Effects of Heavy Ion Irradiation on the Transport Properties of Yttria-Stabilized Zirconia

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Yttria-stabilized zirconia (YSZ) has unique oxygen diffusion properties that make it useful for many applications. The high oxygen vacancy concentration makes it a very good oxygen ion conduction. This oxygen conductivity is strongly dependent on microstructural features such as dislocations and grain boundaries. It can be significantly altered by ion irradiation, which introduces point defects and dislocations in the material.

Bulk single crystals and thin films of YSZ were modified with heavy ion implantation, using 320-450 keV Xe^{3+} ions over a range of doses from 10^{13} to 10^{16} ions / cm^2. They were then heat treated under various conditions.

The microstructure was characterized using transmission electron microscopy (TEM) and high-resolution x-ray diffraction (XRD) techniques. TEM indicates a damaged surface layer, around 140 nm thick, and confirms observations in the literature of the formation of a dense dislocation network. The dislocation density is on the order of 10^{12} cm^{-2}. The XRD θ-2θ profile will undergo changes that correspond to the damage evolution in the material. Reciprocal lattice mapping indicates residual stress in the implanted region that relaxes with heat treatment of the sample.

The transport properties of YSZ were measured using two point impedance spectroscopy. Since dislocations and grain boundaries may have similar effects on the conductivity, the dislocation conductivity can be isolated by measuring single crystals of YSZ. A novel sample preparation technique was used to measure impedance in the thin single crystal samples.

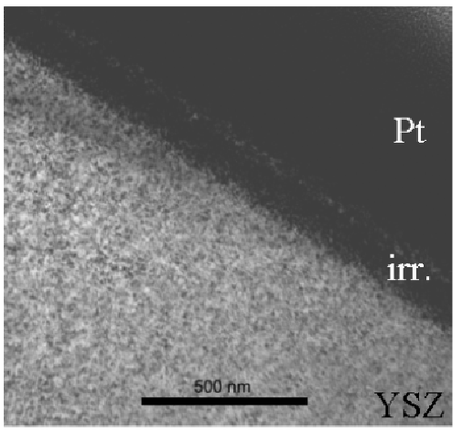

Fig. 1. TEM of ion irradiated single crystal YSZ

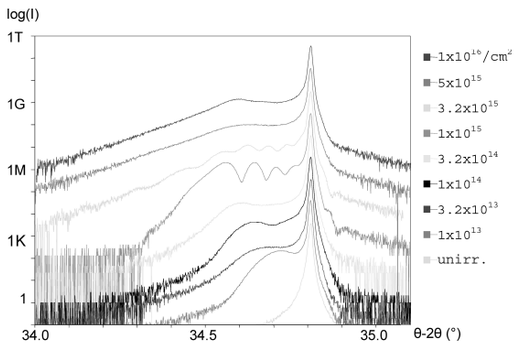

Fig. 2. XRD θ-2θ scans showing damage evolution with ion fluence in single crystal YSZ