Structural evolutions of spinels under ions irradiations

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abstract

Thanks to its high temperature properties and relatively good behaviour under irradiation, the $MgAl_2O_4$ spinel is considered as a possible material to be used as inert matrix for the minor actinides burning. However, it is known to damage at high fluences. Several studies have shown that the damages induced by irradiation lead first to structural modifications and second to an amorphisation inducing an important swelling. In order to propose a better description of these structural modifications, we have irradiated different spinels at room temperature at GANIL facility with swift Kr ions. The irradiation damages was characterised by Raman analysis and X-ray diffraction.

For generality, three different materials were irradiated, $MgAl_2O_4$ and the isomorphic spinels $ZnAl_2O_4$ and $MgCr_2O_4$, this allowing a better X-ray analysis of the cations distributions. As a result, we have unambiguously observed that the first damage stage is not a phase transformation but an order-disorder transition of the cationic sub-lattice. On the other hand, for the three materials, the cations are distributed on the classical 8a and 16d sites: the inversion rates we derive are however much higher than in non-irradiated materials at high temperatures. But the cations are also located on the normally empty sites 16c and 48f, leading to highly disordered structures. The main difference between the three materials is the disordering rate versus the ion fluence, higher for $MgAl_2O_4$.

We have then performed isochronal annealings, which show that the disorder recovers in one stage ($ZnAl_2O_4$, $MgCr_2O_4$) or in two different stages ($MgAl_2O_4$). In the three cases, the initial structure is totally healed after annealing at 1000°C. These results could give some clues to explain the amorphisation stage of the spinels under irradiation and help in selecting a better inert matrix material.