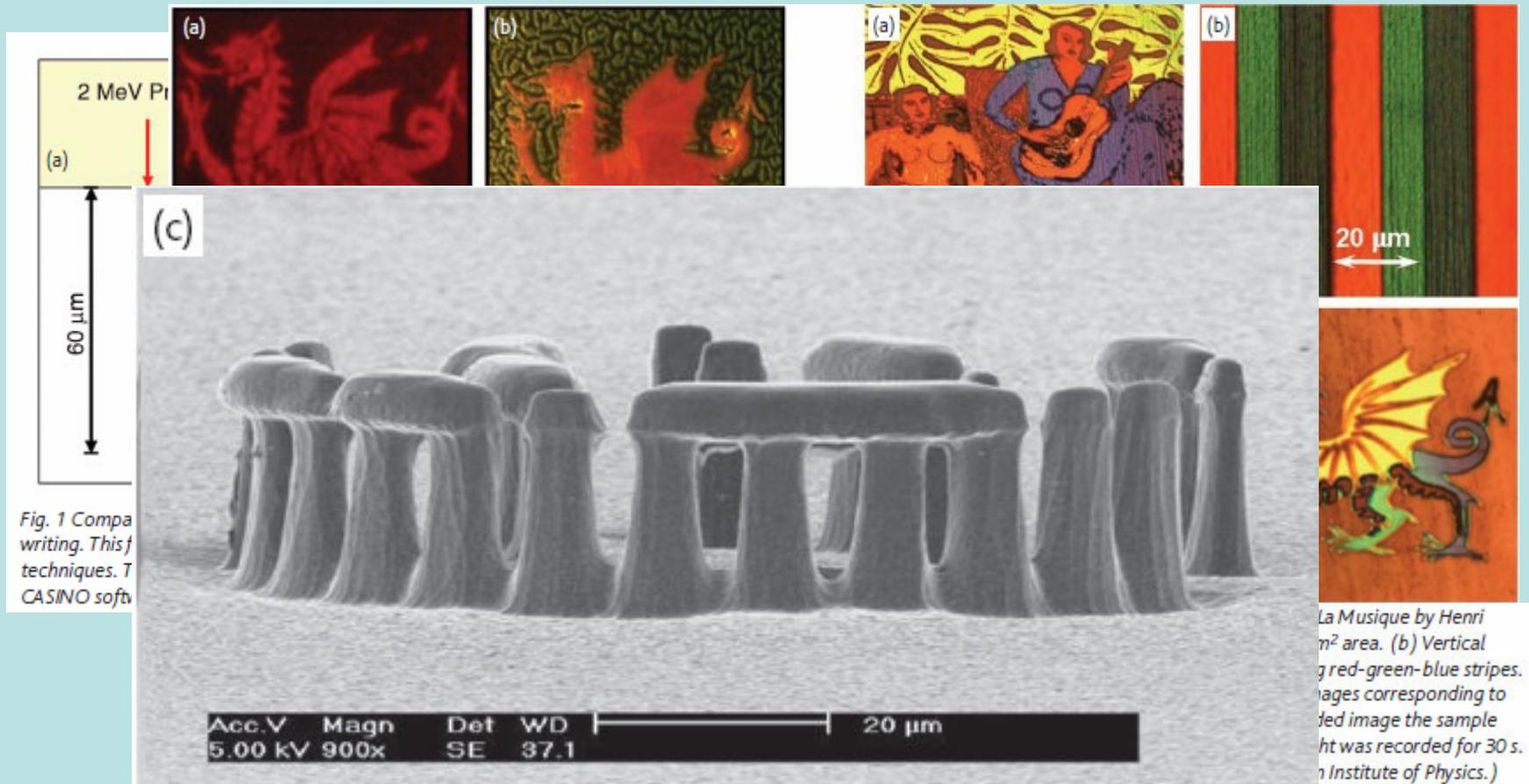
**90° Analyzing magnet ( for Microbeams):** 160 amu-MeV

