Colour centre production in yttria-stabilized zirconia by swift charged particle irradiations

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JOURNAL OF PHYSICS : CONDENSED MATTER 16 (2004) 3957-3971

We have studied the colour centre production by swift electron and heavy ion irradiations of yttria-stabilized zirconia (YSZ), i.e. ZrO_2:Y with 9.5 mol% Y_2O_3. For this purpose, we performed irradiations of <100>- or <110>-oriented YSZ single crystals with 2.5 MeV electrons, 145 MeV ^{13}C, 180 MeV ^{32}S, 200 MeV ^{58}Ni, 230 MeV ^{79}Br, 120 MeV ^{127}I, 200 MeV ^{127}I, 200 MeV ^{197}Au, and 2.6 GeV ^{238}U ions. X-band electron paramagnetic resonance (EPR) and UV-visible optical absorption measurements were used to monitor the point defect formation. The EPR line saturations were measured between 6 and 150 K, in order to obtain the spin-lattice relaxation time (T_1). Electron and ion beams produce the same two colour centres: (i) the first one is identified as an F+-type centre (singly ionized oxygen vacancy) with an axial <100> symmetry, a small g-factor anisotropy (g perpendicular to =1.972 and g||=1.996) and long T_1 values, (ii) the second one is similar to the well known T-centre (Zr^{3+} in a trigonal oxygen environment) with an axial <111> symmetry and a large g-factor anisotropy (g perpendicular to =1.855 and g||=1.986), which is also produced by photon irradiations. A broad optical absorption band centred at a wavelength near 500 nm is observed with an absorption coefficient proportional to the volume density of the F^+-type centre deduced from the room temperature EPR spectra. Since no change of this band occurs between 10 and 300 K, it indicates that the electron-phonon coupling of this colour centre must be strong, in agreement with an F^+-type centre. Owing to the axial <100> symmetry and lack of hyperfine structure of the EPR lines of this defect, it is suggested that the first coordination shell must contain one native oxygen vacancy. The plots of the volume density of this centre versus fluence are on the whole rescaled as functions of the number of displacements per atom induced by elastic collisions.