AMS Depth Profiling of Tritium and Deuterium - a Sensitive Tool for Diagnose in Fusion Experiments

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In fusion experiments the balance of hydrogen isotopes is of a special importance. It can be determined by the ananlysis of the total amount and depth distribution of hydrogen isotopes accumulated in the materials situated at different wall areas of the tokamak. Precise information is obtained from the analysis of so-called long term samples (LTS) made of carbon, which are installed at the beginning of a fusion discharge campaign. For tritium detection and depth profiling Accelerator Mass Spectrometry (AMS) has shown to be the most suitable analytical method. If for bulk AMS measurements no special precautions in respect to the sputtering process on the target are required, in depth profiling the sputter erosion rate has to be uniform on the analysed area of the target and ions sputtered from the crater sides should not be included in the ananlysis. With this aim the Ultra Clean Injector (URI) of the AMS facility of Technical University Munich was upgraded and then used for standard measurments. Measurements have been performed for one campaign (1998-1991) at the Joint European Torus (JET)in Abigdon-England and other four campaigns (1997-1998, 1998-1999, 1999-2000, 2000-2001) at the Axial Symmetic Divertor Experiment (ASDEX-Upgarde) in Garching-Germany. The tritium is produced in the center of the confined plasma by the fusion reaction: D+D $\rightarrow$ T(1.01MeV)+H(3.02MeV). If T leaves the plasma immediately after its production, this would happen with a minor slowing down on drift orbits and impinging on the carbon LTS it will penetrate in depth about 8 μm (see fig.1 below).

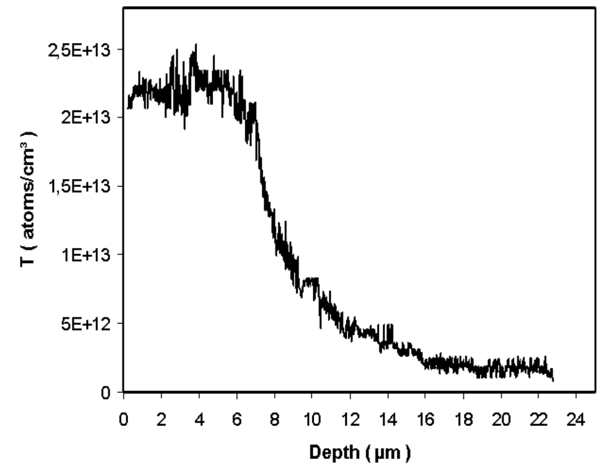

Fig. 1: Tritium depth profile distribution measured by AMS in a JET carbon LTS exposed at DD and DT discharges before 1991.

Such deep distributions were measured until 1994, when the Completely Detached High Confinement modus (CDH) was invented and applied in the tokamak expriments. Since then, the AMS measured T-depth profiles were showing a modified structure as can be seen from fig.2. The depth distribution noted "a" in fig.2 represents a standard distribution that we measure at this moment. The depth profile is sharper than the same distribution shown in fig.1. The comparison shows that the plasma confinement was better preserved during the CDH mode discharges. The new depth distribution can be separated in a surface deposition and a peak at about 0.5 μm from the surface (corresponding to E_T = 30 keV). The surface deposition is due to tritium 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. The peak, if is not extending deeper than 1 μm, corresponds to the tritium ions produced in the fusion reaction, then slowed down by drifting on orbits in the magnetic cage and released with an energy below 30 keV at the end of the discharge period. However, if the peak extends up to a larger depth this implies that some irregularities have occured in the fusion experiment. Such a situation is illustrated in fig.2, by the depth distribution noted with "b".

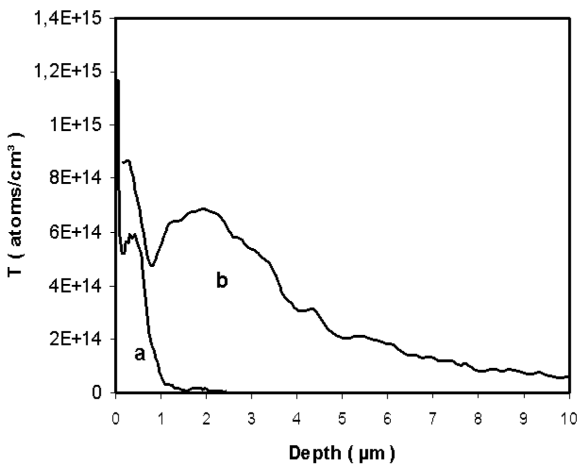

Fig. 2: Tritium depth profile distributions measured in carbon LTS exposed at ASEDX-Upgrade experiment: a) T-depth distribution showing a good preserved confinement (campaign 1998-1999); b) T-depth distribution indicating irregualrities during the discharge campaign (1999-2000).

The AMS measurments produced the complete distributions of toroidal and poloidal depth-profiles and the total inventory of the tritium release in the tokamak experiments. Localisation of the plasma disruption phenomeon was possible and consquently contributing to the improvement of the fusion experiments. Complementary, deuterium depth profiling measured on the LTS provided an estimate of the efficiency of the fusion reaction and information about neutral beam injection used for the plasma heating in the tokamak.