**Micro Beam System:** Oxford Microbeams ( p beam size of < 500nm)



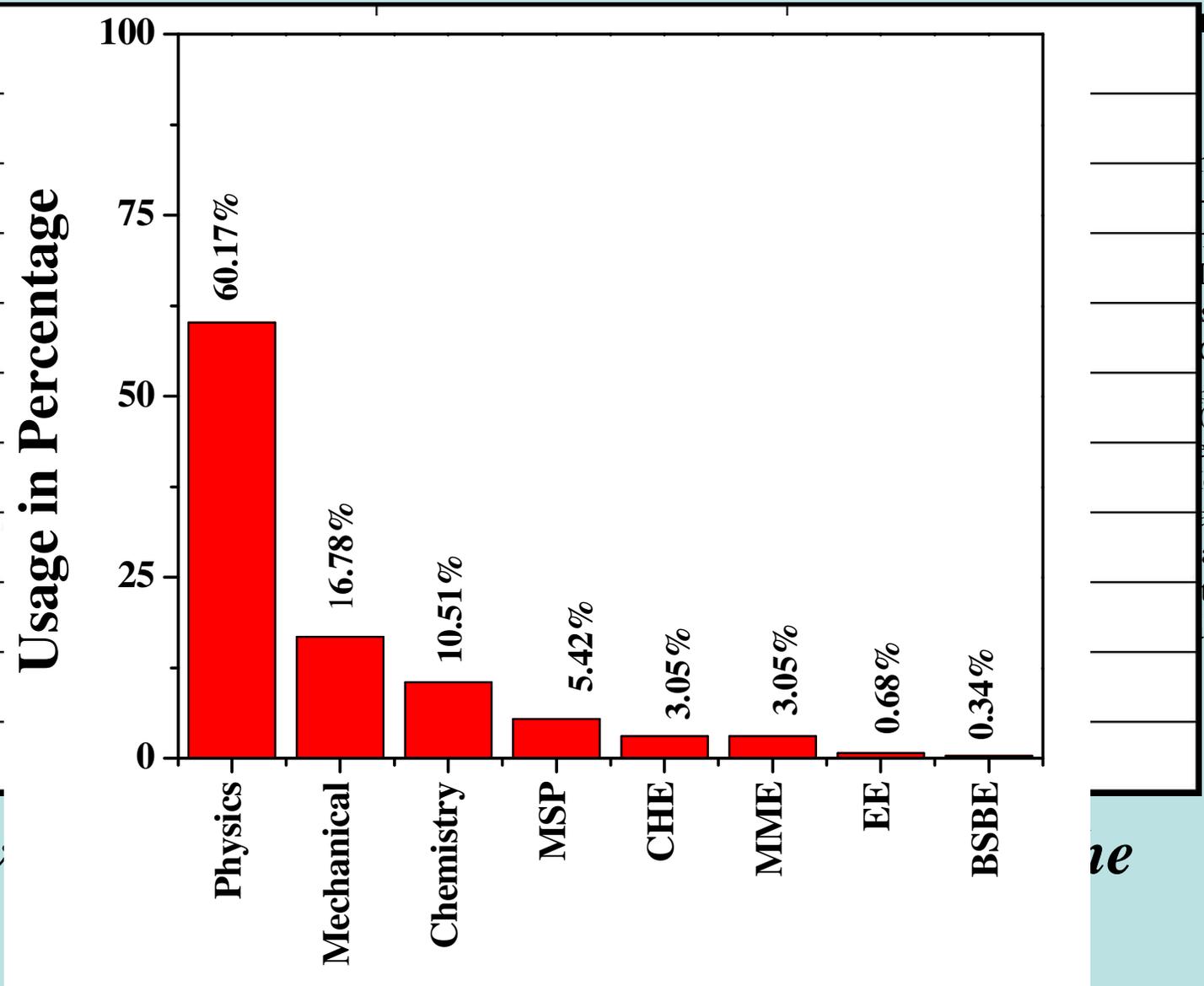
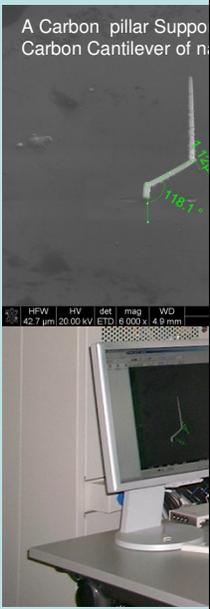
# Proton Beam Writing

