Contribution ID: **14** Type: **Talk**

The Effect of Rhenium on Irradiation Induced Defects in W-Re Alloys Studied by Positron Annihilation Spectroscopy

Monday 28 July 2025 17:10 (20 minutes)

The plasma-facing components in a nuclear fusion reactor have to withstand irradiation by 14 MeV neutrons, which are released in the fusion reaction of deuterium and tritium. A critical requirement of a future fusion reactor will be tritium self-sufficiency. A primary concern of tritium management is the potential for tritium trapping within or diffusion through the first wall of the reactor. Tungsten is considered to be the most suitable plasma-facing material, due to its high melting point, high thermal conductivity and low erosion under fusion reactor operating conditions. In addition to radiation damage, neutron irradiation of tungsten induces nuclear transmutation reactions, resulting in the formation of further elements such as rhenium. This work investigates the effect of rhenium on the defects produced during the irradiation of tungsten. Irradiation with W-ions mimics the radiation damage caused by 14 MeV neutrons and Re-ion irradiation is used to investigate simultaneous rhenium addition and damage creation. Positron annihilation spectroscopy provides a non-destructive, atomic scale resolution measurement of the irradiation damage, as positrons are efficiently trapped in vacancy-type defects. The annihilation radiation of positions and electrons is detected and subsequently analyzed. The Doppler-broadening of the 511 keV annihilation peak reflects the electron momentum distribution at the annihilation site, which provides a measure for the defect concentration in the material. Coincidence Doppler-broadening spectroscopy provides element sensitive measurements of vacancy-type defects. We find that rhenium reduces the defect concentration and/or changes the defect type for irradiation at high temperature.

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Session Classification: Session 3