

Electronic excitation effects on yttria-stabilized zirconia by high-energy ion irradiation

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Introduction

In pure zirconia the irradiation with swift heavy ions induces a phase transformation. Details such as the damage cross section are known to depend on the electronic energy loss of the ions [1,2]. However, according to our recent experiments with heavy ions in the energy range between 7 and 200 MeV, irradiation effects on lattice expansion of yttria stabilized zirconia (YSZ) depend on the elastic energy loss or displacements per atom (dpa) [3]. To clarify the effect of electronic excitation on the lattice structure of YSZ, we performed irradiations with ions of much higher energy in the GeV range.

Experimental

YSZ pellets (8% Y₂O₃ in ZrO₂) were irradiated with 2.2-GeV Au ions at the UNILAC. Fluences in the range from 10¹⁰ – 2×10¹² ions/cm² were applied. To evaluate the irradiation effects on the lattice structure, the samples were analyzed by x-ray diffraction (XRD). The results are compared with data from irradiations with 16-MeV Au ions.

Results and discussion

After ion irradiation the fluorite structure of YSZ remains unchanged. No new phases appear, neither when exposed to 2.2 GeV nor to 16 MeV Au ions. However, when analyzing the XRD peaks at each diffraction angle, we observed a peak shift that allows us to estimate the beam-induced change in lattice constant. Figures 1(a) and 1(b) show the change in the lattice constant as a function of the energy deposited through electronic excitation and by averaged dpa, respectively. The lattice expansion from the irradiation with 16-MeV Au ions is much larger than that for 2.2-GeV Au ions when comparing same energy depositions through electronic excitation (Fig. 1(a)). As can be seen in Fig. 1(b), the lattice constants are well scaled by dpa for both irradiations, 2.2-GeV and 16 MeV Au ions. This result shows that the irradiation effect on lattice constants of YSZ is dominated by the elastic energy loss unlike in the case of pure zirconia, which is quite sensitive to electronic excitation.

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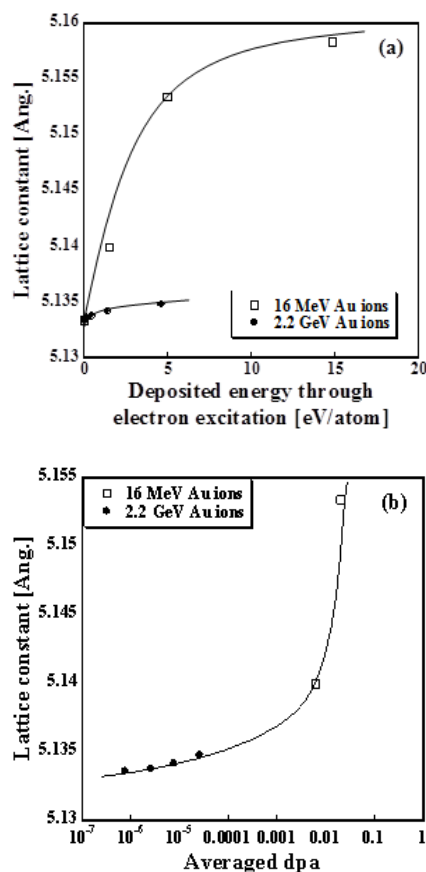


Fig. 1. Lattice constant for YSZ samples irradiated with 2.2-GeV and 16-MeV Au ions as a function of (a) the energy deposited through electronic excitation and (b) averaged dpa.

References

- [1] A. Benyagoub, F. Couvreur, S. Bouffard, F. Levesque, C. Dufour, E. Paumier, Nucl. Instr. Meth. B 175-177 (2001) 417.
- [2] A. Benyagoub, Nucl. Instr. Meth. B 206 (2003) 132.
- [3] K. Nakano et al., SHIM 2012 (Kyoto October 2012)