Materials Today 10 (2007) 20



# FIB system @ IITK

DST funding  
Beam ( FIB) f

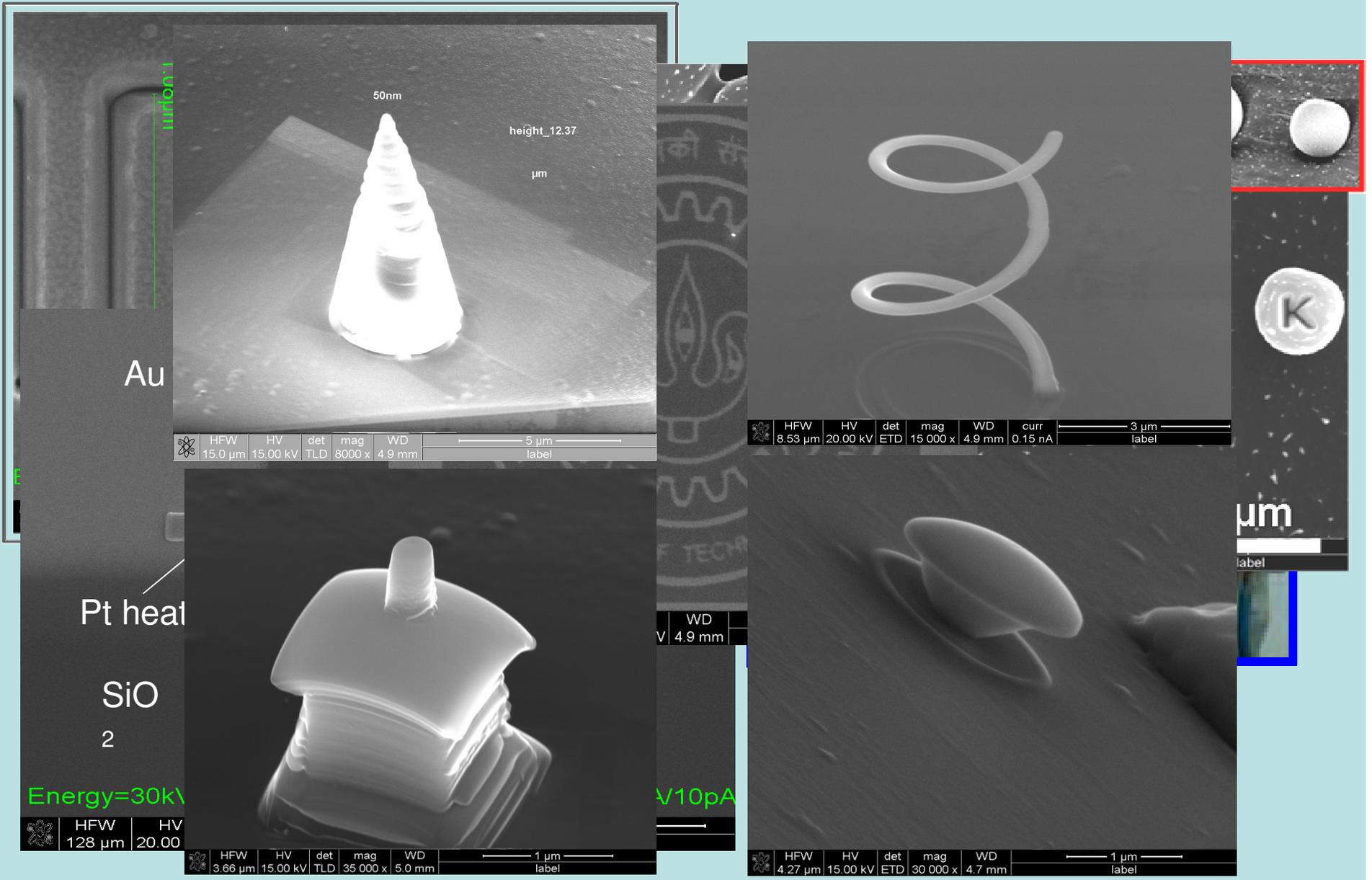


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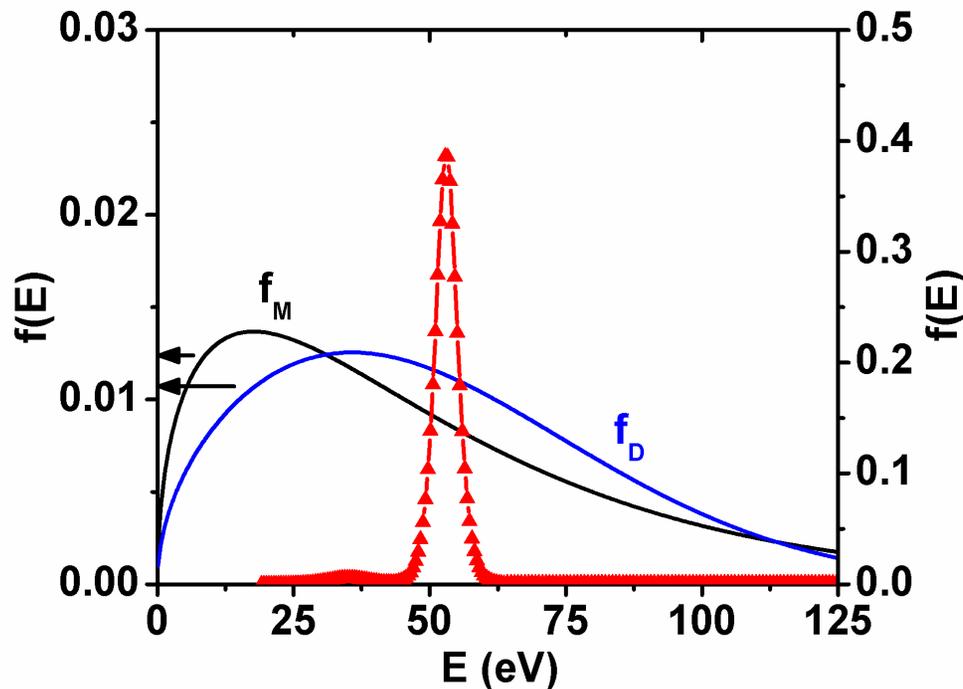
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+ FIB  
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# Works @ IITK

