Statement of Research Interests

I am an experimental condensed matter physicist. My broad research interests include studies of functional materials at nanoscales and apply them to low cost and high performing devices and sensors.

Specifically, my research interest is focused on development of functional materials for applications in energy generation & storage and sensors for gases (particularly hydrocarbon and hazardous gases). I have worked in synthesizing nano- materials that are functional at very low to very high temperature environments. These types of materials have been tested at very low temperature (high Tc superconductor based) as well as high temperature (CMR based) magnetic field sensing. The high temperature functional nano-materials also include layered semiconductors that show thermoelectric phenomena.

A. Nanocrystalline Functional Magnetic Materials and Devices

CMR manganites prepared by a new method (called 'Pyrophoric method') were studied to understand the effect the annealing on the electrical resistivity and magneto-resistance (MR) at low temperatures. It was found that, annealing has the effect of reducing the Mn-O-Mn bond disorders in manganites and enhancing the magneto-resistance. The MR behavior is discussed in the light of 'magnetic-clusters' model and it was found that the average size of clusters of ferromagnetic domains, that controls the low field MR, increased as the temperature approaches the Currie temperature. Efforts had also been made to identify the phonon scattering mechanisms in manganites from the thermal conductivity data. At low temperatures (<90K) 2D-like lattice defects contribute to the phonon scattering dominantly. The spin-wave contributed to ~ 2-15% of the total thermal conductivity (λ) below and close to the Curie temperature. In the paramagnetic regime the unusual increase in λ keeps signature of large dynamic lattice distortion.

B. Gas Sensing Materials and Hydrogen Sensors

Quasi-one-dimensional nanostructures (such as nanotubes, nanobelts or nanoribbons) of semiconducting oxides of zinc, tin, indium, cadmium etc are extremely useful to a number of engineering applications for their high surface-to-volume ratio. These types of materials are therefore applied to variety of adsorption based gas sensing. These types of materials can be synthesized by thermal/ plasma techniques as well as low cost solution based techniques. *We have tried to synthesize SnO_2 nanostructure by a low cost hydrothermal route (150-180 degC, 2-6 hours). The XRD has already revealed the crystallite size about 35-65 nm. Their characterization with TEM would be useful to study crystal and surface structures of nanocrystals. The gas sensitivity and selectivity of these materials with large surface-to-bulk ratio will be studied by resistive technique for different test gases. In near future we are interested to develop*

surface adsorption based H_2 sensor that would be useful for fuel-cell and hydrogen storage applications.

C. Functional Materials for Solid State Energy Generation and Storage

Certain materials such as layered cobaltite, manganites etc. show interesting property of phonon glass and electron crystal (PGEC), *i.e.* low phonon dominated thermal conductivity and large electron mobility. This makes them promising thermoelectric materials. *We have synthesized nano-crystalline cobaltite and manganites by novel 'Pyrophoric routes'. The XRD studies have revealed nanocrystalline grain boundaries and those are highly effective to scatter the acoustic phonon at the surface. This makes them promising phonon glass. On the other hand we are interested to measure their thermoelectric power and to investigate the percolation effect to electronic conduction. We have reached at a conclusion that by controlling the crystallite size the PGEC character is tunable to desired limit. Further studies in this line are underway.*

In the last two decades *cathodic* materials for rechargeable Li-ion batteries have been extensively studied because these batteries show high energy density and long self life. The parent material for this application is perovskite $LiCoO_2$. However, use of this material is limited for safety and economic issues. $LiMn_2O_4$ based spinels are promising materials to replace cobaltites. This spinels are of low cost and environmentally safe materials, however, the un-doped and stoicheometric compound has drawback of decreasing capacity on cycling. *My present interest is to develop doped spinels of composition like $LiMyMn_{2-y}O_4$ ($0<y<1$ and M=Co, Cr, Ni, Fe, Cu, etc) and to study their electrodic behaviours such as charge-discharge characteristics, discharge cycle characteristics, frequency response etc. to make this newly emerging material suitable for real life applications.*

Publications:

Refereed Journals (as joint author)

1. **A. Ray** and **T. K. Dey;** *Thermal Conductivity of $La_{0.67}(Ca_xSr_{1-x})_{0.33}MnO_3$(x=0,0.5,1) and $La_{0.6}Y_{0.07}Ca_{0.33}MnO_3$ pellets between 10 and 300K,* Solid State Communication **126** (2003) pp. 147-152.
2. **A. Ray** and **T. K. Dey;** *Annealing time dependence of electrical resistivity and magneto-resistance of $La_{0.6}Y_{0.07}Ca_{0.33}MnO_3$ pellets prepared by "Pyrophoric" method,* Journal of Magnetism and Magnetic Materials 266 (2003) pp. 268-277.
3. **A.Ray** and **T.K. Dey** ; *Non destructive evaluation of defects in ferromagnetic plates using a sensitive magnetic sensor based on second harmonic response of superconducting $Bi_{1.6}Pb_{0.4}Sr_2Ca_2Cu_3O_{10+\delta}$ pellet*; Bull. Mater. Sci. **25** (2002) pp.101-107.
4. **A.Ray** and **T.K. Dey** ; *Estimation of nonlinear effective flux diffusion barrier U(J, H_d, T) and critical current density of polycrystalline (Bi-Pb)-2223 using a. c. susceptibility measurements*; Mater. Res. Bull. **37** (2002) pp. 833-839.
5. **A. Ray**, **T. K. Dey** and **S. K. Ghatak**; *A novel method for sensing rotational speed, linear displacement and current using superconductive BPSCCO magnetic sensor.* Bull. Mater. Sci. **25** (2002) pp. 463-467.

