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Hydrogen Permeation through Fusion Materials

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Our contribution to this CRP is the investigation of hydrogen permeation and retention in fusion materials. For the prediction, evaluation and calculation of hydrogen permeation and retention in fusion reactor walls, it is essential to know fundamental parameters of hydrogen transport and retention. In order to obtain such basic parameter for hydrogen isotopes, gas-driven permeation measurements are performed and thermal desorption spectroscopy (TDS) measurements will be carried out on relevant gas loaded materials. With nuclear reaction analysis (NRA) the hydrogen depth distribution will be quantified. In order to investigate the influence of the microstructure and sample conditions, sample characterization is performed before and after permeation and retention measurements by surface analysis techniques. Various fusion relevant bare substrate materials, such as steels, tungsten and CuCrZr are under study. Especially for the prediction of the hydrogen retention and permeation through fusion reactor components, the influence of interfaces on the permeation and retention of magnetron-coated substrates are investigated.

For the study of the bulk properties, 316L(N)-IG (IG: ITER grade), Eurofer97, Cu and CuCrZr-IG substrates [1,2] were cut to disks, polished and analysed. The combined material systems were fabricated by magnetron sputter deposition. On the polished substrates, thin W or Cu layers were deposited. The sample preparation, characterization and measuring cycle were kept identical for all samples in order to provide a reliable comparison between the samples. The crystal phase was analysed by x-ray diffraction and the microstructure was investigated by scanning electron microscopy. The deuterium permeation flux was measured between 300℃ to 550℃ at different applied pressures (range: 25 mbar to 800 mbar).

The material systems Cu on 316L(N)-IG [2], W on CuCrZr-IG and W on Eurofer97 [3] were studied. For the comparison of different coatings, the layer permeability [3] was calculated. In order to determine the influence of interfaces between the different materials, the thickness of the Cu layer was varied in the Cu on 316L(N)-IG system.

In this presentation, an overview of the permeability of bulk and combined systems will be given and discussed. The permeabilities of CuCrZr-IG and bulk Cu sample are very similar. The layer permeability of a Cu layer is more than one order of magnitude larger than the W layer permeability. The influence of the microstructure on the permeability is large compared to the influence of interfaces on the permeability in the combined systems.

In a second part, the first results of the 'Gas-driven permeation in fusion materials (GDPFM)' Round Robin Test on Eurofer97 will be presented. Afterwards the further procedure will be discussed with the participants.

[1] A. Houben, J. Engels, M. Rasiński, and Ch. Linsmeier, NME 19, 55 (2019)

[2] A. Houben, M. Rasiński, S. Brezinsek, and Ch. Linsmeier, NME 33 (2022), 101256

[3] A. Houben, M. Rasiński, L. Gao, and Ch. Linsmeier, NME 24 (2020), 100752

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