Hydrogen incorporation in tungsten oxide films deposited by RF plasma

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Tungsten is a candidate for plasma facing materials in tokamaks. The accumulation of hydrogen in the re-deposited layer on the first wall surface is an important issue for tritium inventory. Although very high H concentrations were found in major tokamaks using carbon-based plasma facing materials such as JET, TFTR and Tore-Supra, the remarkably lower H retention was confirmed in JT-60U. The hydrogen accumulation in the re-deposited layer depends on the composition and on the temperature of the deposited area. In the present study, up-take and thermal release of hydrogen in tungsten layer deposited by RF-plasma was investigated in connection with the composition and structure of the oxide layer. Tungsten films of about 500 nm were deposited on a SiO₂ glass by the RF magnetron sputtering with a W metal target using a mixture of Ar and O₂ gas in a deposition chamber under the base pressure of about 1 x 10⁻⁵ Pa, at the substrate temperature varying from 300 to 970 K. The thickness and elemental composition of the deposited layer were measured by the Rutherford Backscattering Spectroscopy. The concentration depth profiles of hydrogen in the films were measured by the Elastic Recoil Detection Analysis. The crystal structure of deposited films was examined by X-ray diffractometry. The surface morphology and cross sectional image was obtained by the scanning electron microscope.

The elemental composition of the deposited W film drastically changed with a partial pressure ratio of O₂/Ar at around 1/10. Tungsten tri-oxide WO₃ was formed with higher O₂ pressure, while a little oxygen (O/W~0.2) was found for the film prepared with lower pressure. At higher substrate temperatures, a considerable amount of hydrogen was uniformly distributed in the WO₃ films, where (002) plane of the monoclinic or orthorhombic phase of WO₃ was grown. The maximum concentration of H was about H/W = 0.8. Because the thermal release of the accumulated hydrogen completed the 700 K, the hydrogen was uptaken after the deposition procedure. The changes of the optical properties of the tungsten films by hydrogen incorporation were also examined by absorption measurements.

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