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Hydrogen isotope retention in C and W mixed co-deposition layer
炭素タングステン混合薄膜における水素同位体吸蔵に関する研究

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In this study, C and W mixed co-deposition layer and pure C deposition layer, which were prepared by the magnetron sputtering device, were exposed to low energy (300 eV) of pure D ion beam. The D retention properties of deposition layers were examined by thermal desorption spectroscopy (TDS). Specimens which have different structural properties were prepared by changes of formation processes temperature. The states were observed by Raman spectroscopy. We discuss the influence of different structural properties and existence of W on the retention properties of deposition layers.

1. Introduction

Carbon (C) and Tungsten (W) are candidates for plasma facing materials for future fusion reactors. C has good thermal and mechanical properties, and low atomic number. However, C has a high sputtering yield and forms co-deposition layers with tritium (T) in fusion reactor. In addition, there is possibility that C-W co-deposition layers are formed. T is radioisotope and its total amount is limited in a fusion reactor. Therefore, studies on erosion and re-deposition behavior of C and W are important for safety reasons for T.

There are two processes by which deposition layers trap T. One is the co-deposition, which mentioned in the preceding paragraph, the other is exposure to T plasma. The latter process seems to be influenced by structural properties and W doped concentration of deposition layers. However, its influence is not known well.

In this study, specimens which have different structural properties and W concentration were prepared by the magnetron sputtering method. After that, they were irradiated by D ion beam, simulating exposure to T plasma. Their structural properties were observed by Raman spectroscopy, and D retention properties by TDS.

2. Experimental

Magnetron sputtering experiments were done at Ar atmosphere. Ar was introduced at the constant flow rate (5sccm) by mass flow controller and ambient pressure was 20 mTorr. A discharge voltage and a current were 550-600 V and 200 mA. Deposition time was 5 h, and those layer thicknesses were around 400 nm. C-W co-deposition layers were prepared by setting W chips on the C sputtering target. In addition, changes of formation processes temperature (200, 400, 600℃) induced different structural properties of deposition layers.

The ion beam irradiation experiments were done with high flux mixed ion beam device HiFIT [1]. The ion beam energy is 300 eV and irradiation flux was ~ 3 x 10^{19} D/m^2s. The irradiation fluence was ~ 1 x 10^{23} D/m^2. The specimen temperature was 377K.

Raman spectra were observed in 800~2200cm-1 region. Raman spectra showed G peak (at ~1570 cm^{-1}) and D peak (at ~1350cm^{-1}). There were various shapes of spectra as difference of formation processes temperature. For data analysis, the G and D peaks were fitted with Gaussian after subtracting background also fitted with Gaussian curve.

The D retention properties of deposited layers have been analyzed with TDS. Samples were heated from RT to 1273 K with heating rate of 0.05 K/s. D_2 signal was calibrated by a D_2 calibrated standard leak and signals from other masses were estimated by using known sensitivity data of Quadrupole Mass Spectrometer (QMS).

3. Research plan

In this presentation, we show the D retention properties of deposition layers and discuss the effects of the different structural properties and existence of W on the D retention properties of deposition layers. To study the above subjects, specimens that have different W doped concentration will be prepared and the series of experiments will be done on the specimens. In addition, TDS analysis for D_2O and CD_4 signals is planned in order to confirm D retention properties. Finally, we discuss risk of T in re-deposition layers in fusion reactors.

References

[1] Y. Ueda, Fusion Eng. Des 61-62 (2002) 255-261.