

**Electrical properties of ultrathin
nanocrystalline gold films
formed at the organic-aqueous interface**

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**Nanoscience
Initiative, DST**

Ved Varun Agrawal

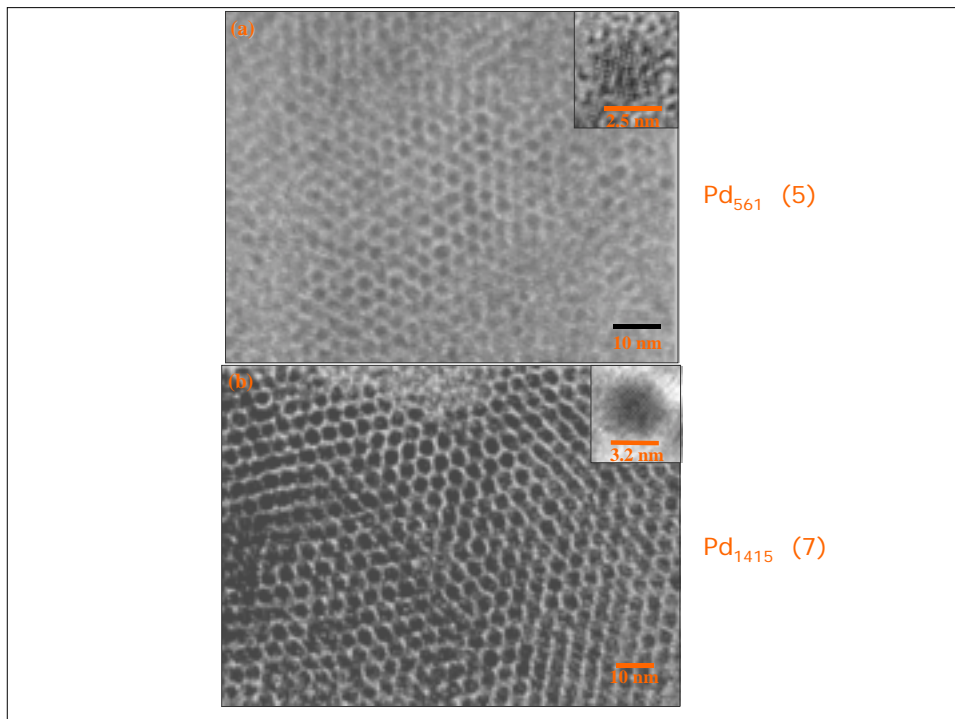
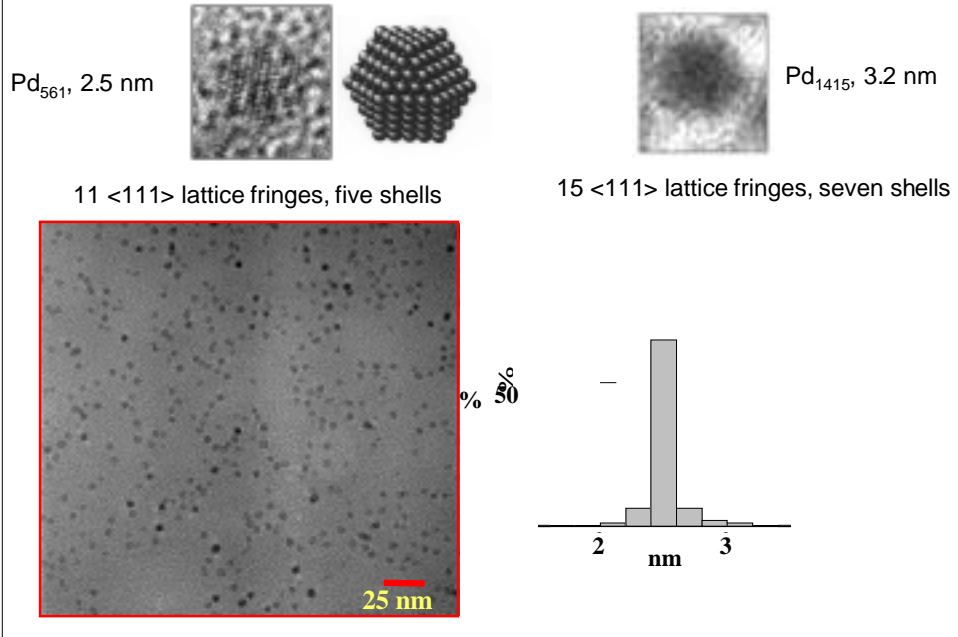
**S.J. Neena
T. Vijayakumar**

Prof. C.N.R. Rao, F.R.S.