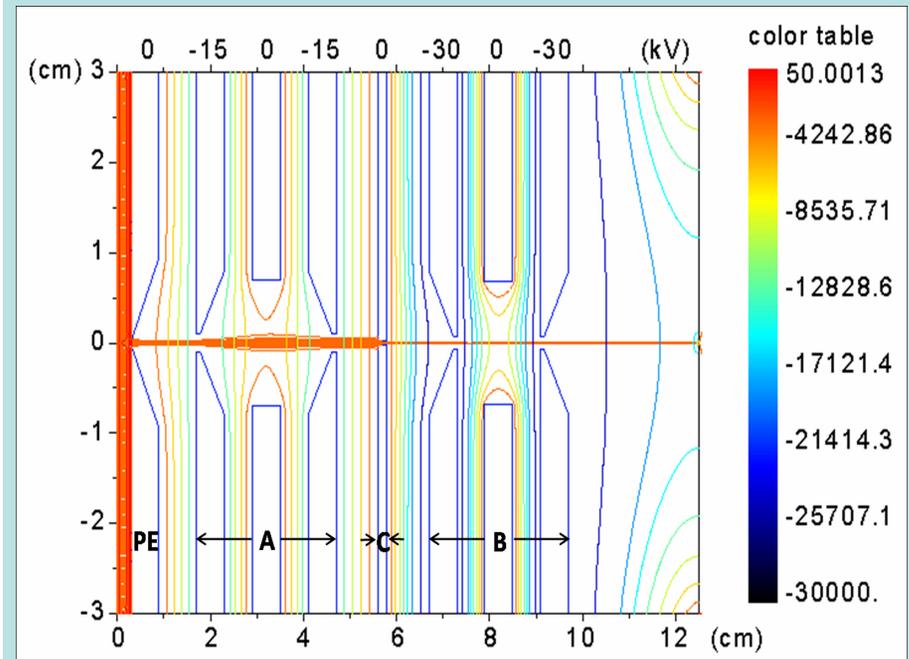




# Focused ion beam measurements and simulations



*Ion energy distribution  
in the plasma meniscus*



FIB: 1 – 10 A/cm<sup>2</sup>  
MEFIB: 10<sup>5</sup> – 10<sup>6</sup> A/cm<sup>2</sup>  
(~ 10 μA focused current)

## Publications:

- ✚ Jose V. Mathew and Sudeep Bhattacharjee, *Journal of Applied Physics (Communications)*, 105, 096101 (2009).
- ✚ Jose V. Mathew, Abhishek Chowdhury, and Sudeep Bhattacharjee, *Review of Scientific Instruments*, 79, 063504 (2008).
- ✚ Indranuj Dey, Jose V. Mathew, Sudeep Bhattacharjee and Sachin Jain, *Journal of Applied Physics*, 103, 083305 (2008).
- ✚ Jose V. Mathew, Indranuj Dey, Sudeep Bhattacharjee, *Applied Physics Letters*, 91, 041503 (2007)

## *Indigenously built ME-FIB @ IIT Kanpur*



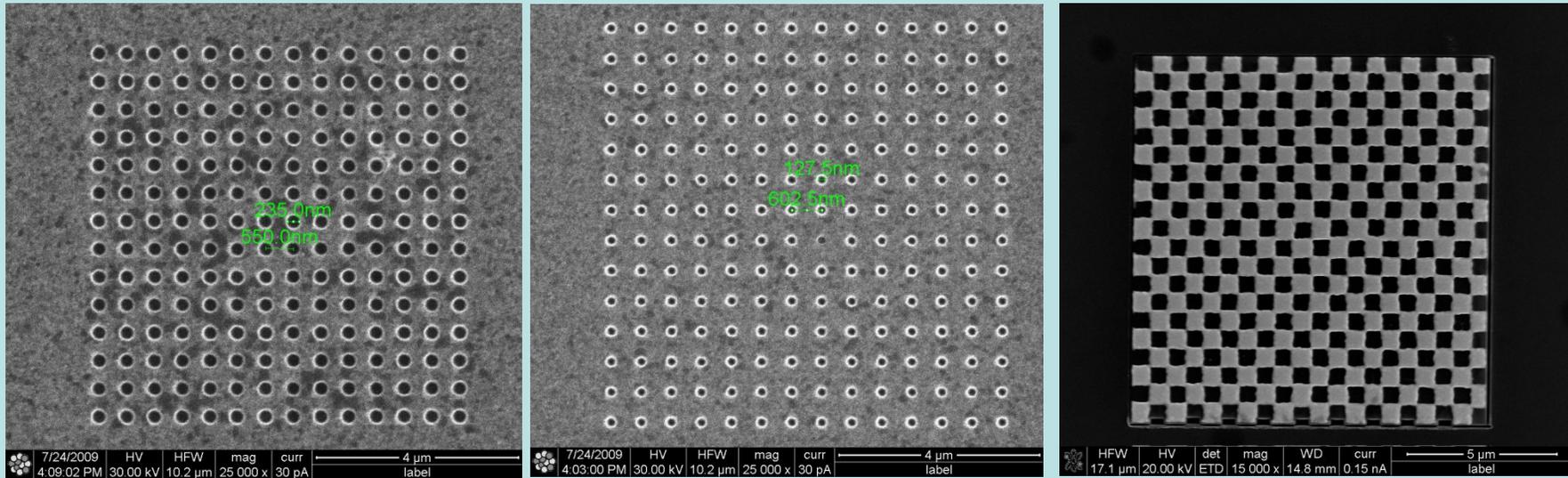
### **FUTURE WORKS:**

- Measurements and optimization of multielement focused ion beam currents and spot size
- Some initial experiments using multielement focused ion beams

### **Publications:**

- ✚ Indranuj Dey and Sudeep Bhattacharjee, *Physics of Plasmas*, 15, 123502 (2008).
- ✚ Sudeep Bhattacharjee and Samit Paul - under review (2009).

