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P2.170 Evolution of constrained beryllium pebble bed mock-ups neutron-irradiated up to 6000 appm helium production

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In the European Helium-Cooled Pebble Bed (HCPB) concept of the DEMO blanket, beryllium pebbles with a diameter of 1 mm are planned to be used as neutron multiplier. A study pebble bed mock-up behavior under high-dose neutron irradiation at the HCPB relevant temperatures in a material testing nuclear reactor should provide an essential database for blanket designers.

Beryllium pebbles with diameters of 0.5, 1, and 2 mm produced by the rotating electrode method were irradiated in the HIDOBE-02 experiment in the HFR, Petten at temperatures of 370-650 °C up to damage doses of 21-38 dpa, corresponding to generation of 3600-6000 appm helium. To simulate thermo-mechanical, swelling and creep issues of the HCPB blanket, the constrained beryllium pebble bed mock-ups with a diameter of Ø14.9 mm and heights of 32 and 45.5 mm were used. Along with the mock-ups, unconstrained beryllium pebble stacks were also irradiated. Post-irradiation examinations included optical microscopy of cross sections of the pebble bed mock-ups and unconstrained pebbles, as well as micro-hardness measurements. This contribution is mainly focused on the behavior of constrained pebble beds.

Neutron irradiation resulted in evolution of the pebble microstructure depending on the irradiation temperature. For unconstrained pebbles, formation of gas bubbles becomes more pronounced above 560 °C. The constrained pebbles obey more developed sub-grain structure retarding bubble coalescence. Sintering of the pebbles in the pebble beds is especially noticeable after irradiation at the highest temperature of 600 °C. For 1 mm constrained beryllium pebbles, micro-hardness reduces from HV0.4 234 at a temperature of 387 °C to HV0.4 164 at the highest irradiation temperature of 600 °C.

The analysis of the obtained results provides deeper understanding of microstructure evolution in the constrained beryllium pebble beds and unconstrained pebbles after high-dose neutron irradiation.

Presenter: CHAKIN, Vladimir (Karlsruhe Institute of Technology Institute for Applied Materials)

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