§94. Development of Measurement (Analysis) Method of Hydrogen Isotopes in the Dust

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1. Introduction

During erosion of wall materials in fusion reactors by plasma-materials interactions, a part of the materials are exfoliated and/or the melted materials are solidified to be tiny particles and their agglomerates as dust[1]. Since collection and removal of the dust is very difficult, tritium retention behavior in the dust will be a great concern to alter tritium inventory in the reactor vessels. However, all the dust does not necessarily uptake much tritium. The dust may consist of alloys, intermetallic and/or non-intermetallic compounds like oxides and carbides with various sizes and shapes. In order to clarify tritium uptake and release behaviors of the dust, those of each particle should be examined. The aim of the present study is to develop and establish measurement and/or analysis methods of hydrogen isotopes in the dust by means of tritium tracer techniques. In the present report, we have proposed a safety handling technique of the dust including tritium and discussed how tritium distribution in the dust could be observed by the tritium imaging plate technique with using a Monte-Carlo simulation.

2. Experimental

Spherical particles of titanium (Ti) were used for a dust mock-up. The sizes of the dust were 45 μm and 150 μm in average as shown in Fig. 1.

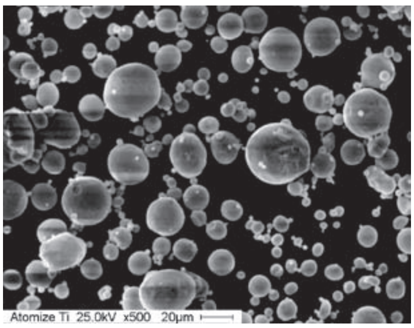

Fig. 1 Photograph of a Ti dust mock-up

Hydrogen and tritium loading to the Ti dust mock-up will be conducted by gas absorption at high temperatures preliminary in Kyushu University. Tritium concentration in hydrogen can be increased for further studies in University of Toyama after validation of a safety handling of the dust including tritium.

We have demonstrated that a Silicon adhesive rubber film and roller worked as good storage and removal of the mock-up dust and easy transfer of the dust to an electron-conductive tape for observation with a scanning electron microscope.

Amounts of tritium retained or released will be measured by the tritium imaging plate technique (TIPT)[2] and a liquid scintillation counting technique (LSCT)[3]. TIPT gives us distribution of the dust including tritium and/or tritium distribution in one particle of the dust as discussed below. LSCT gives us a total amount of tritium in one or several particles of the dust and information for release kinetics of tritium from the dust.

3. Summary

Figure 2 shows geometry of the dust and TIP during measurement of tritium β-electrons from the dust in the air used for the Monte-Carlo electron-photon transport simulation (PHITS 2.64). Figure 3 (a) shows distribution of energy deposition from tritium with uniform concentration through the tungsten (W) dust. Since β-electrons are absorbed in W, the small amount of tritium is emitted from the dust as shown in an upper column and deposited energy in TIPT, i.e. tritium distribution, is unclear as shown in a lower column. Whereas, the same amount of tritium segregated in a shell of the dust (see Fig. 3 (b)), can emit much T β-electrons from the dust to the surrounding air and TIP resulting in clear tritium distribution. These results suggest that tritium distribution in the dust affects quantification of tritium in the dust by β-electrons measurement. In other words, if the size, shape, composition and density of the dust can be confirmed, tritium distribution in the dust can be determined from β-electrons measurement and tritium desorption spectroscopy.

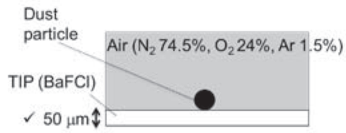

Fig. 2 Geometry of the dust and TIP during TIPT

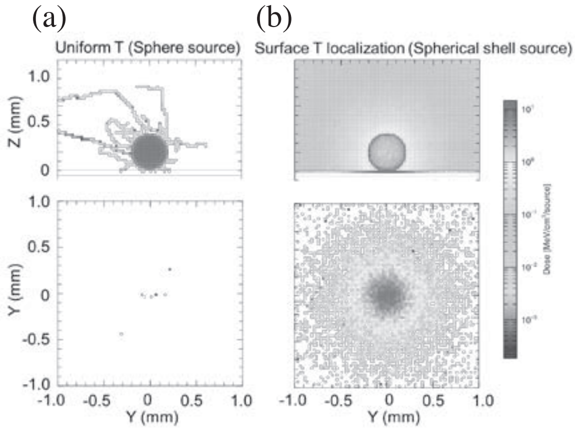

Fig. 3 Distribution of energy deposition from tritium (a) with uniform concentration through the tungsten dust and (b) localized in a shell of the tungsten dust to TIPT and the surrounding air.

1) Winter, J.: PHYSICS OF PLASMAS 7 (2000) 3862.
2) Otsuka, T., et al.: J. Nucl. Mater. 415 (2011) S769.
3) Otsuka, T., et al.: Fusion Sci. Technol. 54 (2008) 541.