§12. A Study of Helium Concentration Analysis in Material by Laser Induced Plasma Breakdown Spectrometry

Fukumoto, K. (Univ. Fukui),
Nagasaka, T., Muroga, T.

1. Introduction

The first wall and blanket system in the fusion reactor is exposed by 14MeV neutron irradiation and a large amount of radiation damage and nuclear transmutation elements are produced. Helium atom is not soluble in metals at all, and stabilizes the vacancy combined with itself. The accumulation of helium can accelerate the growth of the vacancy clusters, and induce the void swelling and intergranular embrittlement at high temperature. Therefore, monitoring technology of helium generation in materials under neutron irradiation will be required in order to understand the helium accumulation mechanism, the correlation between helium behavior and embrittlement mechanism and the life time estimation of structural element for fusion reactor blanket system application.

A helium monitoring method is usually used by a helium collecting apparatus with melting furnace. However, it requires long term and huge cost for the analysis, and some unexpectable radiation exposures occur in dismantling and treating the radio-activated specimens. Moreover, only an average data of helium concentration can be analyzed in a few gram of sample for material inspection.

A recent study on chemical analysis of nuclear materials using laser-induced plasma breakdown spectrometry (LIBS) has been developed and succeeded. It has never been reported on the analysis of helium as an impurity in solid materials including nuclear applications; a topic which may be beneficial in many field of nuclear material sciences as well as industries.

This study aims for helium detection method for nuclear material application using LIBS method.

2. Experimental procedure

Some plates of 15x15x1mm of SUS316 steels were cut out and electro-polished. The helium ion implantation were performed with 200keV He ion with a micro wave ion source ion implantation device at the Wakasa energy research center. The amounts of the helium implantation were estimated from TRIM-Code calculation and maximum amount of helium implantation was up to about 0.5at% around the the peak position.

A couple of Nd-YAG lasers were used for helium detection at Fukui University. The laser irradiation was performed on the specimen surface in water in a cell. The YAG laser output of 50mJ corresponds to the power density of 10^{10}GW/cm^2. The laser oscillation for a couple of YAG lasers was controlled by a delay generator for the pulse interval and timing. At first, the first pulse was condensed and irradiated on the specimen surface with a lens of focal length of 100mm and an air bubble with plasma inside was generated on the specimen surface after the first laser irradiation promptly. When the bubble grew up enough greatly after several hundred micro seconds, the second laser pulse was condensed and irradiation in the center of the bubble and induced the plasma inside the bubble. The luminescence of induced plasma in the bubble was condensed with a lens and conducted into a spectroscope through an optical fiber. The spectrum of plasma was collected in an ICCD detector and analyzed by spectroscope in order to detect the signal of the helium plasma , 587.5nm of wave length.

3. Results

The laser of 300mJ focusing of the first laser could induce the ablation from the range of the surface area in the square of 0.5mm, but signal of the helium could not be detected in the spectrum around 587nm.

In order to take more helium release from the specimen surface, the defocused laser irradiation was performed and a wider irradiation area with a square of 3-4mm was obtained. But no helium signal was obtained because decrease of laser energy density for the laser ablation might not make the excitation of helium plasma due to the laser defocusing.

As a result, the helium excitation plasma cannot be formed enough by double pulse LIBS method in the water with the LIBS system at the Univ. of Fukui. It is necessary to seek an alternative technique enough to excite the helium plasma released from specimen surface after laser ablation in the LIBS experiment.