Indo-US meeting, Aug.11-13, 2004

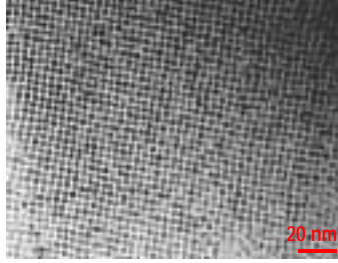


PVP coated Pd nanocrystals

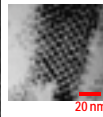


Pd₅₆₁Ni_n core-shell particles

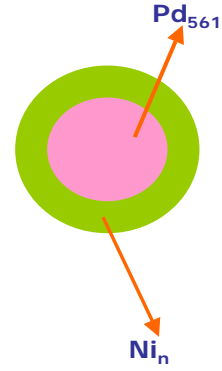
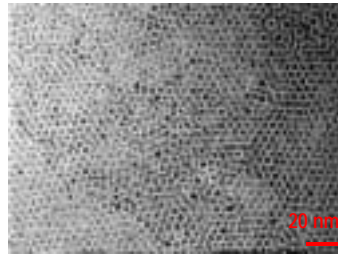
n=561



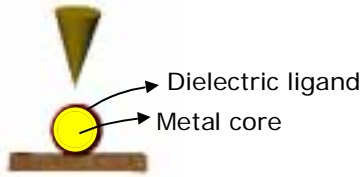
n=3000



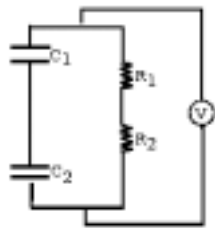
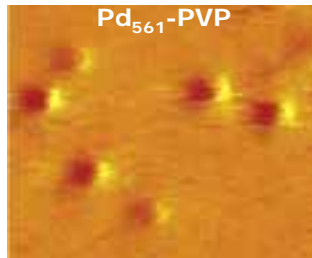
n=1500



Ambient STS: Coulomb staircase



Single electron charging (air, RT)

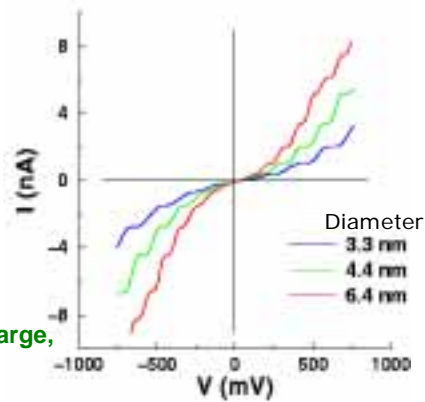


Jumps occur at Voltages,

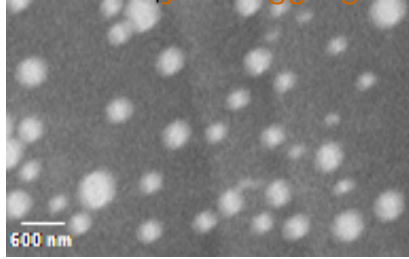
$$V_c = (1/C) \{n_c e + q_0 + e/2\}$$

Where q₀ is the residual charge,

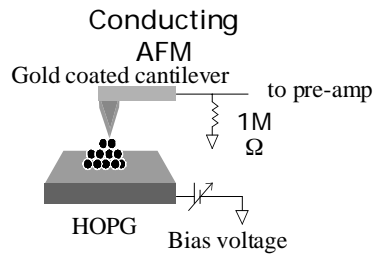
$$C_1 \ll C_2 \text{ and } R_1 \ll R_2$$



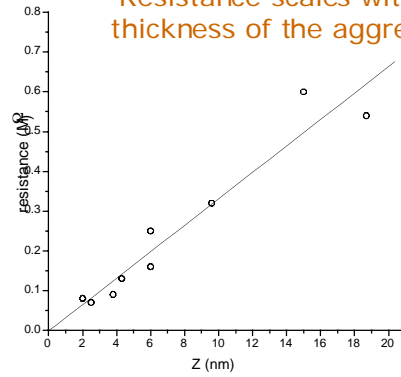
Pd nanocrystal aggregates



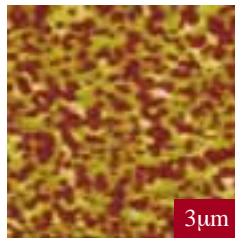
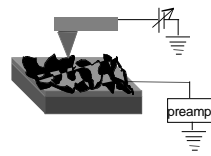
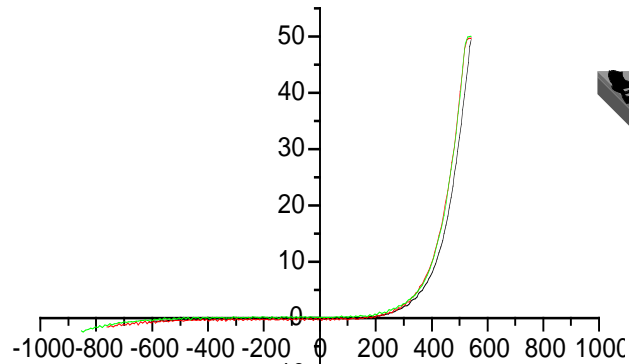
Collective properties



Resistance scales with the thickness of the aggregate!



