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Hydrogen retention behavior in beryllide pebbles as advanced neutoron multipliers

先進中性子増倍材料としてのベリライド微小球の重水素水素保持挙動

Yuta Fujii, Hayato Takesita Mitsutaka Miyamoto Masaru Nakamichi and Hirotomo Iwakiri
藤井悠太[1)], 竹下隼人[1)], 宮本光貴[1)], 中道勝[2)], 岩切宏友[3)]

1)Shimane Univ, 2)JAEA, 3)Univ. Ryukyus
1)島根大, 2)原子力機構, 3)琉球大

Shimane University, 1060, Nishikawatu, Matsue 690-8504, Japan
島根大学 〒690-8504 松江市西川津町1060

The behavior of hydrogen isotope in neutron multipliers are during the operation of a reactor will influence the functional maintenance of the materials and the safety of the system. In this study, the pebble of beryllium intermetallic compound as an advanced neutron multiplier has been examined, focusing on the deuterium retention behavior. Thermal desorption spectroscopy has been applied to understand fundamental aspects of the behavior of hydrogen isotopes in beryllide pebbles. As a result, beryllide pebbles show much lower trapping efficiency of deuterium than pure Be pebbles.

1. Introduction

Fusion reactors require advanced neutron multipliers with great stability at high temperatures. Beryllium intermetallic compounds (beryllide) is considered as an advanced neutron multiplication materials because of its irradiation resistance and high-temperature stability [1]. For the neutron multipliers, hydrogen isotopes retention properties will influence the functional maintenance of materials during an operation of a reactor. In this study, the behavior of hydrogen isotopes in beryllide pebbles fabricated by the novel method [2] are investigated by means of thermal desorption spectroscopy (TDS).

2. Experiments

Samples used in this study are pebble type pure Be, Be7.3at%Ti, and Be7.7at%Ti These samples are fabricated by the method combining plasma sintering and rotating electrode methods [2,3].

To investigate the characteristic of hydrogen retention behavior in these samples, TDS has been applied after low energy deuterium irradiation. The samples were irradiated with 3 keV deuterium ions to a fluence of $1x10^{20}$, $1x10^{21}$, $1x10^{22}$ and $1x10^{23}$ D^+/m^2 at room temperature. After the irradiations the samples were annealed from 300K to 1200K at a constant heating rate of ~1 K/s and released D_2 was monitored using a quadruple mass spectrometer (QMS). The QMS signals were calibrated by a standard leak bottle to estimate deuterium retention behavior quantitatively.

In addition to TDS, microstructure modification induced by the irradiation and the subsequent annealing was investigated using a transmission electron microscope (TEM) equipped with an ion gun. In-situ observation for pre-thinned beryllide sample produced with FIB processing was performed under the irradiation with 3 keV deuterium ions and subsequent annealing.

3. Results and discussion

Fig 1 shows the D desorption spectra from pure Be, Be7.3at%Ti, and Be7.7at%Ti irradiated with 3 keV deuterium ions at room temperature. While two clear desorption peaks occurred at high temperatures side of 870 K and low temperatures side of 680 K for pure Be, it was found for Be7.3at%Ti and Be7.7at%Ti that only a smaller peak at low temperature side accompanied with a tail extended to higher temperatures. From the in-situ observation, this small peak at low temperature seems to be related to desorption from cavities filled with D_2. Fig. 2 shows the microstructural evolution for

Be7.3at%Ti under the irradiation with 3keV deuterium ions to a fluence of $1x10^{21}$ D^+/m^2 and subsequent annealing up to 600 K. The deuterium bubbles induced by the irradiation drastically disappeared at around 600 K as shown in Fig. 2.

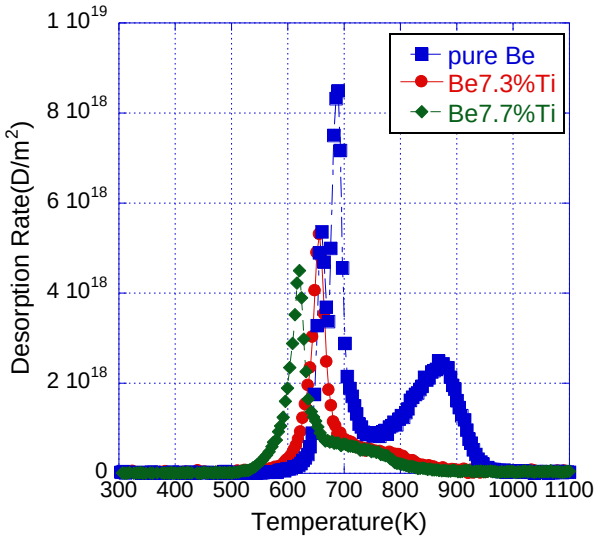

Fig. 1 The desorption spectra from pure Be, Be7.3at%Ti, and Be7.7at%Ti irradiated with 3keV deuterium ion to a fluence of $1x10^{22}$ D^+/m^2 at room temperature.

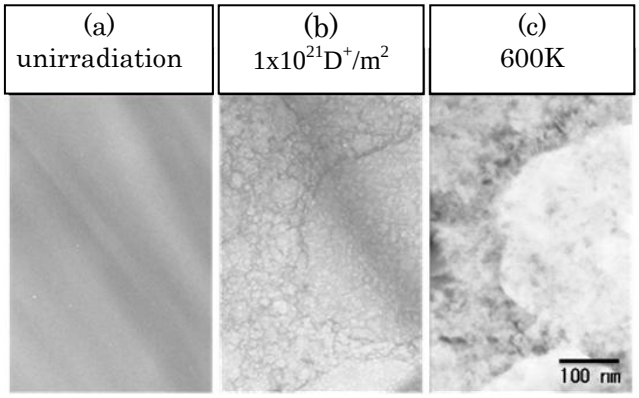

Fig. 2 TEM image of Be7.3at%Ti (a) before and (b) after the irradiation with 3keV deuterium ion to a fluence of $1x10^{21}D^+/m^2$ at room temperature, and (c) after annealing up to 600 K.

Due to the small desorption from beryllide, the total retentions of deuterium in Be7.3at%Ti and Be7.7at%Ti were evaluated to be less than that in pure Be. The total deuterium retention is shown in Fig. 3. In this respect, beryllide pebbles possesses better performance of than pure Be as a neutron multipliers. In the poster session, the results obtained from different compositions beryllide pebble such as $Be_{12}V$ will be also presented.

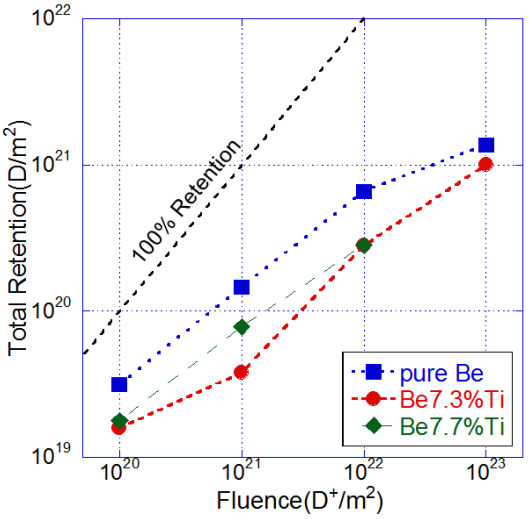

Fig. 3 Total Retention of deuterium for pure Be, Be7.3%Ti, and Be7.7%Ti.

Acknowledgments

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