# *Plasmonic nanostructured metallic films*

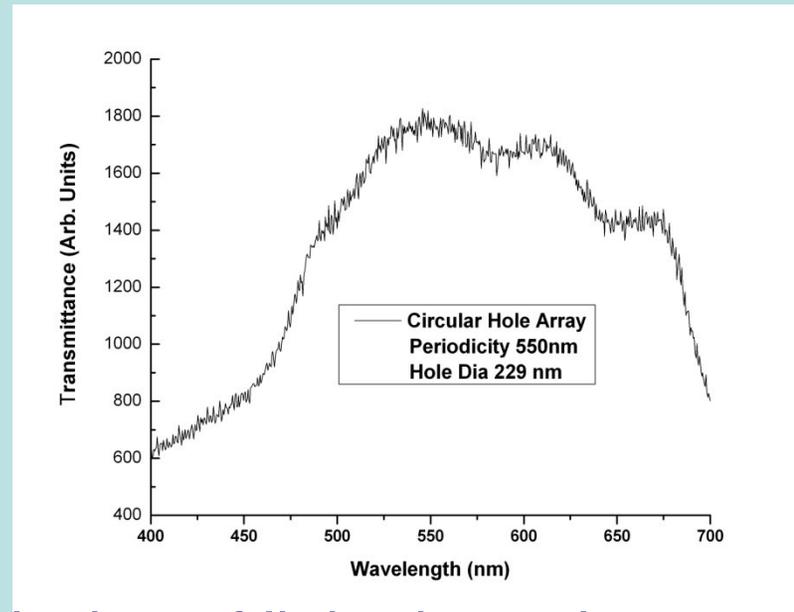
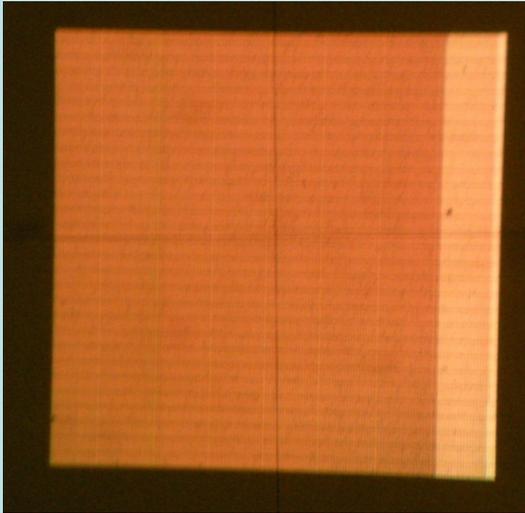


## **FIB milling of silver and gold (optically) thick films**

- Direct milling and ion-induced adhesion techniques
- Cutting of through holes on the metallic films

N. Shukla, S.A. Ramakrishna, S. Dhamodaran, V.N. Kulkarni

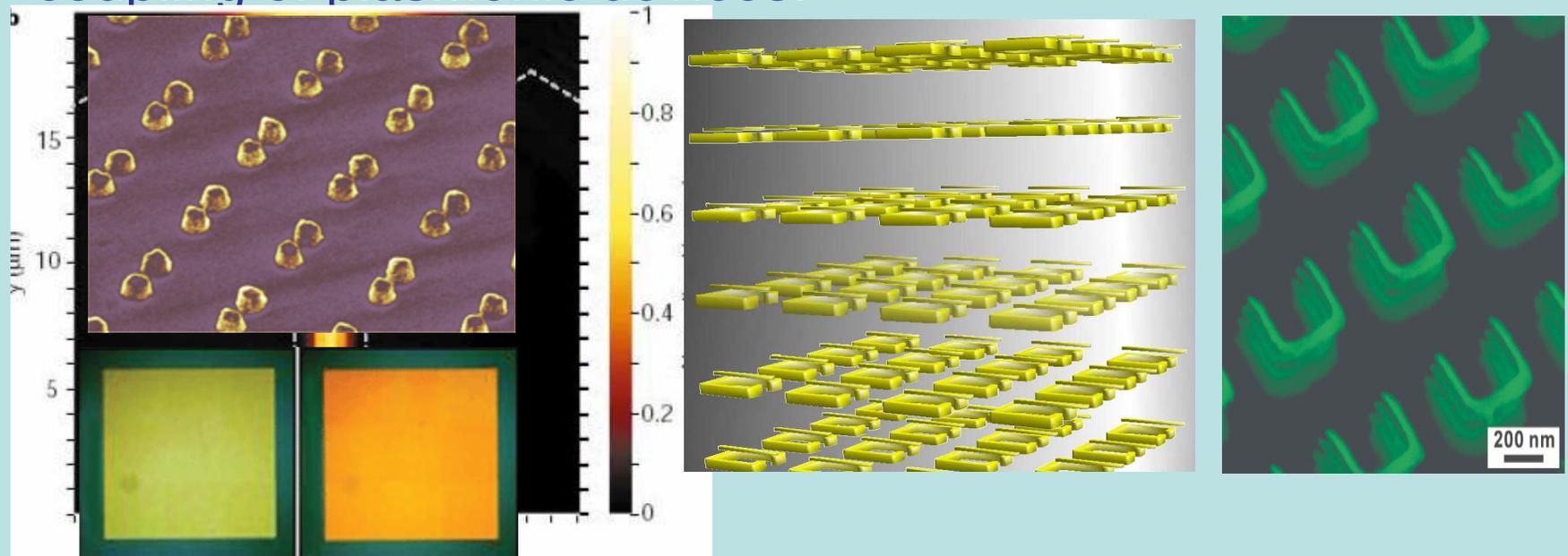
## *Optical properties of the plasmonic films*



