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# Positron Annihilation Investigation of Defects in Neutron Irradiated Tungsten Materials

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Fusion energy production relies on the nuclear reaction of deuterium and tritium, in the form of plasma heated to temperatures in excess of 100 million degrees Celsius, releasing highly energetic neutrons of 14 MeV. Neutrons interact with the fusion reactor materials, resulting in the formation of lattice defects and the creation of transmutation products. The produced damage affects the physical and mechanical properties of the reactor's materials and poses one of the most serious impediments for the realization of fusion energy production. Tungsten is the prime candidate plasma facing material for future fusion reactors due to its high melting point, high thermal conductivity, low coefficient of thermal expansion, high sputtering threshold energy, low tritium retention and low neutron activation properties.

The aim of this work is to investigate the evolution of the open volume defects in W materials neutron irradiated at the dose of 0.12 displacements per atom (dpa) and in the temperature range from 600 to 1200 °C, at the BR2 research reactor, at SCK-CEN, Mol, Belgium, using Positron Annihilation Lifetime Spectroscopy (PALS). Three tungsten grades were studied: W(100) single crystal, ITER grade forger bar and heavily deformed "cold"-rolled sheet in order to elucidate the effect of the initial microstructure in the evolution of the defects. PALS results show that neutron irradiation leads to the creation of dislocations and possibly mono-vacancies as well as voids having a size larger than about 1 nm, at all irradiation temperatures and W grades. It is found that the average void size increases with the increase of the irradiation temperature. The number density of both dislocations and voids decreases as the irradiation temperature increases for all W grades. The results were compared against TEM measurements on the same W materials irradiated to a similar dose and a satisfactory agreement was observed for the dislocation number density. However, the void number density as determined by PALS presented underestimated values compared to the ones obtained by TEM with an increasing difference as the irradiation temperature increases. This discrepancy was attributed to the trapping model inability of describing positron annihilations at large vacancy clusters as their average size increases with temperature. It is found that the plastic deformation of the polycrystalline W bar and sheet in combination with a higher percentage of impurities suppress the dissolution of the voids.