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Structure-Property correlations of magnetic nanoheterostructures

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Magnetic ceramics are important materials for a variety of applications such data storage, tunnel junctions, spin valves, sensors etc. These materials possess extra-ordinary properties at reduced dimensions. The properties of nanostructures are governed by finite size of the particles, lattice distortions and grain boundary effects. In the first part of this lecture the structure-property correlations of $Pr_{1-x}Ca_xMnO_3$ (PCMO, $0.0 < x \leq 0.5$) nanoparticles (NPs) will be discussed. Although PCMO at $x < 0.1$ is conventionally antiferromagnetic (AF), ~40 nm diameter PCMO NPs demonstrate ordering of Pr spins below 50 K with $x < 0.04$. Even in absence of Ca^{2+}-doping, ~35 nm $PrMn_{0.9}O_{3.01}$ NPs show ferromagnetism below 100 K due to the increase in <Mn-O-Mn> bond angles. Riveted analyses of the X-ray diffraction patterns from 300 to 10 K could successfully mirror the four magnetic phases viz. paramagnetic, AF, ferromagnetic (FM) and spin glass ordering. In second part of the lecture, the effect of electron polarization across the grain boundaries of 20 nm $La0._{72}Sr_{0.29}MnO_3$ (LSMO) NPs in demonstrating an unusually large 29.8% low-field magnetoresistance (LF-MR) at 30 K with 50 mT-applied fields will be discussed. The MR in LSMO NPs is influenced by the surface and re-entrant spin glass states below 30 K. In the third part, exchange bias (EB) effect at AF/FM interfaces in the nanostructures to increase the coercivity and anisotropy of the systems will be considered. Although EB is observed under applied cooling fields, spontaneous EB (SEB) is observed at 5 K under zero-field cooling in the stacked 10-14 nm thick PCMO nanosheets, synthesized by pressure-assisted transformation of metal acetates. High ferromagnetic moments and SEB are attributed to the long-range magnetic interactions in the stacked 2-dimensional arrangement of Mn^{3+}/Mn^{4+} *d*-electron spins. Apart from manganite nanosheets, inverted EB nanostructures are equally interesting. One such system was designed where 3.4 wt% of ~9 nm NiO NPs are inserted inside the pores of 30-40 nm clustered $CoFe_2O_4$ particles. The role of *in situ* embedded NiO NPs is to introduce AF/ferrimagnetic exchange coupling to provide a hysteresis loop shift of 233 Oe at 5 K with a cooling field of 2 T.

Biography

Sayan Bhattacharyya obtained his Ph.D. with Prof. N. S. Gajbhiye at the Indian Institute of Technology, Kanpur, India in 2006. He completed Postdoctoral research with Prof. (Emeritus) Aharon Gedanken at Bar-Ilan University, Israel (2006-2008) and Postdoctoral research with Prof. Yury Gogotsi at Drexel University, USA (2008-2010). He Joined IISER Kolkata in April 2010 and became Associate Professor of the Department of Chemical Sciences, IISER Kolkata since February 2015. At present, he is the Founder & Head of the Centre for Advanced Functional Materials. He is a Materials Chemist interested in magnetism, photovoltaics, catalysis for energy and drug delivery. A combination of wet-chemical synthesis and self-assembly of smart nanomaterials, structure-property correlation and device applications are used to attain these research goals. In 2017, Dr. Bhattacharyya has been highlighted as, one of the Emerging Investigators by the prestigious Journal of Materials Chemistry A, Royal Society of Chemistry. He is member of the American Chemical Society (ACS), invited member of the American Nano Society, lifetime member of the Chemical Research Society of India (CRSI), member of the Association for Iron & Steel Technology (AIST), 2009, PA, USA, and member of the American Ceramic Society, 2009, USA

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