6. **A. Ray**, **T. K. Dey** and **S. K. Ghatak**; *Inter-garnular Critical Current Density in Polycrystalline (Bi-Pb)-2223 High Temperature Superconductor by ac Susceptibility Measurements;* Journal of Superconductivity **15** (2002) pp. 201-206.
7. **A. Ray** and **T. K. Dey**; *A highly sensitive magnetic field sensor using thick film BPSCCO superconductor;* Bull. Mater. Sci. **24** (2001) pp. 385-388.
8. **A. Ray, T.K. Dey** and **S.K. Ghatak;** *Low field second harmonic response and ac susceptibility of (Bi,Pb)-2223 pellet in a Generalized Critical State Model.* International Journal of Modern Physics B, **21** (2003) pp. 3831-3846.
9. **M. Battabyal, A. Ray** and **T. K. Dey;** *Magneto-transport studies in yttrium doped lanthanum manganites between 10-300K,* Indian J. Pure & Appl. Phys., **41** (2003) pp. 443-447.
10. **A. Ray, T. K. Dey** and **S. K. Ghatak**; *Development of a novel superconductive magnetic sensor, its protection and instrumentations*. (*Communicated to Sensors and Actuators A*)
11. **S.K. Bandyopadhyay, A. Ray, Pintu Sen, P. Barat and T.V. Chandrashekhar;** *Assay of Stored Energy and Dissipation in Oxygen Ion Irradiated BSCCO Superconductor. (Communicated to Solid State Communication)*

Conference Presentations

1. **A. Ray** and **T. K. Dey**; *Effective flux creep barrier U(J,H,T) in bulk polycrystalline (Bi,Pb)-2223 by ac susceptibility measurements*; Eighth National Symposium in Cryogenics (ENSC) November 21-23 (2001), New Delhi, India.
2. **T.K. Dey** and **A. Ray**; *Harmonic response in high temperature superconductors and its application in non-destructive evaluation of materials*; Proceedings of The 6th. Asian Thermophysical Properties Conference (ATPC) ‘ 2001, Guwahati, India , Vol. II , pp 592-603.
3. **T. K. Dey**, **A. Ray** and **S. K. Ghatak**; *A novel method for sensing rotational speed and linear displacement using superconductive magnetic sensor;* National Conference on Frontiers in Materials Science and Technology (FMST) February 22-23 (2002), Kharagpur, India.
4. **M. Battabyal, A. Ray** and **T.K. Dey**; *Magneto-transport studies in Yttrium doped Lanthanum manganites between 10-300K;* National Conference on Thermophysical Properties (NCTP) September 19-21 (2002), Jaipur, India
5. **P. Barat, P. Mukherjee, A. Ray, A. Sarkar and A. Banerjee;** *Analysis of Portevin Le- Chattelier Effect in Low Carbon Steel in the light of Chaos*; Shanghai International Symposium on Nonlinear Science and Applications – 2003 Ocean Hotel, Shanghai, China, November 9–13, 2003. (*Accepted for oral presentation*.).
6. **S.K. Bandyopadhyay, A. Ray, Pintu Sen, P. Barat, P. Mukherjee and T.V. Chandrashekhar;** *Magnetism Studies of Oxygen Ion Irradiated BSCCO Superconductors through SQUID*; Condensed Matter and Materials Physics Conference (CMMP’04) April, 4-7 (2004), University of Warwick, Warwick, U.K.
7. **S.K. Bandyopadhyay, A. Ray, Pintu Sen, P. Barat, P. Mukherjee and T.V. Chandrashekhar;** *Assay of Stored Energy, Dissipation and Jc in Oxygen Ion Irradiated BSCCO Superconductor*, National Conference on Materials and their Applications (NCMA’04) March, 11-13 (2004), Kurukshetra University, Kurukshetra, India.
8. **P.K. Barhai, A. Ray, B. Pathak and N. Kumari;** *Corrosion Behavior of Stainless Steel (AISI-304) Coated with Al-bronze using Anodic Vacuum Arc Plasma Technique;* DAE-BRNS Workshop on Surface Engineering, September 23-25, 2004, BARC, Mumbai, India.

9. **A. Ray and T.K. Dey;** *Heat Conduction in the Doped Perovskite Manganites at Low temperatures and Possibilities for Thermoelectric Applications*; International Conference on Perovskite, September 5-7, 2005, E.M.P.A., Dubendorf, Zurich, Switzerland.

Workshop/ Seminar attended:

1. 4th National Conference on Indian Energy Sector (SYNERGY for ENERGY-08), March 14-15, Ahmedabad, India.