§29. Control of Heat and Hydrogen Transfer by Improvement of Interface Structure in Heat Exchanger of Fusion Blanket

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The design of the heat exchanger for fusion reactors is important issue. The design has to achieve a large coefficient of heat transfer and a small permeability of tritium at the same time. The tritium permeability is improved by the coating with tritium permeation barrier (TPB) in the heat exchanger. Some ceramic coatings which have high chemical stability, such as Y_2O_3, Er_2O_3 and ZrO_2, can be used as the TPB for the liquid breeder blanket. The function of TPB must be kept during the life time of the heat exchanger. Then, the compatibility of these coatings in the liquid breeders should be improved.

Figure 1 shows the one example of the application of the ceramic coating on the heat transfer tube of the heat exchanger. The thickness of the ceramic coating fabricated by MOD or MOCVD is thin as less than 5μm, and is not suitable for the long- term use in the liquid breeders [1]. The duplex coating is proposed as the fabrication of thermal spray coating on the TPB layer to improve the durability in the present study.

The online deterioration evaluation technology for these functional layers must be established. In the present work, the electrochemical impedance spectroscopy (EIS) is proposed as the online evaluation method [2]. The occurrence of cracking, peeling off and deterioration of the layer can be evaluated based on the impedance response of EIS.

The goal of the present study is to develop the functional layers, which can work for long- term operation of the liquid breeders and the online monitoring technology of the deterioration state of the layers toward the high performance heat exchanger. In the present study, we developed the apparatus which can fabricate the ceramic coating for the long cylindrical specimen. This paper reports the preliminary results obtained by these experimental apparatus.

Figure 2 shows the experimental apparatus, which can fabricate the ceramic coating by MOD method. The Al_2O_3, Y_2O_3 and Er_2O_3 MOD precursor liquids made of low boiling point ester and carboxylate of the metals (Kojundo Chemical Lab. Co., Ltd.) was used for the coating fabrication. The size of the substrates made of SUS316 (Fe-18Cr-12Ni-2Mo) was Φ20 mm×1 mm size and Φ20 mm×40 mm, respectively. Figure 3 (a) shows the coated specimens. The ceramic coatings with various types of oxides were successfully fabricated. The thermal splay layer of the coating was fabricated on the ceramic coating by the Atmospheric Plasma Spraying (APS) as shown in Fig. 3 (b). The functional layers were also fabricated by means of the preoxidation treatment of the substrates of Y metal and Zr metal. The characteristics of these functional layers in the liquid breeders are going to be investigated by means of the electrochemical impedance spectroscopy.

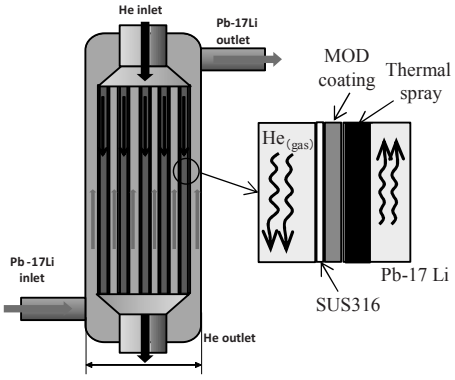


Fig. 1 Application of ceramic coating on heat transfer tube in heat exchanger

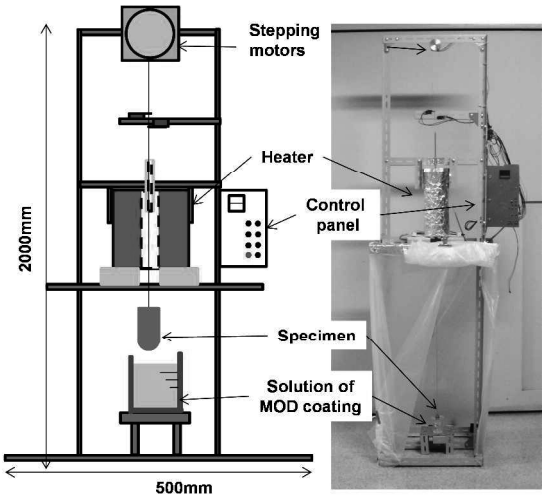
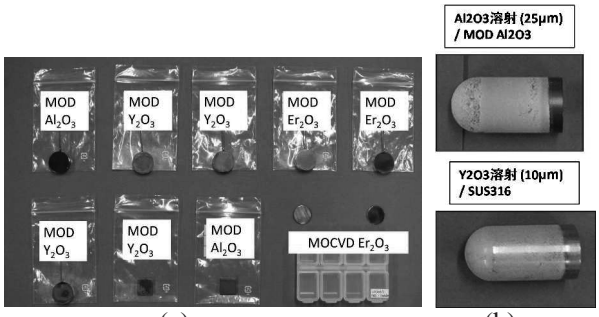


Fig. 2 Experimental apparatus for ceramic coating fabrication based on MOD method



(a) (b)

Fig. 3 (a) Specimens coated by MOD method, (b) Specimens have duplex coating by MOD method and APS

[1] D. Zhang, M. Kondo, T. Teruya, T. Muroga, T. Valentyn, Fusion Eng. Des. 86 (2011) 2508–2511.
[2] M. Kondo, N. Suzuki, Y. Nakajima, T. Tanaka, T. Muroga, Fusion Eng. Des. 89 (2014) 1201–1208.