Measurement of hydrogen isotopes and other light elements in thin films of materials of interest in fusion-reactor technology

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The capability of detecting and depth profiling hydrogen and its isotopes (deuterium, tritium) in the near surface region of solid materials is of great importance in different areas of materials science, one of them being the fusion-reactor technology [1].

Such as, in the investigation of the plasma-wall interaction in fusion research the total content as well as the depth profiles of hydrogen isotopes implanted and accumulated in the surface layers of the vessel walls have to be measured.

Ion beam analysis (IBA) techniques are especially valuable since the quantification of low mass elements is straightforward and sensitive. Among several ion-beam technique for detection and depth profiling of hydrogen isotopes, Elastic Recoil Detection Analysis (ERDA) technique using a low energy ^{4}He beam proposed by Doyle and Peercy [2] is particularly advantageous; all hydrogen isotopes can be profiled simultaneously with a sensitivity as high 0.1 at.%, the measurements can be performed using a relatively low energy accelerator and the samples undergoes less damage as compared with the use of high-Z analysis [2,3].

The large recoil cross sections and the possibility of placing detectors at forward (ERDA) and backward (RBS) angles was leading to a rapid development of the technique. So, the helium-induced hydrogen forward-recoil method has been finding increasing use in different laboratories.

A) The ***PN-II-PT-PCCA-2011-3090 / 2012-07-02*** project, namely *Characterization by IBA (Ion Beam Analyisis) and other advanced techniques of hydrogen and other light elements in thin films of materials used in nuclear industries(partners: Horia Hulubei National Institute of Physics and Nuclear Engineering,* *National Institute for Laser, Plasma & Radiation Physics (INFLPR) and National Institute for Materials Physics)* has as main objective the "*development of a performance experimental setup for the characterization of hydrogen isotopes and of other light elements using IBA techniques in thin films of materials used in nuclear industries".* The envisaged materials are of high interest for fusion technology (for both actual ITER and future DEMO fusion reactors): mixtures of W and C containing H or D, and also SiC. The present stage of the project has in view the investigation of SiC thin films produced by pulsed dual magnetron sputtering. This novel deposition method is known for producing "extremely dense with no discernible structural features or defects" in case of few materials (e.g. Al_2O_3 [4]). For evaluating the ability of pulsed dual magnetron sputtering technique in producing good quality SiC thin films, various sets of experimental parameters will be tested. Sole Ar and mixtures of Ar with H_2 and/or D_2 will be used as working gases. In the present stage of the project, the SiC samples will be investigated as regarding their elemental content by IBA. Supplementary, the as deposited SiC samples will be investigated by SIMS, XRD, FTIR, SEM, EDX, for obtaining a complete set of material characteristics. Following project stages will test the ability of SiC samples implanted with He in acting as diffusion barrier for H and D.

Beam request:

4 days (12 shifts) at the 3 MV Tandetron

4 days (12 shifts) at the 9 MV Tandem

References

[1] H Nakamura, J Dietz, P Ladd, Wall conditioning in ITER, Vacuum, 47, 6-8, 653-655, (1996)

[2] B. L. Doyle and P. S. Peercy, Appl. Phys. Lett. 34 (1979)811

[3] B. L. Doyle and P. S. Peercy, Proc. Of Workshop on the Analysis of Hydrogen in Solids, Albuquerque, NM (Jan. 23-25, 1979)

[4] Kelly P.J. , Abu-Zeid O.A., Arnell R. D., TongJ.SurfCoatTechnol, 1996;86-87:28-32

B) In the frame of the EURATOM programme, the section devoted to fusion technology, starting with 2014, the research proceeds in a new frame, that of EUROfusion Consortium. As part of EUROfusion Consortium there are Romanian partners focusing on topics devoted to materials for fusion. The work planning is in course of signature end of June, and among the topics we mention that of retention/desorption of hydrogen isotopes in W materials. In these projects samples of bulk tungsten or deposited thin films, or W nanopowder will be fabricated, and exposed to various plasma types for hydrogen isotope incorporation, but also for isotopes release. The main work of material preparation will be performed at the National Institute for Laser, Plasma and Radiation Physics. The assessment of retention and of desorption, and the study of influence of plasma conditions on retention/desorption needs determination of hydrogen isotopes content in W and W thin films or powders, at various stages of plasma processing. These techniques are well developed at IFIN-HH and we apply for a number of beam days in order to study the retention/desorption of hydrogen isotopes from W materials.

Beam request

3 days (15 shifts) at the 3 MV Tandem