RECENT RESEARCH ACTIVITIES

General area of research: Experimental Condensed Matter Physics, Materials Physics and Nanosciences

Current areas of interest :

a) Nanoscience and nanotechnology particularly fabrication of single nanowires devices using nanolithography tools and physical experiments on single nanowires.

b) Physics of correlated transition metal oxides particularly perovskite oxides including electrical, magnetotransport and magnetic properties (like manganites that show colossal magnetoresistance) .

c) Opto-electronic properties of wide band gap semiconductor like ZnO and applications.

Some of the past areas worked on:

a) Low energy excitation in glasses and physics of glassy state.

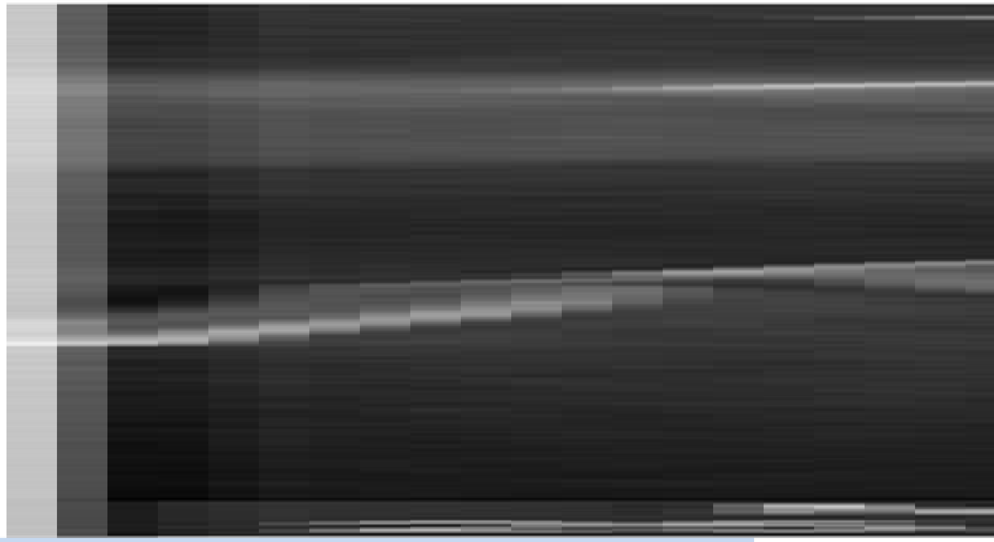
b) High temperature superconductor.

c) Metal insulator transition in oxides.

Present research problems that will be pursued by AKR group in next 5 years:

a) Physics of size reduction:

In recent years the group focused on the general areas of nanoscience and nanotechnology, particularly on measurements of single nanowires.



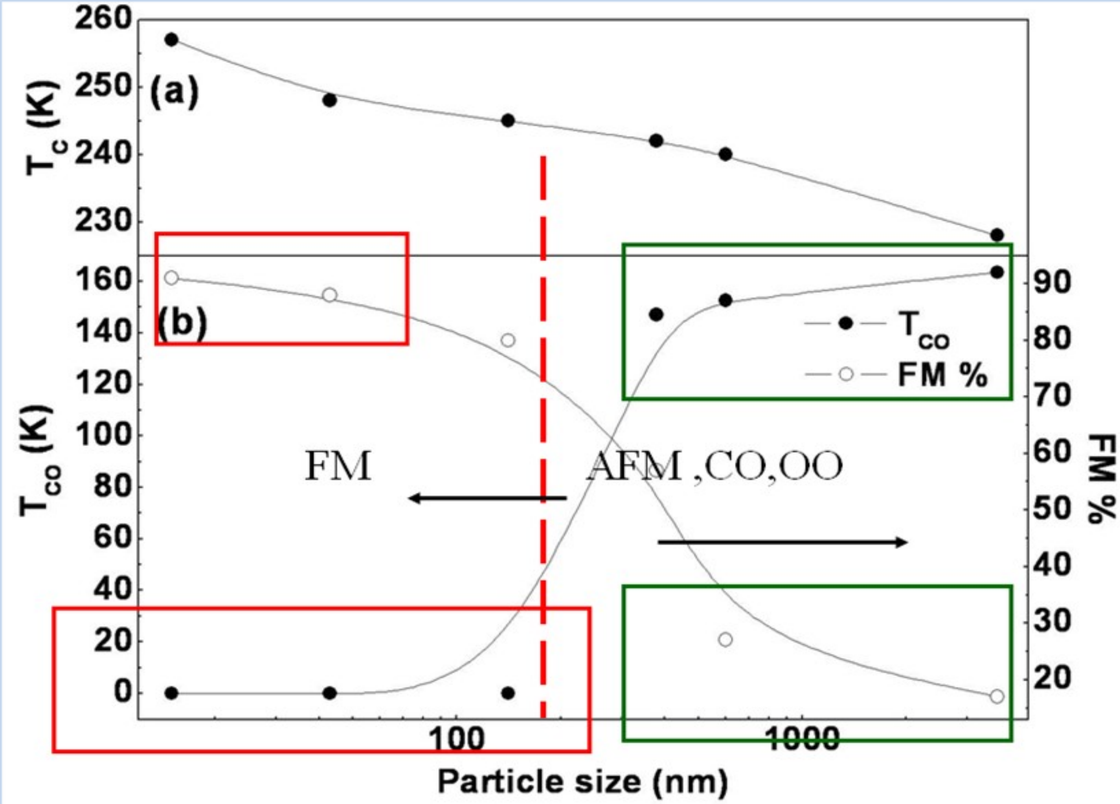
A specific problem of size reduction is that it can affect cohesive energy and related properties like mechanical properties, melting point, Debye temperatures etc . Our investigation is directed to understanding of how the basic thermodynamic properties get affected by size reduction.