Metal-non metal bilayers (JPC B, 2004)

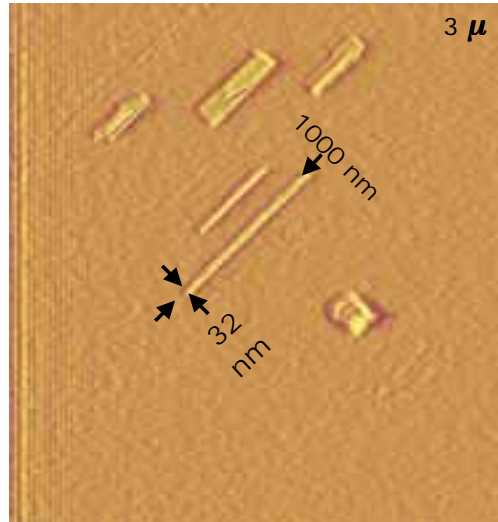
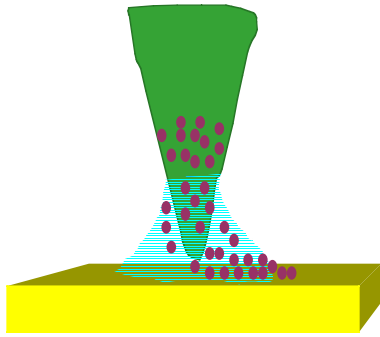


Si/GdSt/Au(3.5 mN/m)

With Prof. M. Sanyal, SINP

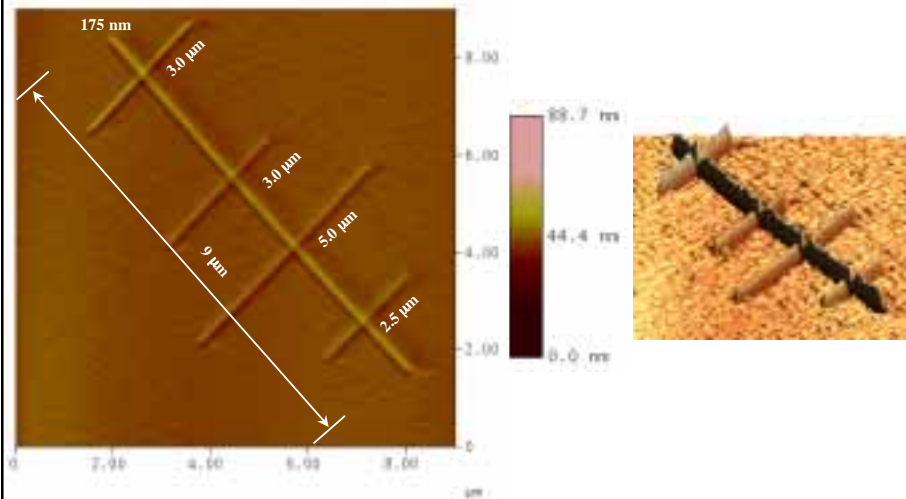
Dip-pen lithography using Gold hydrosol

AFM Cantilever tip as a pen



Dip-pen lithography

$\gamma\text{-Fe}_2\text{O}_3$ sol on Mica



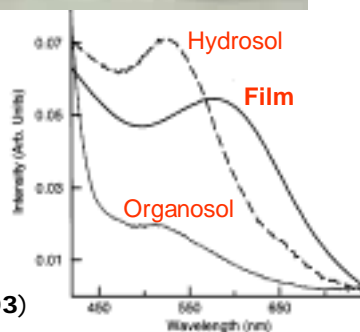
References

- G.U. Kulkarni, P. John Thomas and C.N.R. Rao, "Mesoscopic Assembly and other properties of metal and semiconductor nanocrystals", in *Recent Advances in the Chemistry of Nanomaterials* (Eds. C.N.R. Rao, A. Mueller and A.K. Cheetham), **2004**.
- G.U. Kulkarni, P. John Thomas and C.N.R. Rao, Mesoscopic organizations of metal nanocrystals, *Encyclopedia of Nanoscience and Nanotechnology* (Ed. H.S. Nalwa), American Scientific Publishers, Los Angeles (**2004**), Vol. 5, pp.277-289.
- C. N. R. Rao, G. U. Kulkarni, P. John Thomas, P. P. Edwards, "Size-dependent Chemistry: Properties of nanoparticles", *Chemistry: An European Journal* **8**, **2002**, 28.

