SURFACE HYDROGEN ISOTOPES DETECTION BY LOW ANGLE ION SCATTERING SPECTROSCOPY

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Hydrogen isotopes retention in thermonuclear fusion reactors is limited due to safety regulations and should be well controlled. Surface conditions can strongly affect accumulation rates of hydrogen isotopes in the bulk of plasma facing materials. Therefore, *in vacuo* methods of surface composition control may help to investigate mechanisms of this effects.

Low- and medium-energy ion scattering (LEIS/MEIS) and direct recoil spectroscopy (DRS) are widely used techniques for surface analysis [1–4]. These methods have extreme surface sensitivity and even can analyze only the first atomic layer of adsorbate without any signal from the background [5]. In addition, DRS is sensitive even for hydrogen isotopes adsorption [6]. Thus, capabilities of the LEIS+DRS combination for the estimation of hydrogen isotopes concentrations in the very first surface layers are discussed.

LEIS and DRS were conducted on the “Large Mass-Monochromator “MEPhI” facility, which utilizes ion scattering spectroscopy by hydrogen and noble gas ions with the energies in the range of 1-25 keV. The apparatus is described in details in [7,8]. The scattering angle is fixed to 32°, which allows to obtain higher sensitivity and depth resolution compared to the backscattering analysis, although reduces mass resolution. Ar^+ ions were chosen for the analysis because it has higher scattering cross-section in comparison with neon. The optimal energy for the analysis was found to be 18 keV.

Initially only protium recoils were found in the energy spectrum on the polished tungsten surface. After that surface was precleaned by sputtering Ar gun, the recoil peak intensity decreased by 3 times. Then, deuterium gas was puffed into a vacuum chamber up to the pressure of 10^{-3} Torr and the sample was exposed in these conditions for 10 minutes. However, subsequent LEIS has not detected any deuterium recoils and protium recoils could be mostly result of water vapor than D_2 or H_2 adsorption. The reasons for that can be understood from a further specially designed experiment with heavy water (D_2O) adsorption. A thermal decomposition of $Ca(OD)_2 \rightarrow CaO+D_2O$ was utilized as a heavy water vapor source. Similar vapor source, but with $Ca(OH)_2$ was used in work [9].

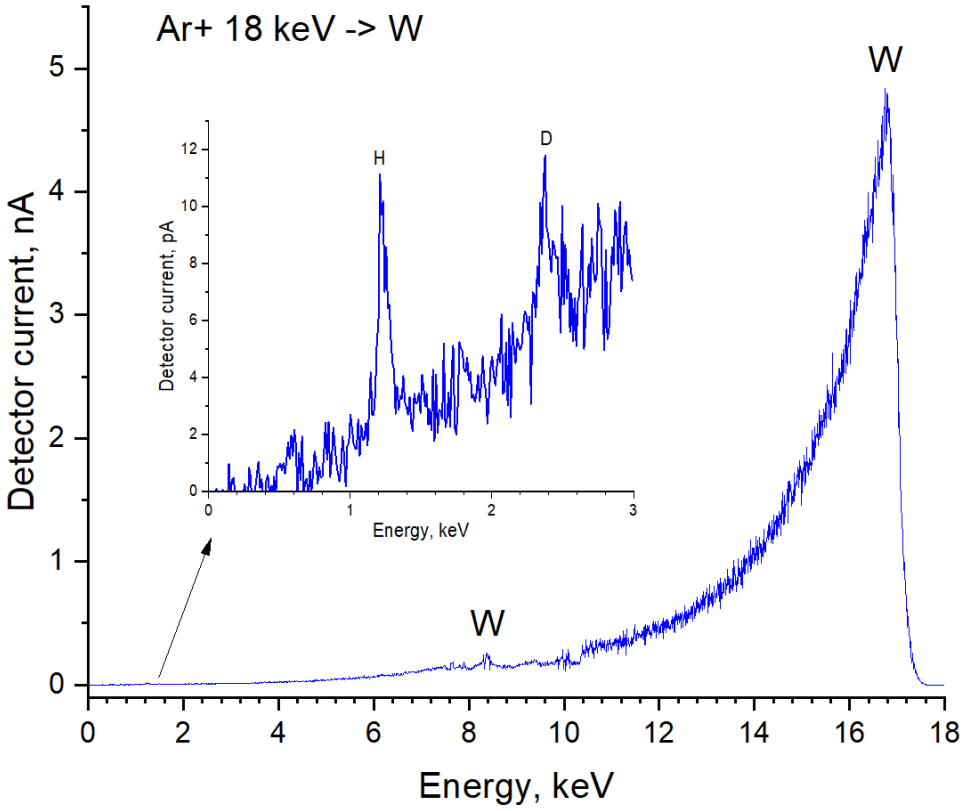

Fig.1 Typical LEIS spectrum for tungsten surface with D_2O vapor injection.

