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Growth and Chracterization of Ta_2O_5 Thin Films on Si by Ion Beam Sputter Deposition

K. S. Park, D. Y. Lee

Dep. of Mat. Sci. & Eng. Korea University

K. J. Kim, and D. W. Moon

Surface Analysis Group, Korea Res. Inst. of Standards and Science

Tantalum pentoxide thin films have been studied extensively because of their potential application as capacitor dielectrics in DRAM and SRAM. Very high dielectric constant(20-25), thermal and chemical stability were attractive properties for a VLSI DRAM capacitor material. but as the film thickness decrease, their interface instability is one of the problems of this material for the application of VLSI DRAM capacitor.

In this study, we investigated the chemical state at the interface of Ta_2O_5 and Si substrate in details. Tantalum pentoxide thin films on silicon were prepared by ion beam sputter deposition(IBSD) and dual ion beam assisted deposition(DIBAD) at the temperatures between 100℃ and 400℃. Before and during the film deposition, the surface state was monitored by the in-line XPS and SIMS analysis. The chemical state of the thin films were depth profiled by XPS using 7 keV oxygen ion beam of 70° incidence angle as a sputtering source. We found the metallic Ta component at the interface of the Ta_2O_5 thin film grown by IBSD but Ta was completely oxidized at the interface of the sample grown by DIBAD. The same results were observed at the in-situ XPS analysis of the initial growing stage of the thin film growth. The change of the relative dielectric constant value with the total film thickness and the post-annealing was explained with the chemical state profiles of Ta and Si through the Ta_2O_5 film and the Ta_2O_5/Si interface.