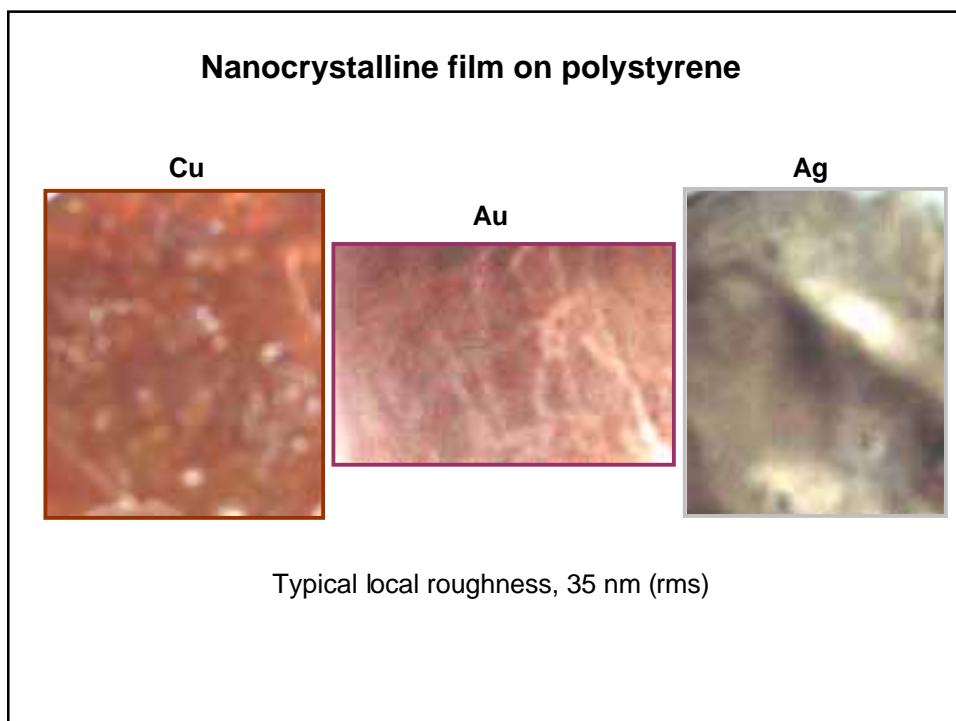
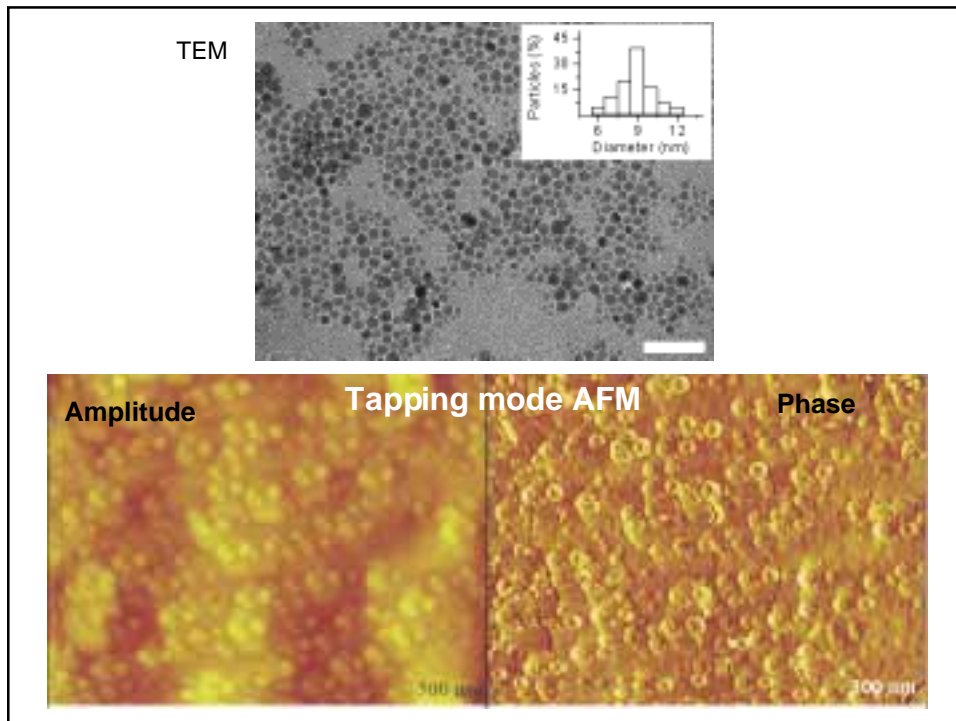
Nanocrystalline film at liquid-liquid interface



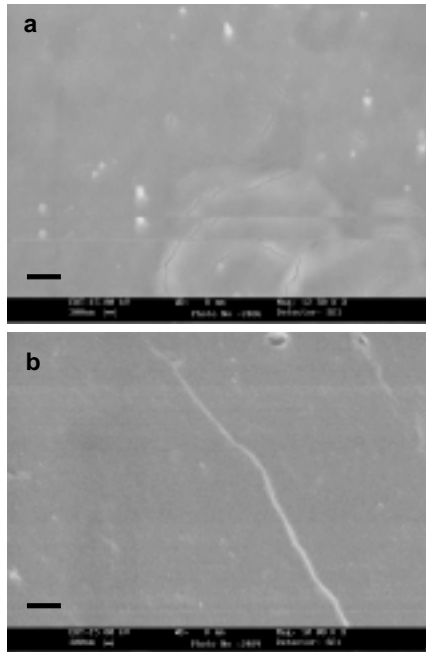
One step process
(Synthesis + Organization)