LEIS energy spectrum for tungsten surface during heavy water injection is given in fig. 1. Two tungsten peaks in the spectrum corresponds to Ar^+ and Ar^{++} scattering from tungsten as scattered ions separated by energy to charge ratio. Energies of two peaks in low-energy part are in good agreement with calculated energies for knock out H^+ and D^+(recoils). Recoils intensity is three orders of magnitude smaller than for Ar^+ ions, but scattering cross-section, that is 7.7 times less for H^+ recoil and 17 times less for D^+ should be taken into account for estimation hydrogen isotope consternation on the surface.

The dynamics of H^+ and D^+ peak depending on partial water pressure roughly estimated from residual gas analyzer is shown in fig. 2. For maximum D_2O pressure of $6 \cdot 10^{-6}$ Torr, the concentration of deuterium on the surface is 1.3 time higher than for protium. Some deuterium still remains on the surface for 5 minutes after turning off D_2O source. Thus, the technique is indeed sensitive to the presence of the hydrogen isotopes on the surface. On the other hand, one can conclude that the origin of H isotopes at the surface in our conditions is a water vapor, and it dominates even in the case of much higher H_2 gas pressure.

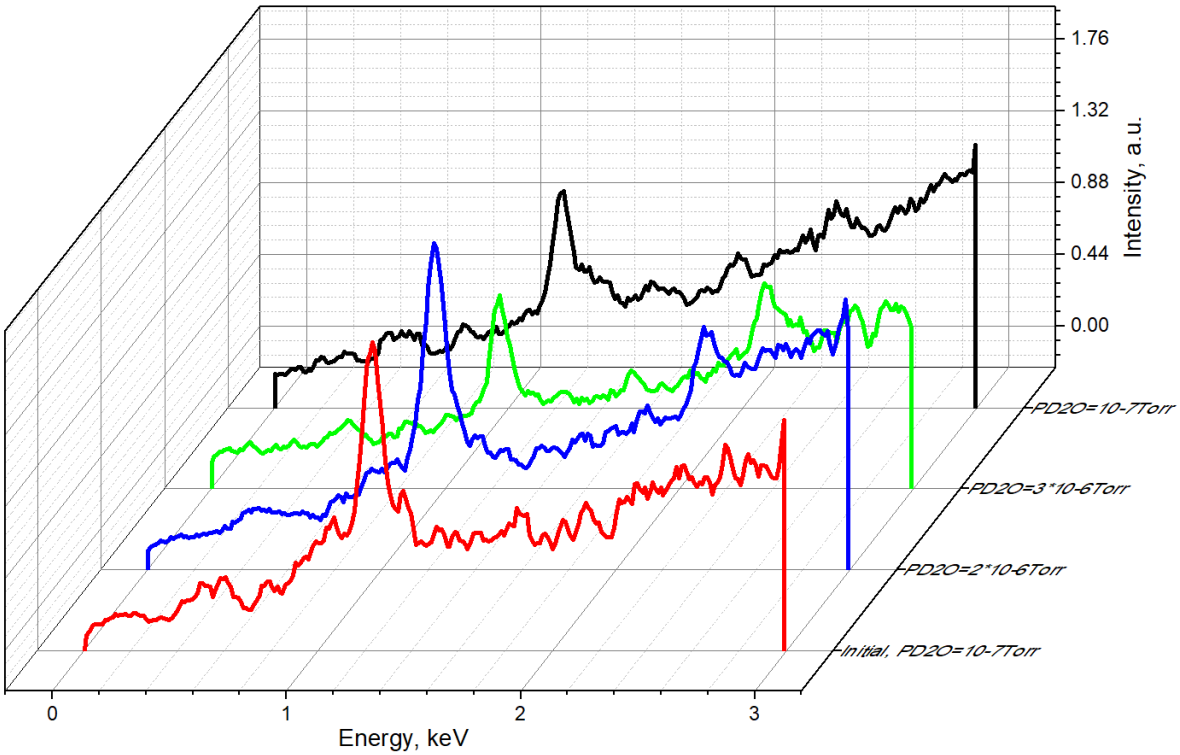

Fig. 2 Dynamic of protium and deuterium recoils during D_2O vapor generation.

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