MODELING AND EXPERIMENTAL VLAIDATION OF HYDROGEN BEHAVIOR IN BERYLLIUM

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Beryllium is proposed as a neutron multiplier material in ceramic tritium breeding blanket concept of nuclear fusion reactor. Under irradiation, beryllium suffers from swelling and degradation of mechanical properties induced by interaction of displacement damage with helium and tritium produced by neutron induced transmutation. It is commonly supposed that tritium is trapped by vacancies and their complexes as well as associated with helium bubbles. Both total amount of tritium in the blanket and daily release rate should be limited by the safety regulations. Therefore, the evaluation of the residual tritium inventory after end-of-life of the blanket is crucial for this design concept. As far as suitable intense neutron sources with an energy spectrum similar to that of the DEMO fusion reactor are not yet available, such evaluation should be based on reliable extrapolation of the available experimental results which is impossible without advanced modelling of the processes involved and careful experimental validation.

This contribution presents our recent advances in understanding of tritium behavior (and in general hydrogen isotopes) in beryllium based on first principles modeling. We discuss hydrogen interaction with beryllium surface (external or internal surface of gas bubbles) resulting in severe surface reconstruction and formation of stochastic BeH_2 polymer-like chains, hydrogen behavior inside bubbles filled with helium, impact of displacement damage on hydrogen desorption and possible origins of synergetic effects of their simultaneous presence on bubble growth. We estimate hydrogen mobility in beryllium bulk and near bubble surface as well as the binding energy of hydrogen within gas bubbles and compare these and the above mentioned results with the tritium release experiments and microstructural investigations (including optical microscopy and TEM) performed on beryllium pebbles after the high dose beryllium irradiation campaigns HIDOBE-01 and -02. TEM observations of helium bubbles with hydrogen strongly support our modelling results.

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