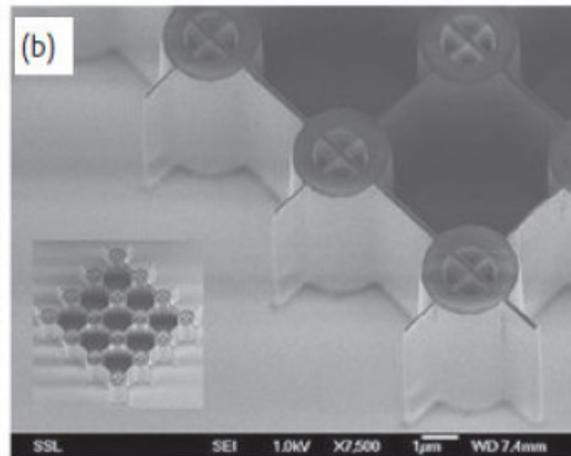
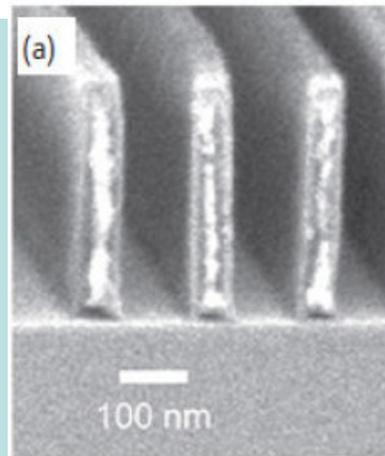
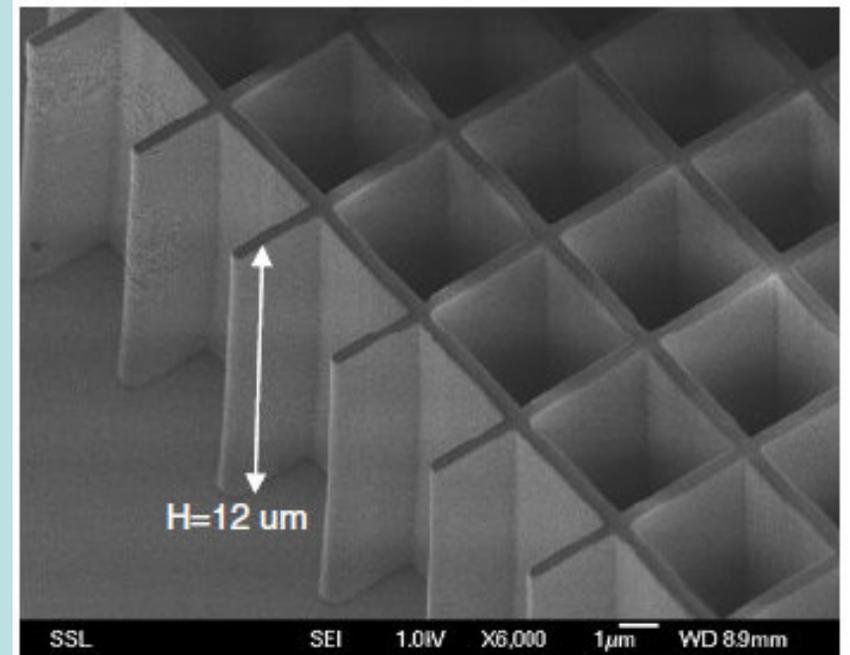
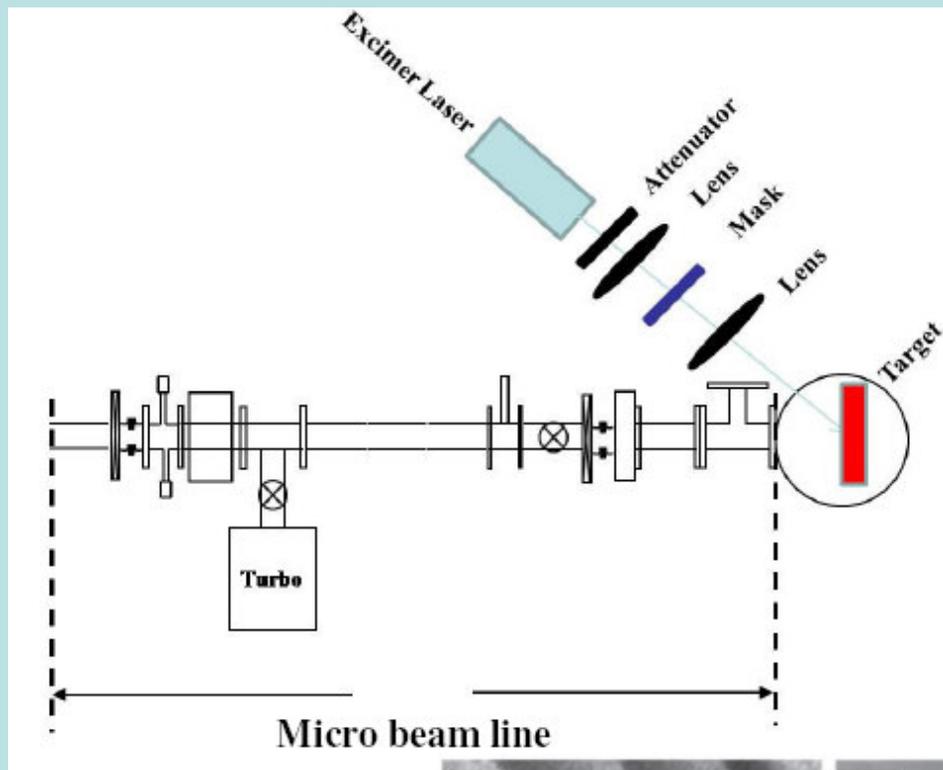
- Extra-ordinary transmission of light through arrays of nanoholes with a effective collection area of upto 32 times the hole sizes.
- Large far-field scattering from defects in checkerboard films
- Strong spectral modification of the transmitted / reflected light for use as spectral filters.

