Influence of local structure on the ionic transport in fluorite and perovskite oxide ion conductors

The search for new materials that exhibit fast ion conduction is driven by the need to develop electrochemical power sources as an alternative to conventional sources based on fossil fuels. 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 (unreachable for conventional combustion heat engines), fuel flexibility (hydrogen, hydrocarbons, biomass, carbon dioxide, methane etc.), with no harmful emissions. The limitations in widespread commercialization of fuel cells originate mainly from high manufacturing costs associated with the expensive component materials.

The general objective of the present proposal is to develop new oxide ion conducting materials that would reduce the cost of manufacture and operation of one of the fuel cell types, Solid Oxide Fuel Cells (SOFCs). Currently used SOFCs are usually based on yttrium stabilized zirconia as electrolyte and operate at high temperatures, above 800 °C (HT-SOFCs), to reach the required levels of oxide ion conductivity. However, there are a number of problems associated with operating at such high temperatures, which include high costs of component materials and high component degradation rates leading to device failure. As a result, SOFCs are currently impractical for portable devices or vehicles. Therefore, research is focused on developing new materials showing high ionic conductivity at lower temperatures, which would allow reduction of the operating temperatures for SOFCs. This new class of fuel cells will operate in the intermediate temperature range of 500 to 700 °C and have therefore been termed IT-SOFCs.

To develop materials for IT-SOFCs requires a fundamental understanding of the relationship between the properties and structure of these materials. Characterizing this relationship allows the materials composition and performance to be optimized for the particular requirements of an IT-SOFC. As the materials being developed will be ionic conductors it is important to understand their structure at the atomic level. To this end, we will be using a wide range of advanced characterization methods that allow both local and long-range structure to be elucidated. This will help to establish just how these materials conduct and how that conductivity can be enhanced. Such a project requires broad expertise in different fields such as physics, chemistry and materials science. The proposed project involves collaboration with internationally recognized experts in the field of structural science, as well as access to unique equipment, and world-leading research facilities. An important aim of this international collaboration is the training of a new generation of research scientists, with expertise in advanced methodologies and will ensure the continued development of internationally leading science in Poland.