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Investigations of Tungsten as Candidate Plasma Facing Material under High Repetition and Intense Fusion-relevant Pulses

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For the purpose of investigating the damage processes of surface layers during transient heat loads, fuel retention and dust issues of tungsten as candidate plasma facing materials, the International Atomic Energy Agency (IAEA) organized a dedicated Coordinated Research Project (CRP F1.30.13) from 2011-2015. The CRP involved 18 institutions from 15 member states. The activities concentrated on the irradiation and characterization of PLANSEE double forged tungsten (PDF-W; tungsten forged in two orthogonal directions aiming to obtain a dense and nearly isotropic grain structure). These samples were provided by Forschungszentrum Juelich, Germany to all participating research teams. More than 100 samples of 12 mm × 12 mm × 5 mm were investigated. All samples were expected to be identical, which was also demonstrated through microstructural and compositional investigations.
Round-robin tests were performed using different plasma/nuclear facilities and particle accelerators. A total of 25 different devices were used for irradiation during this CRP which included plasma accelerators, dense plasma foci, a tokamak, a nuclear fission reactor, a cyclotron, and electron beam facilities. These facilities span a wide range of irradiation parameters thus allowing a meaningful contribution to the clarification of damage mechanisms under powerful heat loads and the dynamics of erosion products.
The mechanisms of plasma material interaction and surface modifications were identified in different devices used.
A database of surface damage, structural and compositional changes of tungsten materials irradiated under well-defined heat and particle load conditions in different plasma and particle accelerators was generated. It was established that the main factors affecting the performance and adequacy of double forged tungsten during transient events are (i) the base temperature of the material, (ii) the heat flux factor (W.s0.5.cm-2), (iii) thermo-mechanical properties of the material, (iv) the pulse duration, (v) total fluence, and (vi) the pulse frequency.
The investigations carried out within the framework of this IAEA CRP have allowed gaining insights into the issue of the adequacy of tungsten for fusion reactor environment.

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