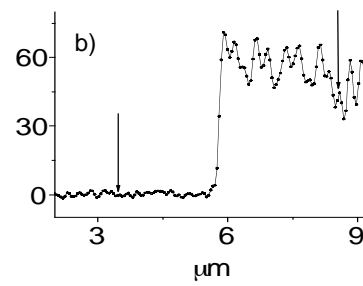
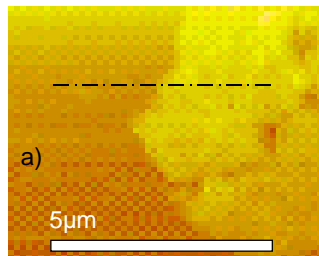
J. Phys. Chem. B **107**, 7391-7395 (**2003**)



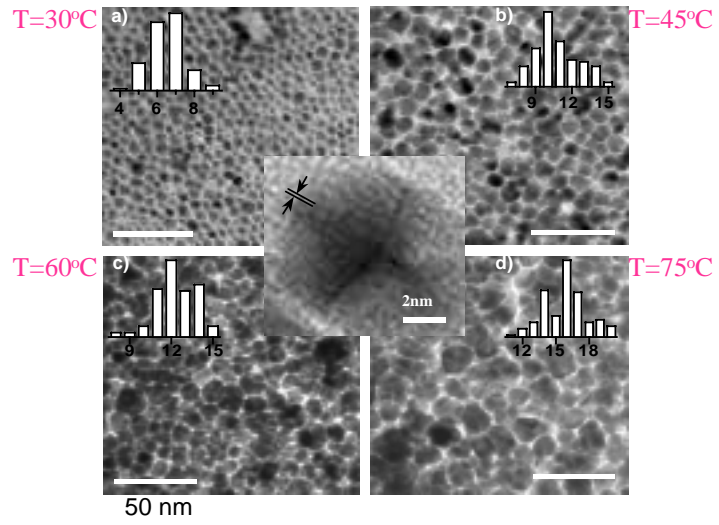
