Defect concentration changes at phase transitions in bismuth oxide based oxide ion conductors

The development of new materials is driving progress in nearly all everyday life devices. For example, research studies on new generations of light sources and high capacity batteries has been critical in the popularization of smartphones, laptops and electrical vehicles. However, due to problems with insufficient performance of present day batteries, increasing attention is being paid to other electrochemical power sources. In this context, of particular interest is the technology of fuel cells, characterized by very high efficiency of energy conversion from chemical to electrical energy and no harmful emissions (unreachable for conventional combustion heat engines) as well as zero charging time and limitless capacity.

In this project we seek to develop an understanding of the properties of oxide-ion conducting materials that would potentially reduce the cost of manufacture and operation of one of the fuel cell types, Solid Oxide Fuel Cells (SOFCs). Promising materials, exhibiting record-breaking oxide-ion conductivity values, are bismuth oxide based compounds. Unfortunately these materials face instability issues under SOFC operating conditions, namely during prolonged annealing at elevated temperatures and under reducing atmospheres, which makes them currently inapplicable in SOFCs. In this project we will study this fundamental problem of instability through developing an understanding of structure-property relationships specifically through characterizing the redistribution of oxide ions in the structure and the influence of defect concentration on ionic conductivity that occur at the critical point when these materials change structure. For this purpose, a wide range of advanced characterization methods that allow both local and long-range structure to be elucidated will be used. This will help to establish just how these materials conduct and how that conductivity can be enhanced.

This will aid the development of new oxide-ion conductors for advanced electrochemical devices like solid oxide fuel cells, gas sensors, electrolysers or oxygen pumps.