§34. Dynamic Behavior of Tritium Release from Stainless Steel for LHD

Matsuyama, M., Hatano, Y., Torikai, Y., Hara, M., Akaishi, K. (Univ. Toyama), Okuno, K., Oya, Y. (Shizuoka Univ.), Hino, T. (Hokkaido Univ.), Nisimura, K., Masuzaki, S., Ashikawa, N., Tanaka, M., Kawano, T., Uda, T., Asakura, Y., Sagara, A.

Since a given amount of tritium is generated when the D-D fusion experiments are conducted in LHD (Large Helical Device), it is of a great importance to examine preliminarily the trapping and release behavior of tritium in the construction materials of LHD from viewpoint of tritium safety. A part of tritium generated is exhausted by the vacuum pumps from the device, but the others are mainly retained in the materials of the first wall and diverter. A part of tritium trapped in the surface layers of those materials will be chronically released from the materials based on a concentration gradient of tritium. Such release behavior is of a serious problem when an operation of the device is stopped and an atmospheric gas is introduced into the device for maintenance of the device. This is due to a reason that a chemical form of tritium released from the materials is mainly the oxidized form of tritium. From this view point, dynamic behavior of tritium release from type 316L stainless steel (SS316L) used for a given period in LHD has been examined.

As a first step, small SS316L samples were exposed to tritium gas diluted with deuterium under the given conditions of temperature, pressure and time. After thermally exposed, the tritium amount retained in the surface layers of a sample was evaluated by β-ray-induced X-ray spectrometry (BIXS). Size of the samples is 10x10x0.5 mm^3, which were prepared cutting a part of the protection plates used to plasma experiments in LHD. Two kinds of samples were prepared in this study: namely, one is that the surface of a sample was the surface exposed to plasmas, which is denoted as the "as-received surface", and the rear surface was a polished surface. The other sample is that both surfaces of a sample were finally polished with a buff.

The tritium amount retained on the as-received surface was about 6 times greater than that on the rear surface (polished surface). Large difference in both surfaces is roughness of the surfaces. To examine the effects of surface roughness, one surface of a polished sample was scratched using four kinds of emery papers. After these samples were exposed to tritium gas under the same conditions, tritium retention was examined. As a result, the amount of tritium retention on the scratched surface was about 10-80% greater than that on the polished surface. This indicates that the large difference in tritium retention mentioned above is not due to the effects of surface roughness.

To examine the effects of an annealing temperature before tritium exposure, the samples heated at 673, 873 and 1073K in vacuum were prepared and subsequently each sample was exposed to the same pressure of tritium gas. Consequently, tritium retention had a tendency to be small with increasing a pre-heating temperature, but the effect for tritium retention was not so large.

There appeared depositions on the as-received surface of a sample, and a large amount of tritium retention was observed. Figure 1 shows a typical X-ray spectrum observed for the as-received surface by BIXS. Intensity of Ar(Kα) line is proportional to the amount of tritium retained in the surface layers of a sample. It is seen from the X-ray spectrum that the deposited layers on the as-received surface contains titanium as well as constituent elements of SS316L, although a chemical form of titanium is unclear. Existence of titanium in the deposition layers was similarly confirmed by EDX analyses of an electron microscope. Thickness of the deposition layers was about 2 μm. Since titanium is well known as one of materials that interactions with hydrogen are very strong, the present observation of large retention of tritium may be due to the effects of titanium.

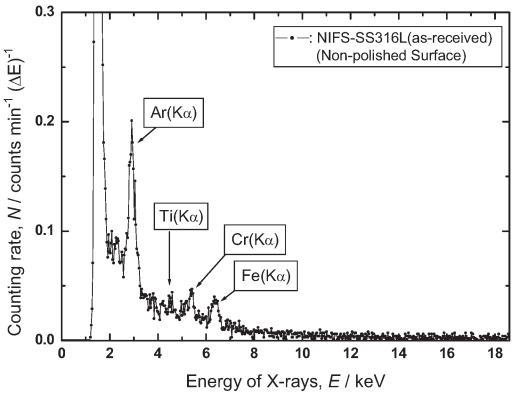

Fig. 1 Typical X-ray spectrum induced by β-rays of tritium retained in the as-received surface of a sample.

Release rate of tritium from the deposition layers was examined by immersing two deposited films (2 cm^2) into a liquid scintillator. As a result, it was seen that tritium activity in the scintillator gradually increased with time and the activity reached about 70 kBq after 17 days, but saturation tendency did not appear. Namely, it was suggested that the deposition layers may be a main source of tritium release.