## *Optical properties of the plasmonic films*

- Plasmonic networks and plasmonic guidance: nanochannels, chains of nanoparticles, nano-antennae
- Surface plasmon amplification due to stimulated emission of radiation (SPASER): Gain media with nano-antennae
- Optical and near-infra-red nanostructured metamaterials
- Ion-beam irradiated photonic waveguides for integrated coupling of plasmonic devices.



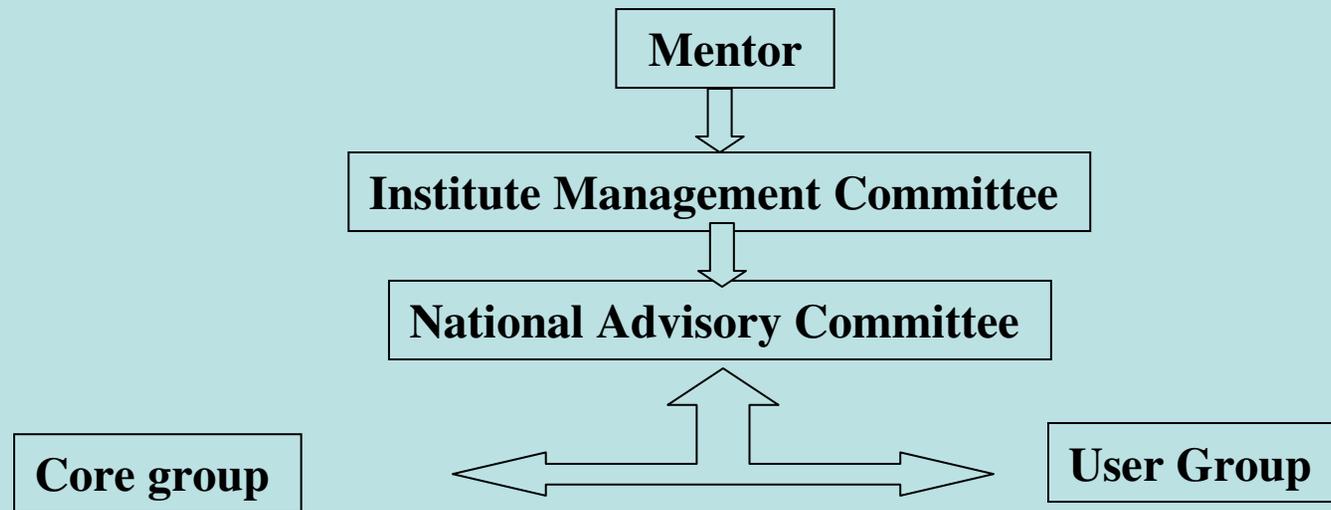
# *Excimer & Micro Beam Integration*



## *Benefits of Integration*

1. Micro Ion beam milling has a lower Material removal rate which will be enhanced by using excimer for course milling
2. Complex 3-D structure (few microns) can be made in single setting
3. Making 3D of single and multiple structure Application in Solar cell, Polymer
4. Micro Ion beam can be also used for online health monitoring of excimer lasing
5. Ion beam induced chemical vapor deposition of micro and nano components.
6. Cold fusion - is our dream

