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Oxygen ion conducting materials for energy conversion in fuel cells and batteries

Interest in materials exhibiting oxygen ion conduction has increased owing to their great importance for energy conversion in Solid Oxide Fuel Cells (SOFC), Solid Oxide Electrolyzer Cells (SOEC) and Rechargeable Oxide Batteries (ROB). Ceria-based oxides are regarded as key oxide materials because rare earth-doped ceria shows high oxygen ion conductivity even at intermediate temperatures. Using Density-Functional Theory (DFT), we have investigated defect formation and migration energies as well. Using Kinetic Monte Carlo (KMC) simulations, we then investigated the oxygen ion conductivity. We show that all interactions between the defects, namely vacancy-dopant attraction, dopant-dopant repulsion and vacancy-vacancy repulsion contribute to the so-called conductivity maximum of the ionic conductivity. Solid oxide electrolyser cells based on yttria-doped zirconia as electrolyte were operated for 6100 h and 9000 h, respectively. They were analyzed concerning degradation by various electron microscopy as well as micro-analytical techniques. We found several degradation phenomena such as formation of nano-sized pores at grain boundaries, formation of $SrZrO_3$ at the interface electrolyte/anode and agglomeration of nickel particles in the cathode. The origin of these degradation phenomena is discussed in terms of the mass transport processes in the electrolyte caused by the two applied driving forces, namely the electrical potential and the oxygen potential gradient. Finally the new concept of Rechargeable Oxide Batteries (ROB) will be discussed.

Biography

Manfred Martin is a Professor and Head of the Institute of Physical Chemistry of RWTH Aachen University, Germany. He was WCU Professor at Seoul National University and currently, he is an Adjunct Professor. He has more than 30 years of experience in education and research of physical chemistry of solids. His current research focuses on Materials for energy conversion, resistive switching, solid-state reactions, secondary ion mass spectrometry, and computer simulations. He has published >200 scientific papers in international refereed journals. He received Carl-Wagner Award and has been elected as member of the Royal Society of Chemistry. He has supervised more than 50 PhD students and more than 20 Post-doctoral fellows.

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