Crystal Structure-Ionic Conductivity Relationships in Doped Ceria Systems

In the past, it has been suggested that the maximum ionic conductivity is achieved in ceria, when doped with an acceptor cation that causes minimum distortion in the cubic fluorite crystal lattice. In the present work, this hypothesis is tested by measuring both the ionic conductivity and elastic lattice strain of 10 mol% trivalent cation-doped ceria systems at the same temperatures. A consistent set of ionic conductivity data is developed, where the samples are synthesized under similar experimental conditions. On comparing the grain ionic conductivity, Nd0.10Ce0.90O2−δ exhibits the highest ionic conductivity among other doped ceria systems. The grain ionic conductivity is around 17% higher than that of Gd0.10Ce0.90O2−δ at 500°C, in air. X-ray diffraction profiles are collected on the sintered powder of all the compositions, from room temperature to 600°C, in air. From the lattice expansion data at high temperatures, the minimal elastic strain due to the presence of dopant is observed in Dy0.10Ce0.90O2−δ. Nd0.10Ce0.90O2−δ exhibits larger elastic lattice strain than Dy0.10Ce0.90O2−δ with better ionic conductivity at intermediate temperatures. Therefore, it is shown that the previously proposed crystal structure–ionic conductivity relationship based on minimum elastic strain is not sufficient to explain the ionic conductivity behavior in ceria-based system.