“Engineering” properties of nanomaterials in a predetermined and controlled manner would need an understanding of ionic diffusion as well as creation and diffusion of defects. AKR group is trying to understand some of the basic issues involved in this

process through controlled experiments on lithographically fabricated nanostructures.

Size reduction , in complex systems, can tune their ground state. In complex oxide nanowires and nanoparticles this can lead to very different transport and magnetic properties as compared to the bulk. Understanding the evolution of different electronic and magnetic phases and their dependence on the structure can be utilized to design the physical properties of nanomaterials using size as the control parameter.

Destabilization of charge order and evolution of Ferromagnetism with size in half-doped $LaCaMnO_3$ system



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Size reduction as in nanowires can also affect the noise and and fluctuations significantly as the smaller size of the nanowires make them more prone to fluctuations. These noise can come form structural origin, electronic origin and also from spins which in nanowires are aligned by shape anisotropy but are *prone to creation of domain walls by thermal fluctuations.*

<u>Single nanowires devices as ultra-sensitive detector of charge and radiation:</u>

Very recent work by the group has shown that certain types of nanowires when configured as a single nanowires device can act as ultra-sensitive detectors of photons which may open the path for single photon detection. The group is now trying to develop this type and reach sensitivity of single photon detector. A related , although not the same problem, is development of ultra-sensitive charge detectors. The group would like to embark on this challenging problem

<u>Physics of correlated oxides:</u>

AKR group has been working on correlated oxides like transition metal oxides for some time. In recent years it has investigated current driven resistance state transition in such oxides. In such materials , when the doping level is low it shows an insulating state that is ferromagnetic in character. The recent work in the group has investigated the onset of metallic state in such ferromagnetic insulators on application of hydrostatic pressure. The AKR group is also investigating the "glassy electronic" state in such materials that freeze out the charge relaxation kinetically using measurement of charge and polarization fluctuation. A future endeavor .will be to tune the glassy electronic state by pressure/strain and investigate whether it gives rise to a quantum phase transition.

Physics and application of wide band gap semiconductor ZnO:

The AKR group has been active in this area since 2005. Currently it is working on Thin Film Transistor (TFT) made from ZnO and is investigating new effects that can enhance their response and hence the applicability as detectors . These TFT's are made either from solution based deposition or as multilayered structure made by pulsed laser deposition. In recent years the group is investigating effect of polymer electrolyte gate on such ZnO- TFT. This type of gate creates an Electric-Double layer gate that can introduce large charge to the material that makes the channel in the TFT. Recently it has been discovered by our group that illumination of UV light on such EDL-FET ZnO-TFT leads to new effects that include gate controllable persistent photo *conductivity and a synergetic response of the TFT with both gate and illumination.*

Problems for new Ph.D students:

The group is currently looking for two Ph.D students who are likely to work on the following areas:

- *Fabrication of ultra-sensitive charge and radiation detector using single nanowires devices.*

- *Fabrication of ZnO nanowire Field effect nano-transistor and its opto-electronic properties.*

- *Electrical and magentotransport properties of ultra-thin epitaxial film of correlated oxides and sulphides*

Techniques used and developed for the research:

- ✓ **Materials synthesis**

a) Synthesis of materials particularly Nanomaterials by chemical routes.

b) Vapour phase synthesis using pulsed laser deposition (PLD) and magnetron sputtering.

c) Nanolithography using a combination of optical lithography, e-beam lithography and focused ion beam lithography.

- ✓ **General materials characterization:**

The group uses a combination of materials characterization techniques that range from XRD, SEM,HRTEM , Raman, Infrared, UV-Visible spectroscopy , Scanning Probe Microscopy, DTA/TGA, Ellipsometry, DLS and such techniques as are necessary for the problem in hand.

- ✓ **Experimental Measurements:**

In the group

- Electrical Transport and magneto transport measurements down to 2K in 10T field.
- Dielectric measurements upto 10 MHz.
- Magnetic measurements using VSM .
- Optical conductivity measurements.
- Low temperature UHV Scanning Probe Microscopy
- 1/f noise spectroscopy
- Dynamic thermal and mechanical measurements.

Out side national facilities

- SQUID magnetometry
- Synchrotron radiation (Photon Factory, ESRF)
- Neutron diffraction (ILL, Druva)
- Measurements below 1K.