PIM Facility for the gas and plasma driven hydrogen permeation studies [[1]](#footnote-1)\*)

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One of the important problems in the development of thermonuclear energy is the safety issues of thermonuclear reactors (TNR) justification. Tritium, one of the TN fuel components, is radioactive and expensive isotope, and its reproduction rate in TNR is usually close to unity. In this regard, it is necessary to predict the behavior of tritium in TNR and its various subsystems: its accumulation in structural materials and its leakage into the coolants. For the correct experiment performing, it is extremely important to take into account the specifics of the TNR: low pressure of hydrogen isotopes, temperature window of investigated materials, possible plasma irradiation. In a case of accidents, it is also important to predict tritium leakage through the safety barriers elements, which is relevant not only for TNR, but also for research facilities using tritium.

This paper presents the most interesting results of experimental studies performed at the PIM facility [1] (NRC Kurchatov Institute), devoted to the hydrogen isotopes permeation through promising materials for TNR usage. The installation consists of two vacuum volumes: a “high pressure” chamber (exposure chamber) with a plasma source and a registration chamber equipped with separate pumping systems. Investigated sample is fixed in a removable heated holder and, thus, separates these two vacuum volumes. During experimental studies inlet surface of the sample is exposed in gas or irradiated by plasma, and a permeating hydrogen flux is registering. The registration chamber is equipped with a quadrupole mass analyzer (QMS), which records the partial pressures of some gases during the experiment. The developed QMS calibration system allows to perform conversion of relative partial pressures (ion currents) into the absolute values of the gas fluxes penetrating to the registration chamber with high accuracy. Thus, it became possible to measure the penetrating deuterium flux with an error of 0,5÷2% in the range of 1010÷1017 molecules D2∙s‑1. As a result of the complex of upgrades made earlier, vacuum conditions were significantly improved: the ultimate background pressures in the exposure chamber and registrations are 2·10‑6 and 5·10‑8 Pa, respectively. Also, gas purification systems such as: nitrogen traps and palladium filter for diffusion purification of hydrogen isotopes were put into operation. Thus, it became possible to perform experiments in the low pressure range of 0,1–100 Pa and temperatures of 300–1000 K, which are typical of TNR, as well as to study some features regarding to surface state and to processes on it, including the effects of plasma irradiation.

The updated PIM installation was used to study the permeation of deuterium through a number of promising materials for TNR usage: EK‑181 ferritic-martensitic steel, ChS‑68 austenitic steel, V‑4Cr‑4Ti alloy, also with deposited AlN coatings, porous materials based on fine-grained graphite.

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References

1. A.V. Golubeva, D.I. Cherkez, A.V. Spitsyn, S.V. Yanchenkov, A facility for permeation measurements under plasma irradiation. Instruments and Experimental Techniques. 60, 843–852 (2017).

1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/XLVII/Pt/ru/GV-Cherkez.docx) [↑](#footnote-ref-1)