AMS Depth Profiling of Tritium and Deuterium for Diagnose in Fusion Experiments at ASDEX-Upgrade

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Last three years the Upgraded Ultraclean Injector (UCI) of the Munich Accelerator Laboratory was used to measure T and D depth profiling with Accelerator Mass Spectrometry (AMS). The measurements were performed on polished carbon long term samples (LTS) placed between the vessel wall protection tiles of the Axial Symmetric Divertor Experiment (ASDEX-Upgrade). The depth resolution of such measurements depends on the flat bottom of craters produced by the sputter ion beam. Modern instruments provide uniform sputter currents by sweeping a finely focused primary beam in a raster pattern over a square area. In other instruments, apertures select secondary ions from the crater bottoms, but reject those from the edges.Alternatively, the data processing system ignores all secondary ions produced when the primary beam is at the ends of its raster pattern. In AMS all applied solutions are moving the target holder in front of the Cs-sputter ion beam. Similar to SIMS, in order to avoid crater rim effects the secondary ions are ignored by the data acquisition system when the Cs ion beam is sputtering on the crater walls. In our first experiments we were using a computer controlled periodic raster movement of the target sample in front of the ion beam. The number of scanned cycles were determining the depth of the crater in the sample. Using profilometry at the end of the expriment the cycle number was converted to depth. Finally, by setting a digital window on the flat crater bottom the crater rim effects were eliminated. However, the target movement or the beam sweeping produce both a tremendous increase of the analysis time in comparison to a static bombardment.Therefore,we developed and used in our last experiments a mathematical unfolding procedure which corrects the AMS depth profile distribution for the perturbing contribution added by the secondary ions when sputterd from the sidewalls of the produced crater. The unfolding procedure uses the crater dimensions provided by the profilometry measurement that is performed at the end of the in-beam analysis. Fig.1 shows the layout of the toroidal sector distribution in the ASDEX-Ugrade Tokamak and the two Neutral Beam Injection (NBI) heating devices. The LTS were installed in toroidal sectors but also in a poloidal distribution at sector 5 for every studied campaign. Until now, we have studied five discharge campaigns between 1997 and 2002 aiming to perform by AMS a diagnose of the fusion experiments. Interesting information was obtained on the improvement of the plasma confinement and stability after introducing the CDH-mode, the complete toroidal and poloidal distribution of T and the inventory of the T release in the tokamak.The depth profiling of deuterium provided information on the neutral beam injection (NBI) used for the suplementary heating of the plasma. Recently, a correlation between the T and D toroidal distributions was established. Tritium is produced during the plasma discharge in its center by the fusion reaction:D+D $\rightarrow$ T(1.01MeV)+H(3.02MeV). Being ionised, T moves gyrating around the closed magnetic field lines and is confined by the superposition of magnetic fields in the Tokamak.Its lifetime is of the oder of hundred of miliseconds drifting on closed orbits until it is slowed down at the end of the discharge. Interactions with other particles may produce scattering and escape form the magnetic confinement.

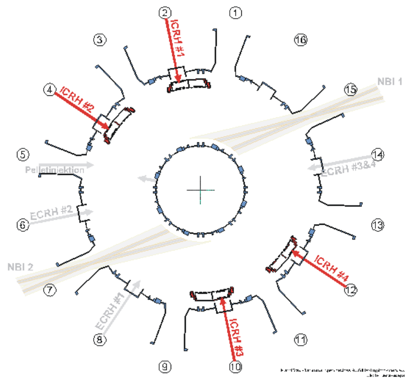

Fig. 1: The toroidal Sectors in the ASDEX-Upgrade Tokamak

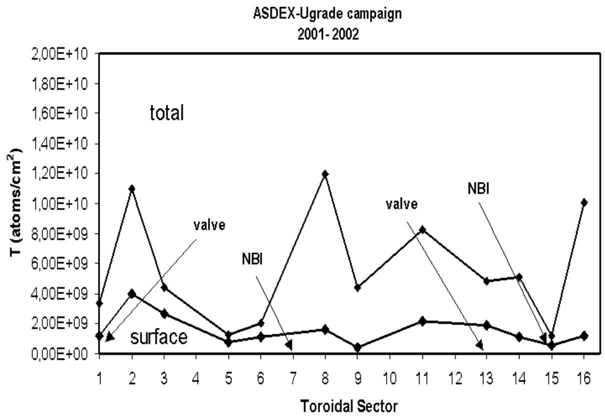

Fig. 2: Tritium total and surface depth distributions measured in carbon LTS exposed at ASEDX-Upgrade experiment. The arrows are indicating the positions of NBI and D-gas inlet valves.

This is to be seen in Fig.2 were the total T-distribution shows peaks in the vicinity of the toroidal sector numbers where the NBI (N= 7 and 15) and the gase inflow valves (N=1 and 13) are active. The peak postions are shifted about one sector contra clock wise as it would be expected for a T-D scattering produced on the inner plasma orbit. The surface deposition (up to 0.1 μm) is due to T ions having energies in the 100 eV range, except for a low flux of neutral atoms with energies up to the keV range, which are produced by charge exchange collisions in the 10 keV hot plasma. This contribution is only slightly affected by the scattering process.

References

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