Contribution ID: **76** Type: **not specified**

Gas driven hydrogen permeation – a complementary method for investigation of fusion relevant materials

Monday, 4 October 2021 16:00 (30 minutes)

Classic gas-driven permeation experiments with gaseous hydrogen isotopes represent a complementary tool for the insight on the hydrogen diffusion mechanisms through fusion relevant materials. We found the double-layer membrane technique as suitable for studying hydrogen diffusion through highly impermeable first-wall metals W and Be. They were deposited as a film atop of highly permeable Eurofer substrates. Evaluation of experimental data consists of comparing the data to a suitable theoretical model. By the same technique, several novel nitride films as potential tritium permeation barriers on future fusion-reactor walls were studied. Some of them were highly efficient and can be aligned into the group of the most promising candidate barrier materials. Similarly, in-situ grown oxides were also investigated as potential hydrogen permeation barriers. Tungsten and chromium films on Eurofer substrate were evaluated before and after controlled surface exposure to pure oxygen at 400℃. Noticeable suppression of the permeation rate was found only with the tungsten oxide film. Contrary, the chromium oxide film was inefficient which was just opposite than expected from published data. This discrepancy was studied in a new set of experiments with a refined analysis of process at the upstream metal surface. By adding 5% oxygen to the upstream hydrogen permeation was completely blocked. An explanation might be an ultrathin hydroxide as a metastable film enabling catalytic reaction. All surfaces were subsequently characterised by various surface sensitive analytical techniques, but detecting ultra-thin layers containing OH groups is a challenging task.

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Session Classification: Atomistic Modelling