SEM



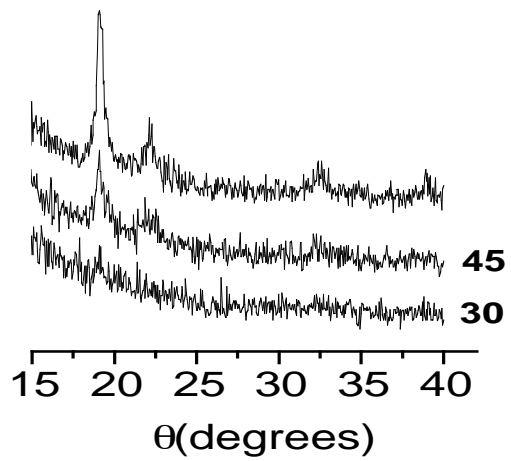
AFM

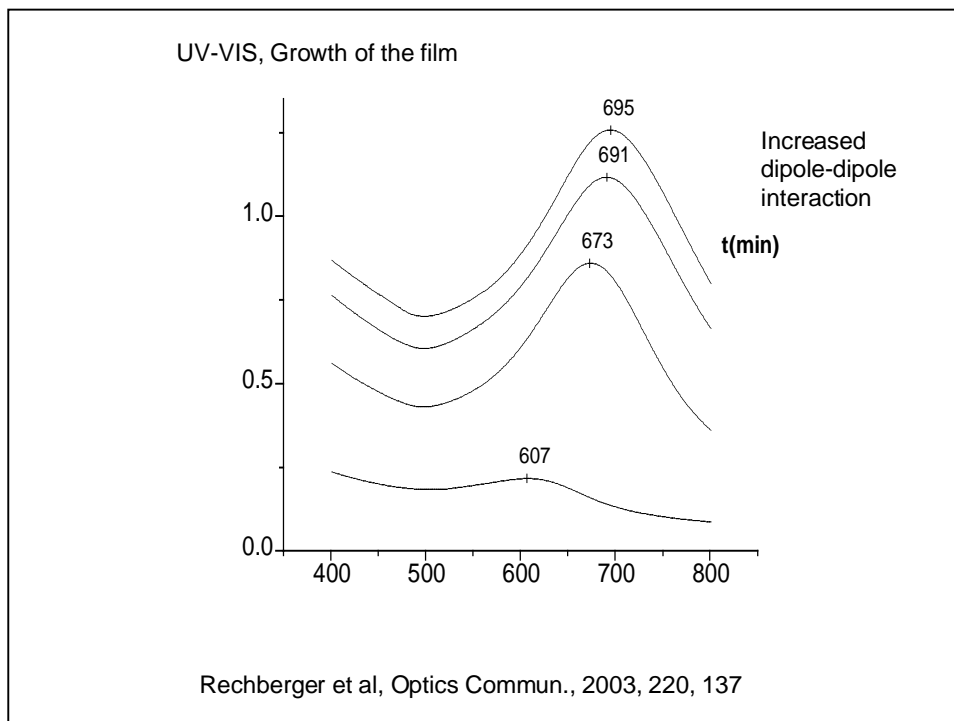
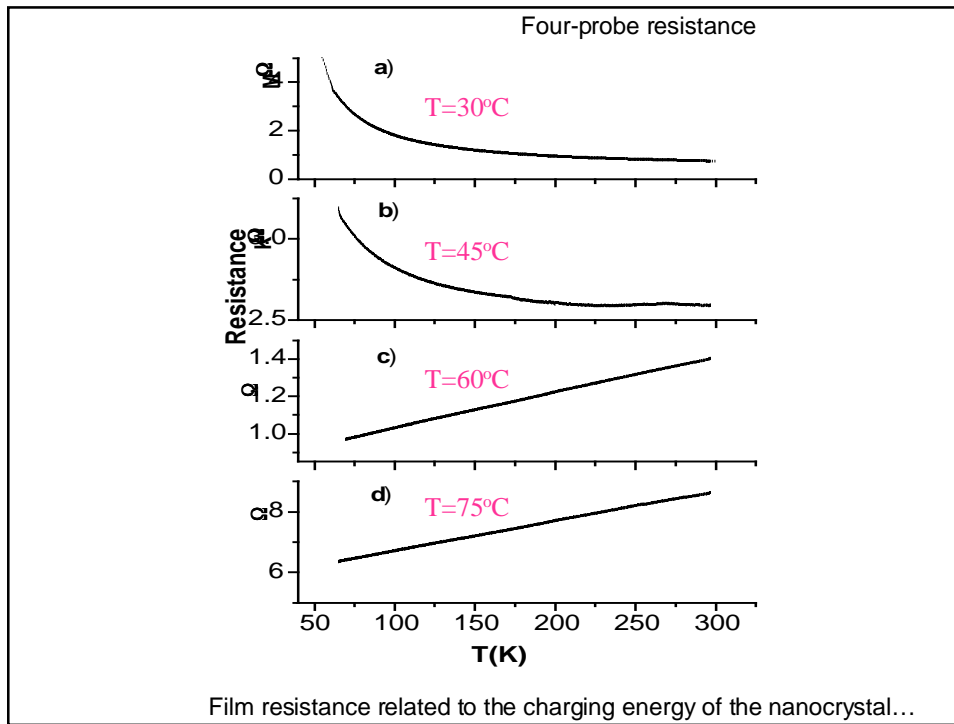