# Organizational Structure



- Core group**
1. Dr. V. N. Kulkarni
  2. Dr. H. C Verma
  3. Dr. S. Bhattacharjee
  4. Dr. S Dhamodaran
  5. Dr. J. Ramkumar
  6. Dr. S. A. Ramakrishna

1. Dr. Sandeep Verma
2. Dr. Anjan Gupta
3. Dr. Bikramjith Basu
4. Dr. S. C. Agarwal
5. Dr. Ashish. Garg
6. Dr. Ashutosh Sharma
7. Dr. P K Dwivedi
8. Dr. Satyajit Banerjee
9. Dr. Jitendra Kumar
10. Dr. Amitabha Gosh
11. Dr. P. K. Panigrahi

12. Dr. R. C. Budhani
13. Dr. S. Manoharan
14. Dr. Kamal Kar
15. Dr. V. Chandrasekar
16. Dr. S Sangal
17. Dr. K. P. Rajeev
18. Dr. S. Bhattacharya
19. Dr. D. Katti
20. Dr. Utpal Das
21. Dr. Asima Pradan
22. Dr. V. K. Jain
23. Mrs. A. Kulkarni

## *Methodologies*

- Create an interactive environment for interdisciplinary research and focus on application oriented programmes involving energetic ions, to deliver viable technological solutions and methodologies in the manufacturing of modern and futuristic macro, micro and nano devices and components for variety of applications.
- Attract young new faculty to the Institute who would take up challenging new problems in basic and applied sciences, augment existing facilities and create novel types of ion beams for futuristic technologies.
- Establish links with other research groups in India for active collaborative efforts in focused areas.
- Have synergy with National projects to develop required micro and nano-scale devices using ion beam technology for specialized applications.

## *Objectives and Deliverables*

- Enhance experimental knowledge of ion matter interaction for augmenting present technological applications.
- Develop new ion beam based technologies and applications.
- Fabrication of Prototypes of nano Sensors, photonic and electronic devices and MEMS and NEMS using focused keV and MeV ion beams.
- Fabrication of special sensors/components needed for space and energy research.
- Provide nano patterns for crucial scientific and technological studies to researchers in India.
- Extend state of the art ion beam analysis facilities to the researchers in India to enhance the understanding of the new materials and fabrication processes.
- Generate manpower who can handle modern and state of the art equipment and are trained to take up challenges to find technological solutions.
- Provide training to students and researchers in Universities/Institutes.

# Requirements

## Staff

Scientific Officer/Research Engineer:2  
 Technical Staff for support :5  
 (Present strength 3, one person  
 retiring in Feb 2010)  
 Operation & Maintenance Engineer :1

**Total Staff needed : 8**

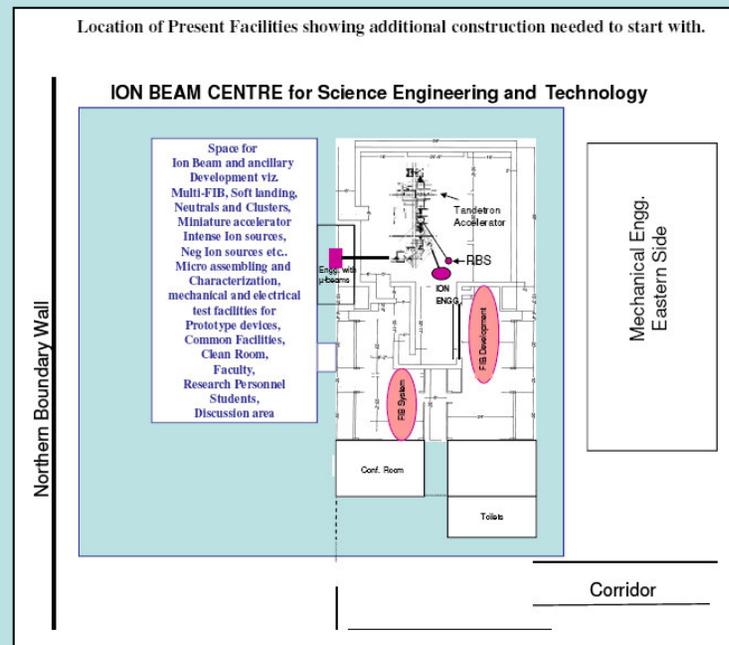
## Space

MEFIB : 2500 Sq. Ft  
 Nano-photonics : 1000 Sq. Ft  
 Micro-machining : 1000 Sq. Ft  
 Common equipment : 500 Sq. Ft

**Total space required : 5000 Sq. Ft**

## Finances

**Should be suffice to run to  
 Operate the facilities smoothly.  
 With budget provision for cons.  
 Nonconsu. and travel.  
 ( total of ~20 lakh)**



*Thanks*