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Electrical conductivity in CeO_2 based materials with extended interfaces

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Abstract – A brief review of the most recent reports of the effect of extended interfaces in the electrical conductivity of classic ionic conductors is presented. This brief review is followed by the author's own work on the electrical properties of nanoceramics of ceria-based materials. Two main experimental results are observed in nanoceramics of lanthanide-doped ceria: at high temperatures (>700ºC) and mild reducing conditions the material becomes more reducible and therefore electronically conductive and at low temperature (<200ºC) the materials present proton conduction.

Recently, there have been several articles concerning the enhancement of the ionic conductivity of materials with extended interfaces such as inter-layered CaF_2-BaF_2,[1], nanoceramics of Yttria stabilised zirconia (YSZ) [2,3] or doped-CeO_2 [4-7] and heterostructures of YSZ/$SrTiO_3$ [8]. In particular, there has been a constant, yet not always consistent, search to understand the effect of extended interfaces in classic oxygen-ion conductors such as YSZ and CeO_2. Gadolinia doped ceria is the electrolyte of choice for intermediate temperature Solid Oxide Fuel Cells and the high oxygen ion mobility is well documented [9]. In this article, the electrical properties of dense samples of lanthanide doped CeO_2 with grain sizes below 300 nm is presented. Nanoparticles of the lanthanide doped ceria were pressed into pellets and then sintered at temperatures below 1200ºC for times shorter than 1 hour to obtain dense samples. The nanoceramics obtained exhibit some surprising properties as observed from the conductivity measurements: at high temperatures in relatively mild reducing conditions the material displays an enhancement in conductivity for Y and Gd doped CeO_2 due to an increased presence of electronic conduction. Yet the most striking result is found at low temperatures when the material becomes a proton conductor in wet atmospheres. The results seem to indicate that this is a grain boundary effect and that the bulk conductivity is not modified by size or atmosphere.

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