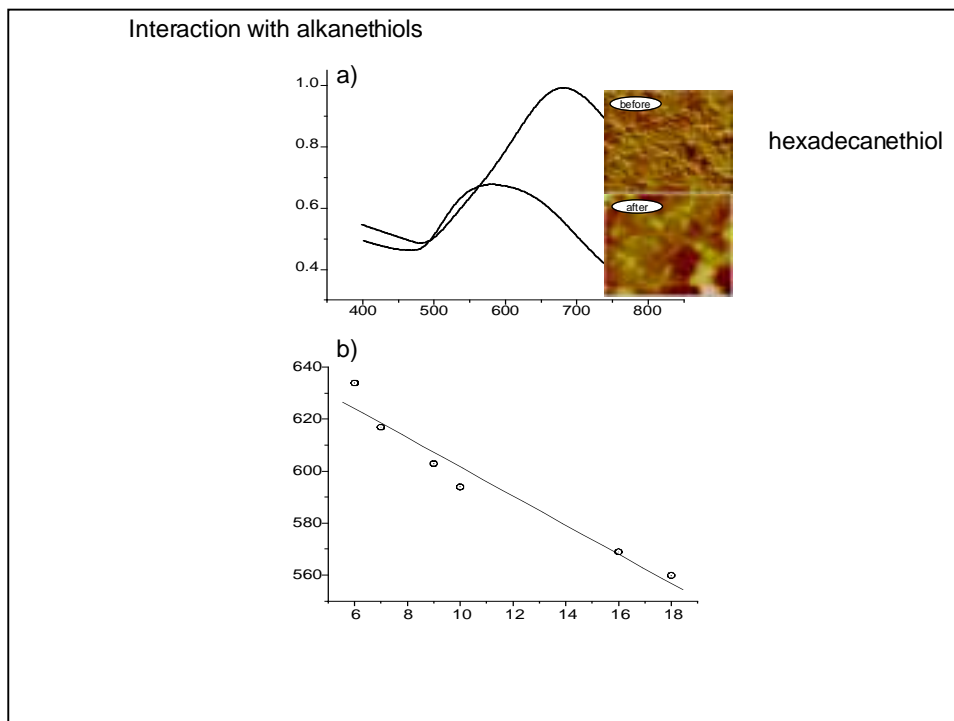
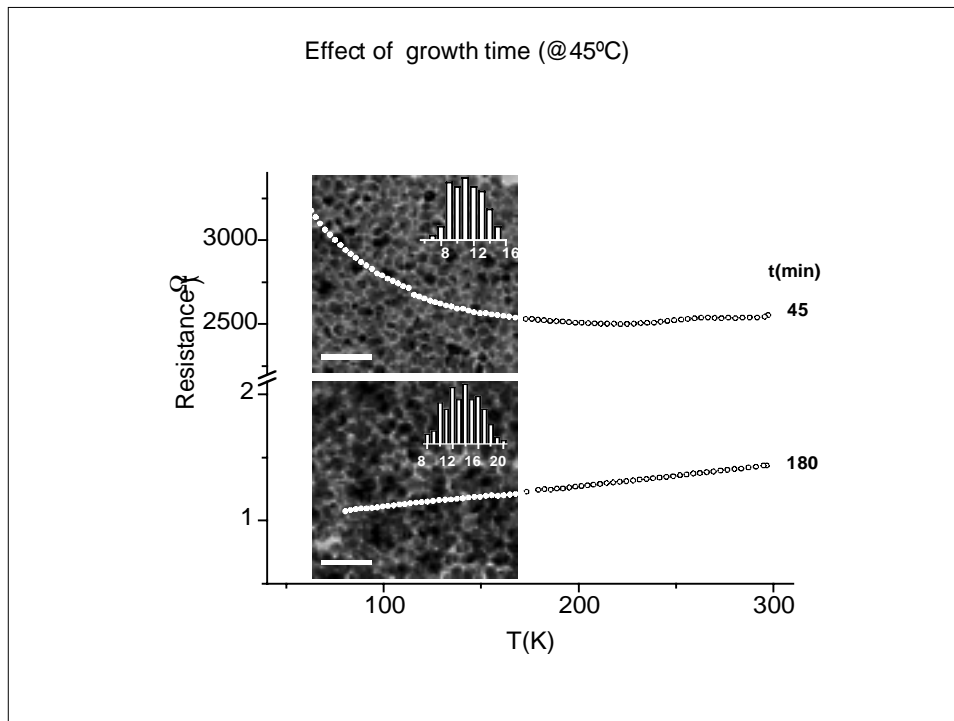
Gold film at water/toluene interface

