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Quantification of irradiation induced structural disorder in nuclear waste-form ceramics with µ-luminescence spectroscopy of lanthanides

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The investigation of radiation damaged or metamict minerals and their synthetic analogues has increased appreciably over the past two decades, stimulated by the potential use of mineral-like ceramics as waste forms for the immobilisation of reprocessed spent nuclear fuel and other radioactive waste. In this research field, however, a fast and inexpensive technique operating in the micrometre range may open up new opportunities in the characterisation of radiation damage.

We present first results of a heavy-ion (Au) irradiation-study of the important nuclear waste-form matrices zircon (ZrSiO4), xenotime-(Y) (YPO4) and zirconolite (CaZrTi2O7). Bulk, poly-crystalline ceramics were irradiated with accelerated heavy ions (Au) with energies up to 35 MeV. Comparably high heavy-ion energies are chosen to ensure irradiation penetration-depths of 4 - 5 µm accessible to the spatial resolution of optical confocal spectrometers.

Summary

We use surface-sensitive, grazing-incident X-ray diffraction of irradiated bulk ceramic pellets for the estimation of the amorphous fraction produced and demonstrate how photoluminescence spectroscopy may be used as a tool for the characterisation and quantification of irradiation-induced structural damage in nuclear waste-form materials on a µm-scale. Ln3+ ions are common substitutes on regular lattice sites in respective ceramic hosts. Their luminescence emissions may be used as structural probe and are very sensitive to their local crystal field

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