TIFR Centre for Interdisciplinary Sciences
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Seminar

Oxides for Energy Storage and Energy-Efficient Devices

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Metal oxides are a remarkable class of compounds that exhibit almost every known condensed matter phenomenon such as ferroelectricity, ferromagnetism, anti-ferromagnetism, high-T_c superconductivity and metal-insulator transitions. Furthermore, Li-intercalating metal oxides such as $LiCO_2$ and $LiFePO_4$ are used as cathode materials in Li-ion batteries, which have led to the widespread adoption of portable electronics and to the development of electric automobiles. In this talk, we will present our work on two distinct oxide systems – Li_2O_2 and VO_2 – with applications in energy storage and low power electronic devices, respectively.

First, we will discuss the formation and morphological evolution of Li_2O_2 in the context of Li-O_2 batteries, where Li_2O_2 is the battery's discharge product. During the battery discharge, electrochemical deposition of Li_2O_2 causes electrode passivation because Li_2O_2 is an electronic insulator. This limits the maximum deposited thickness of Li_2O_2 and results in poor battery capacity. In this work, we show that activating an electrochemical solution-mediated pathway favors the deposition of large Li_2O_2 particles. Consequently, there is manifold increase in the battery's discharge capacity. We discuss the design rules for selecting electrolyte solvents that favor this alternate pathway and the implications of this research for metal-air batteries.

Next, we will discuss our work on VO_2-based heterostructures and devices. VO_2 is an archetypal correlated electron system that exhibits a near room temperature metal-insulator transition (MIT) with a concomitant structural phase transition. In this second part of our presentation, we will discuss the control of MIT in liquidelectrolyte gated VO_2 devices and epitaxially-strained single-crystalline VO_2 films. We comment on the role of oxygen vacancies in inducing the MIT in electrolyte-gated devices. And, using epitaxially-strained VO_2 films, we show that the MIT in VO_2 can be deterministically controlled by tuning the V 3d orbital configuration. We discuss possible device strategies that exploit MIT in VO_2 and related materials.

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11:30 AM (Tea/Coffee at 11:15 AM)

Seminar Hall, TCIS