Mass and Charge Transport in Mixed Ionic Electronic Conductors

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Mixed ionic electronic conductors (MIECs) are materials that combine semiconducting and ionic properties. Their functionality relies on mobile electronic charge carriers (electrons/holes), and mobile ions (cations, anions, vacancies) and their reactivity at surfaces and interfaces. As functional ceramics, MIECs are the centerpiece of many important devices and applications particularly in the field of energy conversion and storage. They allow efficient conversion of chemical to electric energy and back in solid oxide fuel and electrolysis cells (SOFC, SOEC), in lithium ion batteries (LIB) they enabled today's use of portable devices and e-mobility. They are also the active component for thermochemical solar-to-fuel conversion or may even be used as memristive nonvolatile memories.

Equally important to understanding the functionality of MIEC materials are their bulk (where defect thermodynamics can be used to describe MIECs) and their surfaces and interfaces (where electrostatic, elastic effects or sub-nm segregation or impurity phases may dominate material properties). Several examples of my research activity on MIEC materials for above topics are presented, highlighting new in-situ approaches for gaining knowledge on materials, mechanisms and device functionality. Thin films of 5-100 nm thickness are of particular interest for these tasks, since they offer unique opportunities to investigate and manipulate materials in terms of structure, composition or elastic properties.