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Ion beam irradiation effects of Niobium oxide thin films formed by oxygen cluster ion beam assisted deposition

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Introduction

The thin films metal oxides, for example Nb_2O_5 will be used for multi-layer thin films for optical devices combined with SiO_2 thin films. It is necessary for the improvement of the optical properties to control accurately the refractive index and the optical transparency of the Nb_2O_5 layer, i.e. high stoichiometry and so-called 'amorphous' structure.

The fluorescence XAFS analysis is one of powerful tools to analyses the valence state and the structure of the 'amorphous' thin films at the atomic level instead of the conventional X-ray diffraction technique. In this study we made the fluorescence XAFS measurement of Nb oxide thin films, which were obtained by the oxygen gas cluster ion beam assisted deposition techniques.

Experimental

The Nb K-XAFS spectra of Nb oxide thin films with 200nm thickness, which were formed by both the oxygen gas cluster ion beam assisted deposition and an electron beam deposition only, were measured in fluorescence XAFS mode by a Lytle type ionization chamber using incident X-ray beam monochromatized by double Si(111) crystals at beam line 12C. Also the Nb K-XAFS spectra of various Nb oxide samples including Nb oxide deposition target material were measured as reference.

Results and Discussion

Fig. 1 shows the comparison of the Nb K-XANES of the samples. The XANES spectra of the Nb oxide thin films obtained by the oxygen gas cluster ion beam (GCIB) assisted deposition were closer to stoichiometric Nb_2O_5 than that by the electron beam deposition only.

Table 1 shows the results of the curve-fitting analysis for the first shell Nb-O peaks. Coordination numbers ***N***, interatomic distances ***R*** and mean-square-relative displacements σ are listed. Also this indicated that the Nb oxide thin films obtained by the GCIB assisted deposition were more similar to stoichiometric Nb_2O_5 than that by the electron beam deposition only comparing with the Nb-O distances and their distribution.

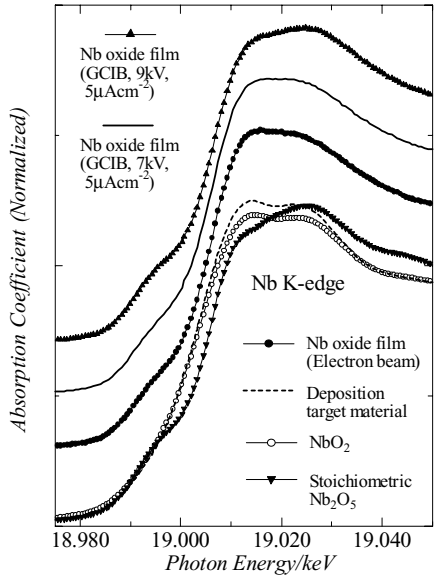

Fig. 1. Nb K-XANES of Nb oxide thin films, which were formed by the GCIB assisted deposition and electron beam deposition together with those of various Nb oxides.

Table 1. The results of the curve-fitting analysis.

Sample	***N***	***R*** [Å]	σ[Å]
Stoichiometric Nb_2O_5	2 (fixed) 2 (fixed) 2 (fixed)	1.854(5) 2.010(6) 2.166(1)	0.076(8) 0.062(4) 0.131(16)
NbO_2	6 (fixed)	2.05	0.09
Deposition target material	6 (fixed)	2.05	0.08
Nb oxide film, (Electron beam)	6 (fixed)	2.11	0.13
Nb oxide film (GCIB 7 kV, 5μAcm^{-2})	2.5 3.5	1.99 2.16	0.09 0.09
Nb oxide film (GCIB 9 kV, 5μAcm^{-2})	2.7 3.3	1.99 2.16	0.10 0.10

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