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Recent instrument developments for improved studies of hydrogen permeation in fusion relevant material

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In this contribution, we will present newly installed and presently developed instrumentation located at the Tandem Laboratory at Uppsala University, which can be used for studying hydrogen permeation of materials, in particular for energy applications. The capability of the instrumentation is partially demonstrated by studies of hydrogen and its kinetics in fusion-relevant materials such as tungsten, beryllium, EUROFER or even compound systems as well as by other complementary studies. Specifically, we aim to show:

(i) the present status of the SIGMA set-up at the 5 MV pelletron at Uppsala University [1][2]:

We have recently used the set-up to study hydrogen retention in tungsten [3] and beryllium [4] combining ion beam analysis with thermal desorption spectroscopy. Very recently, also redeposited layer from EUROFER [5] have been analyzed. We have furthermore installed a quartz-microbalance system providing another handle on e.g. hydrogen release or uptake or oxidation via the induced mass change [6].

(ii) recent upgrades to the MEIS-system enabling in-situ studies of hydrogen diffusion

We are presently commissioning a system for in-situ characterization of synthesis and modification at our medium-energy ion scattering (MEIS) facility, for which we recently also demonstrated the high depth resolution achievable for light species in transmission experiments [7]. In combination, with recent experiments depositing thin films from EUROFER [5], the system opens up for new ways of studying permeation in redeposited materials.

(iii) an auxiliary system for gas-loading experiments at different temperatures

A system for gas loading as well as outgassing experiments at controlled temperatures in combination with optical spectroscopy was developed and recently commissioned [8].
We are at present also designing a completely new set-up for in-situ hydrogen depth profiling during gas exposure at different pressures and temperatures.

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[2] P. Ström et al., Journal of Instrumentation 17 (2022) P04011
[3] K. Kantre et al., Physica Scripta 96 (2021) 124004
[4] C. Cupak et al., Nuclear Materials and Energy 33 (2022) 101249
[5] E. Pitthan et al., Nuclear Materials and Energy 34 (2023) 101375
[6] E. Pitthan et al., Materialia 27 (2023) 101675
[7] R. Holenak et al., Vacuum 204 (2022) 111343
[8] D. Moldarev et al., Rev. Sci. Instruments - accepted

Primary author: PRIMETZHOFER, Daniel (Uppsala University)

Presenter: PRIMETZHOFER, Daniel (Uppsala University)

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