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The Effect of the Oxygen Flow Rate on the Electronic Properties and the Local Structure of Amorphous Tantalum Oxide Thin Films

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The electronic properties and the local structure of tantalum oxide thin film with variation of oxygen flow rate ranging from 9.5 to 16 sccm (standard cubic centimeters per minute) have been investigated by X-ray photoelectron spectroscopy (XPS), Reflection Electron Energy Loss Spectroscopy (REELS), and X-ray absorption spectroscopy (XAS). The XPS results show that the Ta4f spectrum for all films consist of the strong spin-orbit doublet Ta4f_{7/2} and Ta4f_{5/2} with splitting of 1.9 eV. The oxygen flow rate of the film results in the appearance of new features in the Ta4f at binding energies of 23.2 eV, 24.4 eV, 25.8, and 27.3 eV, these peaks attribute to Ta¹⁺, Ta²⁺, Ta³⁺/Ta⁴⁺, and Ta⁵⁺, respectively. Thus, the presence of non-stoichiometric state from tantalum oxide (TaO_x) thin films could be generated by the oxygen vacancies. The REELS spectra suggest the decrease of band gap for tantalum oxide thin films with increasing the oxygen flow rate. The absorption coefficient μ and its fine structure were extracted from the fluorescence mode of extended X-ray absorption fine structure (EXAFS) spectra. In addition, bond distances (r), coordination numbers (N) and Debye-Waller factors (σ^2) each film were determined by a detailed of EXAFS data analysis. EXAFS spectrapresent both the increase of coordination number of the first Ta-O shell and a considerable reduction of the Ta-O bond distance with the increase of oxygen flow rate.

Keywords: Tantalum Oxide, REELS, XPS, EXAFS