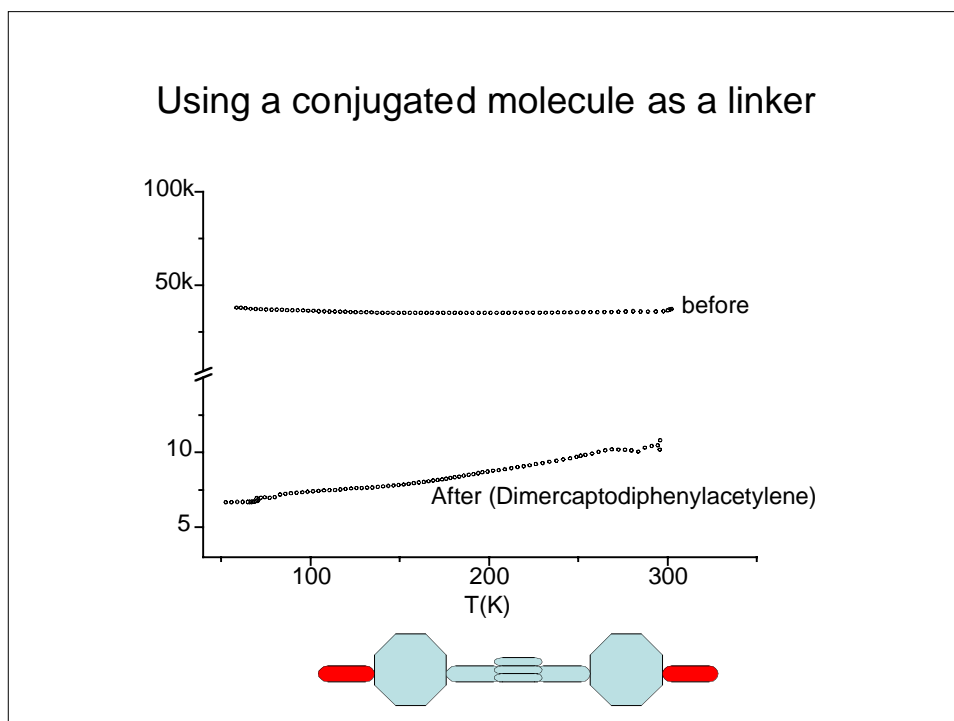
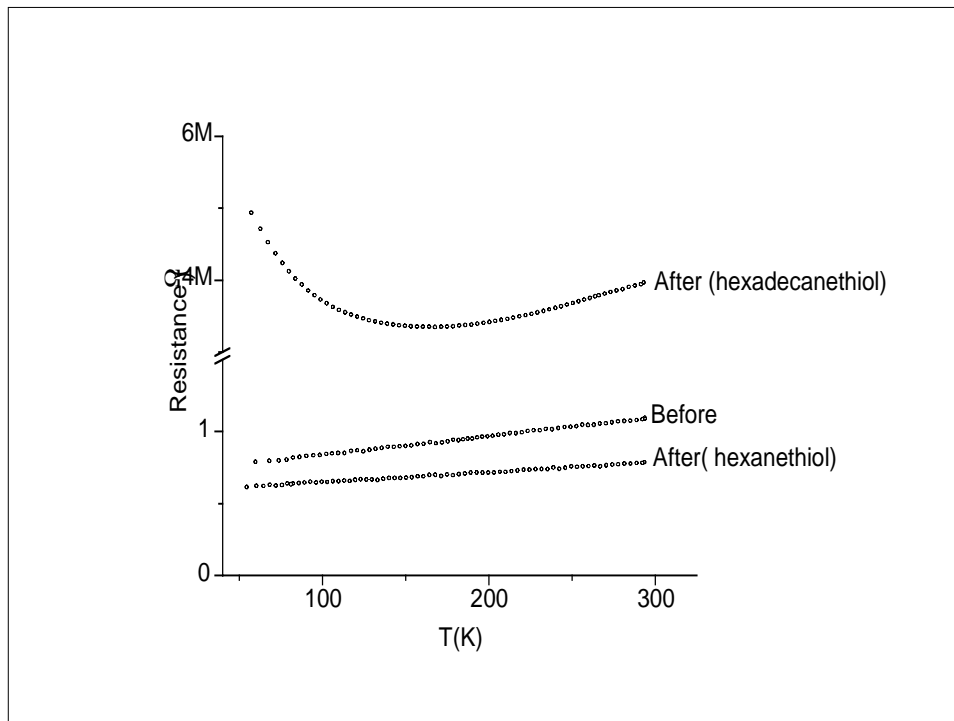


XRD









Unit on Nanoscience and Technology (UNANST-DST)

@

**Jawaharlal Nehru Centre for
Advanced Scientific Research**

Bangalore

...activities to begin with the new year...

List of projects

Developing new strategies for the synthesis and purification of nanowires and nanotubes; multiwalled and single walled carbon nanotubes, junction nanotubes, nanowires and nanotubes of transition metal oxides, nitrides, carbides and chalcogenides, new precursor routes to metal and semiconductor elemental nanowires, aligned nanotubes

Synthesis of metal and semiconductor nanocrystals in colloidal sols as well as at liquid-liquid interfaces, ligand shell modification, core-shell nanocrystals, magic nuclearity nanocrystals, mesoscalar assemblies

Thin films of novel functional oxides, transition metal oxides of interest in high T_c superconductivity, giant magnetoresistance and spintronics, synthesis using RF magnetron sputtering

Characterization of nanoobjects using electron and scanning probe microscopy techniques, UV-Vis spectroscopy, X-ray photoelectron spectroscopy

Characterization of nanomaterials using high-resolution powder X-ray diffraction, RDF from Rietveld analysis, Reflectivity studies on films

Electrical and magnetic properties of the oxide films as well as on nanocrystalline metal and semiconductor films

Direct measurement of electrical properties of nanowires and nanotubes coupled to nanoelectrodes drawn using e-beam lithography, Nanocrystals anchored to conducting organic molecules
Theoretical calculations of conductance, capacitance and current as a function of the external bias, temperature and magnetic field, Effect of the dimensionality and the geometry of the contacts, modeling advanced materials showing rectification and those of interest in spintronics.

Basics in Nanoscience

1. Not all atomic or molecular systems are Nanosystems!

This should provide essential definitions and create a foundation

2. For matter, size matters

How length scale becomes an important parameter. Illustrate with few examples. How conventional band picture or molecular orbital picture fails. Fate of the fermi surface. Chemical potential is not a good player too. Size-dependent properties (electric, magnetic, optical, chemical)

3. ...Don't use a sledgehammer to crack walnut!

The dumb says 'Can't help it'.

How coupling becomes as important. How it can influence transport properties.

4. Harmony in a little community

Coherence effects, Lasing in nanosystems....

5. Seeing is believing

Quantum corral (particle in a box), twisting a nanotube changes conductivity, many more SPM based observations...

6. An acid test for thermodynamics

???

7. Much more than gadgets

Routine application ideas (chips, sensors etc), nano in nature/biology, Future directions...

THANK YOU