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Japan-US Joint Research Project PHENIX (2013–2018); Heat Transfer Tests, Neutron Irradiation and Post-Irradiation Examinations for Development of He-Cooled Tungsten Divertor

Wednesday, 19 October 2016 14:00 (4h 45m)

The goal of the Japan-US joint research project PHENIX (2013–2018) is to understand the feasibility of He-cooled W divertor for DEMO applications. To achieve this goal, the project has three major objectives: (1) to understand heat transfer in a divertor module cooled with high-temperature and high-pressure He gas, (2) to establish database on thermomechanical properties of W materials after high temperature (˜500, ˜800 and ˜1200 degree C) neutron irradiation with fusion-relevant energy spectrum, and (3) to clarify tritium (T) trapping and permeation in neutron-irradiated W materials. Heat transfer tests for a He-cooled modular divertor with multi-jet (HEMJ) have been performed, and the problem of heat transfer degradation by re-laminarization was identified. The irradiation capsule with thermal neutron shielding was designed for high temperature neutron irradiation in the High Flux Isotope Reactor (HFIR), Oak Ridge National Laboratory (ORNL) with fusion-relevant transmutation. The expected damage level is 1–1.5 displacements per atom (dpa). Heat load resistance, thermal conductivity, mechanical properties and microstructures are examined in ORNL after the irradiation. Mechanical properties of W single crystal samples irradiated with neutrons in HFIR at 90–850 degree C without thermal neutron shielding have been examined for comparison. Significant hardening was observed after irradiation to > 1 dpa. Microstructural examinations revealed that the hardening was mainly caused by formation of irradiation-induced precipitates consisting of W, Re and Os. Comparison with new samples irradiated in the capsule with thermal neutron shielding will show the effects of irradiation temperatures and transmutation elements. Retention and permeation of hydrogen isotopes including T in neutron-irradiated samples are examined in Idaho National Laboratory, and permeation of H and D in samples damaged with surrogate irradiations (heavy ions, electrons, etc.) is measured in Sandia National Laboratories, Livermore, to study hydrogen-defect interactions in wider conditions. High temperature D permeation tests performed for W damaged at 300 degree C with high energy Fe ions showed significant trapping of D at radiation-induced defects at temperatures as high as 900 degree C.

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