Alpha particle irradiation in nanospheres of Y_2O_3 embedded in a matrix of Tungsten

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Synopsis We developed a simple model of an ODS tungsten alloy to study the primary damage produced by alpha particle irradiation on it. We show that the size of yttria nanoparticles embedded in a tungsten matrix is an important quantity to take into account under alpha particle irradiation. In addition, we establish a critical scale parameter for the model we use, making a comparison with bulk tungsten.

Future generation of fusion reactors are based in the Deuterium - Tritium (DT) nuclear reaction. This process has as its reaction products a 3.5M eV α particle and a 14.1M eV neutron. This amount of liberated energy makes that the materials, particularly the tungsten forming the first wall of the reactor, be exposed to extreme radiation conditions, given place to a severe radiation damage [1]. Of promising interest are oxide dispersion strengthened (ODS) tungsten-based materials, which allow improving the mechanical properties of the base material, in particular the creep strength at high temperatures. It is also expected that such materials exhibit improved resistance to radiation damage, as the numerous interfaces between the particles and the matrix may act as sinks for the irradiation-induced defects. Mechanical alloying (MA) is being used to produce intimate mixing of these materials [2].
However, the radiation resistance mechanisms associated with the embedded nanoparticles are still controversial and there is no consensus about these intrinsic mechanisms. For this reason, it is of interest to understand the process of localized radiation inside and around a Y_2O_3 nanoparticle.
In order to analyze this complex system, we assume a pure W matrix in which Y_2O_3 spherical nanoparticles are embedded
We use the so called Binary Collision Approximation (BCA) simulations, that are useful for examining the collisional stages of high energy cascades in statistically significant numbers. BCA simulations consider only the interactions between two colliding atoms at a time and in sequence.
Based on BCA, we choose the IM3D code 13, that uses the TRIM-SRIM [3] database.
Each trajectory corresponds to a particle (ion or knocked target atom) with a specified starting position, a given direction, and an incident or primary energy. The particle is tracked as a random sequence of straight free-flight paths, ending in a binary nuclear collision event where the particle changes its direction of movement and/or loses energy as a result of nuclear and electronic interactions. We show that the size of yttria nanoparticles embedded in a tungsten matrix is an important quantity to take into account under alpha particle irradiation. In addition, we establish a critical scale parameter for the model we use, making a comparison with bulk tungsten.

References

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