Photo-Enhanced Ionic Conductivity across Grain Boundaries in Polycrystalline Ceramics

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High ionic conductivity is one of the key requirements for all electrochemical energy conversion system such as fuel cells, electrolyzers and batteries. While materials with very good conductivities have been developed for these applications, severe grain boundary conductivity limitations are ubiquitous in technical systems, and researchers are struggling to find ways to overcome this issue. Various approaches have been reported, but there is no successful universal strategy yet.

I will show that illumination with above band-gap light can be utilized to decrease the grain boundary resistance in solid ionic conductors. Specifically, I will demonstrate the ability to increase the grain boundary conductance of a 3mol% Gd doped ceria thin film by a factor of almost four at 250°C. Together with our collaborators at MIT, we have developed a model to describe this effect and demonstrate that it is associated with space charge barrier reduction by photo-generated electron carriers. With the aid of electrochemical impedance spectroscopy (EIS) and intensity-modulated photocurrent spectroscopy (IMPS) measurements on polycrystalline and epitaxially grown films, we further show that it is neither caused by heat nor photo-generated electronic conductivity.

This discovery could pave the way for the development of new electrochemical storage and conversion device technologies operating at lower temperatures and/or higher efficiencies. The exemplified opto-ionic effect can be further used for fast and contactless control of ionic conduction or in situ characterization.