

## THEME: Materials for Electrochemical Energy Storage

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### Invited Lecture:

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#### **Influence of defect chemistry on the performance of Li<sup>+</sup> or O<sup>2-</sup> ionic conducting materials for electrochemical energy storage.**

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#### **Abstract**

Finding new and improving existing renewable energy solutions is a global challenge of the 21<sup>st</sup> century. Solid ionic conductors play an important role for several new energy technologies such as Li batteries or solid oxide fuel cells. Their performance as electrolyte and their reactivity as electrolyte is granted by ionic defects. Understanding defect equilibria in ion conducting materials is therefore key to improve existing materials and developing more efficient materials and devices. In this contribution two examples how to measure and manipulate defect chemistry are presented: Fast Li ion conducting garnets as Li battery electrolyte and mixed oxygen ionic and electronic conducting electrodes for solid oxide fuel cells.

The garnet Li<sub>7</sub>La<sub>3</sub>Zr<sub>2</sub>O<sub>12</sub> (LLZO) has received a lot of attention towards replacing today's liquid electrolyte Li-batteries by all solid state, which would be desirable to avoid safety and durability issues such as dendrite driven short circuit or thermal runaway. Essential for high room temperature Li conduction is the stabilization of cubic phase(s) and avoiding the tetragonal phase. The effects of donor doping and sintering parameters on the defect chemistry of LLZO and associated with that the crystallographic phase and the electric performance is discussed. Importantly, not only cation defects are present in LLZO, but also oxygen vacancies have been found to have an influence. Experiments proving their existence in LLZO single crystals and polycrystals are presented and their impact on the cation defect concentration is discussed.

Mixed oxygen ionic and electronic conducting perovskite are state of the art cathode materials for solid oxide fuel cells. Their defect chemistry determines not only their partial conductivities, but also surface catalytic properties. By deliberate shifting and manipulation of their defect chemical parameters it is possible to determine, change and optimize materials properties. Three

examples of different acceptor-doped perovskite oxides ( $\text{La}_{1-x}\text{Sr}_x\text{MO}_{3-\delta}$  M=Mn, Fe, Co) are presented. Different drivers for directly affecting defect chemistry such as electric potentials, oxygen partial pressure or mechanical strain are probed in different experiments and discussed towards their implication on materials properties.

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**Invited Lecture:**

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**Unraveling the Critical Role of Materials Design on Electrochemical Performance**

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**Abstract**

Ion and electron transport at small length scales (as well as at reduced dimensions) play a critical role in determining the effective macroscopic parameters of electrochemical devices. The materials composition and structure has a major influence and intrinsically determines the electron and ion transport in the bulk and at various interfaces. Composite and hybrid (inorganic-organic) assemblies, where synergistic and confinement effects play a critical role, offers multiple opportunities for the design of advanced functional materials for efficient energy generation and storage. The talk will highlight and discuss through a few case studies the importance of chemical design of materials on the effective electrochemical phenomena in the context of rechargeable batteries.

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**Invited Lecture:**

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**Electrochemical Behavior of  $\text{LiFePO}_4$  Cathode: Function of Nonstoichiometry, Doping and Impurity**

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**Abstract**

The olivine  $\text{LiFePO}_4$  has been attracting lot of attention as promising cathode material for Li ion batteries. However, its poor electronic conductivity is a major challenge for its industrial applications. Different approaches have been taken to address this problem. Here, we report a method of improving its electrical conductivity by varying the annealing condition and doping with indium ions at the Fe site of  $\text{LiFePO}_4$ . Another set of samples were also prepared in