Electrical Conductivity of 10 mol% Sc2O3-1 mol% M2O3-ZrO2 Ceramics

The oxide-ion conductivity behavior of 10 mol% Sc2O3-ZrO2 co-doped with 1 mol% trivalent metal oxide has been determined from 350 degrees C to 700 degrees C in air. All the powders were synthesized using conventional solid-oxide route. XRD patterns collected at room temperature show the presence of beta-phase in the predominant cubic phase in 1Sc10ScSZ, 1Yb10ScSZ, and 1Y10ScSZ, although 1In10ScSZ consist entirely of beta-phase at ambient temperature. As evident from the cubic symmetry of 1Gd10ScSZ and 1Sm10ScSZ, the beta-phase can be suppressed by the slight addition of co-dopant elements of larger ionic radius. The total conductivity of 1M10ScSZ initially increases with increasing size of the co-dopant, reaches a maximum at 0.95 angstrom and thereafter decreases. At 600 degrees C, 1Yb10ScSZ exhibits the highest total conductivity, namely 14 mS/cm. The grain interior and the grain boundary follow similar conductivity trends with the maximum at 1In10ScSZ and 1Y10ScSZ, respectively. Around 475 degrees C, 1In10ScSZ but not other compositions exhibits an abrupt drop in the conductivity on cooling, due to the cubic to beta-phase transformation. At 600 degrees C, the activation energy for the oxide-ion conductivity in 1M10ScSZ compositions ranges from 1.06 to 1.15 eV, with 1Yb10ScSZ exhibiting the smallest value. Long-term stability studies of the conductivity were performed on the sintered pellet of 1Yb10ScSZ in both oxidizing and reducing conditions at 600 degrees C. After 2000 h of exposure to air and reducing conditions, the 1Yb10ScSZ composition shows 9.1% and 12.0% loss in the total conductivity, respectively. After the first 1000 h, 1Yb10ScSZ exhibited a degradation rate of 1.1%/1000 h in both the conditions. From impedance studies, it was shown that, during annealing, the grain interior resistivity remains almost stable, while only grain boundary contributes toward the rise in total resistivity in both the conditions.