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Tin Oxide Thin Film Deposition for Gas Sensor by Reactive Ionized Cluster Beam(R-ICB)

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Polycrystalline tin oxide thin films have been deposited by a number of methods such as sintering, sputtering, rapid thermal oxidation, and other chemical reactions. In this study those methods are reviewed, and new technique to fabricate thin film type SnO_2 gas sensor as prototype of semiconductor oxides for detecting reducible and flammable gases such as H_2, CH_4, C_3H_{10}, and CO with high sensitivity is introduced. In order to fabricate tin oxide film on Si and glass substrates by R-ICB, hybrid ion beam system, which were composed of two metal ICB sources and one cold cathode type gas ion gun, was constructed. Tin oxides films were prepared by three ways of deposition conditions: 1. Pure tin metal evaporation by ICB with blowing oxygen gas near substrate; 2. Pure tin metal evaporation by ICB with assisted ionized oxygen by ion gun; 3. Pure tin oxide evaporation by ICB at various oxygen pressure. Crystalline structure of deposited tin oxide thin films could be easily controlled by change of acceleration voltage, ionization current, and oxygen pressure. In particular, nonstoichiometry of deposited film was also influenced by deposition rate and substrate temperature. Chemical reaction between tin and oxygen was microscopically identified by grain growth as acceleration voltage was increased and oxygen flow rate was varied in AFM study. Composition of two SnO/SnO_2 phases was analyzed by XPS study and those results were referenced to determine mixed crystalline structure deduced from XRD. Optical property of deposited tin oxide film on glass substrate was also investigated by measuring reflectivity in visible range. For the ultimate purpose, resistivities for all tin oxide films deposited at various conditions were measured by self-designed four point probe which can be operated under vacuum. CH_4 was used as a source gas and its sensitivity and kinetics of deposited thin film was studied at various gas concentration and heating temperature.