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Ta_2O_5/SiO_2 Multilayered Thin Film on Si as a New Reference Material for SIMS Depth Profiling

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In sputter depth profiling analysis, ion beam is generally used as a microsectioning source. However the ion beam bombardment always modifies the surface composition and structure, which results in broadening in depth resolution. Improvement of the depth resolution is one of the most important tasks in sputter depth profiling. In order to optimize the experimental parameters and calibrate the depth scale, well-defined thin film standard reference materials are required. These materials must have flat surface and sharp interfaces. Moreover, the surface modification by ion beam sputtering must be minimized. These reference materials provide an important basis to certify the reliability of the depth profiling results obtained in different laboratories.

Amorphous Ta_2O_5 on Ta(NPL CRM No. S7B83 ; BCR No. 261)[1], polycrystalline Ni/Cr multilayers on Si(NIST SRM 2135)[2], and single crystalline GaAs/AlAs on GaAs substrate[3] have been developed as standard reference materials for sputter depth profiling. Recently a marker-type multilayer structure consisting of thin layers of Cr_2O_3 between thicker layers of Cr has been developed as a standard reference material for SIMS depth profiling(NIST SRM 2136)[4]. The oxide marker layers can be easily identified by the enhanced metal-ion signal at the oxide interfaces. However SIMS depth profiling of the sample has shown that the interfaces are broadened with sputter depth due to the surface topographic development by Ar ion beam sputtering. Moreover, oxygen ion beam can not be used as a sputtering source for the SRM.

In this study a marker-type oxide multilayered thin film is being proposed as a standard material for SIMS depth profiling. This material is composed of 7 thick Ta_2O_5 layers separated by delta-doped SiO_2 layers. The Ta_2O_5 and SiO_2 layers were grown on a HF-treated Si(100) surface by reactive sputter deposition of Ta and Si targets under oxygen gas flow. At the oxygen partial pressures above 5.0 x 10^{-4} Torr, only stoichiometric Ta_2O_5 peaks were observed at 26.5 and 28.3 eV. As the same manner, Si 2p core level XPS spectrum of the SiO_2 thin film grown at that oxygen pressure shows also stoichiometric SiO_2 peak at the binding energy of 103.6 eV. From the above result, the Ta_2O_5 and SiO_2 layers of the standard thin film were grown by sputter deposition under the oxygen partial pressure of 6.0 x 10^{-4} Torr. The growth rates of the Ta_2O_5 and SiO_2 layers were 3.1 nm/min. and 6.7 nm/min., respectively.

Surface topography of the thin film was studied by AFM before and after ion beam sputtering. The surface of the as-deposited thin film is very flat with respect to the bare or HF-treated silicon surface. And surface morphology after sputtering shows that there is no great topographic development by ion beam sputtering under various experimental conditions, which is well correlated with the result that there is no great deterioration of SIMS interface resolution with sputter depth. This standard material should be effectively used to optimize the experimental parameters to get the best depth resolution and to calibrate sputtering rate.

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