Tritium Distribution and Chemical Forms In The Irradiated Beryllium Pebbles Before And After Thermoannealing

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Beryllium pebbles are foreseen as a neutron multiplier to the reference concept of the helium-cooled pebble-bed breeding blanket (HCPB) in the European Breeding Blanket Programme for the DEMO design [1]. Tritium inventory in the beryllium as a result of neutron-induced transmutations is a significant safety and technological issue for the operation of the breeding blanket.

Tritium release rate from the irradiated beryllium at the different temperature regimes has been measured previously [2, 3]. In order to describe and predict the diffusion process of tritium during thermo-annealing, the estimation of both initial and resulting percentage of chemical forms and distribution of tritium in the bulk of the pebble is necessary. The diffusion process depends not only on the state of the tritium, but also on the properties of the material where the diffusion is taking place. Therefore, the structure and impurities also have to be taken into account at the estimation of the diffusion process.

In this study, beryllium pebbles from 3 different irradiation experiments: BERYLLIUM, EXOTIC 8-3/13 and PBA, performed at High Flux Reactor (HFR) in Petten, the Netherlands have been investigated. The distribution of tritium in the bulk of the pebbles and abundance ratios of chemical forms of tritium T^o, T^+ and T_2 have been investigated before and after the different thermo-annealing experiments. In order to determine the percentage of the chemical forms of the tritium, the method of chemical scavengers has been used. The structure analysis has been done only on the PBA experiment pebbles since samples from BERYLLIUM have been described elsewhere [4], but samples form EXOTIC 8-3/13 have insufficient diameter for such studies. The scanning electron microscopy method has been used for this investigation.

The main chemical form of the tritium localized in the irradiated beryllium pebbles is T_2, especially in the highly irradiated pebbles from PBA experiment. As a result of thermo-annealing, the abundances of the T_2 and T^0 change, T^+ stays unaffected up to relatively high temperatures. The distribution of the tritium in the bulk is uneven – it increases rapidly at the centre of the pebble. It could be explained by the existence of a technological hole in the centre of the pebble that was found during the structure studies in all of analyzed pebbles. Porosity and grain sizes have been measured for the PBA samples.

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