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Growth Characteristics and Dielectric Properties of ALD-Ta_2O_5 Thin Film Using $TaCl_5$ Precursor

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Due to the rapid shrinkage of the devices like DRAM, the development of high-k dielectric materials has been attracted much interest to satisfy the high cell capacitance in the future device. A wide variety of high-k materials are currently being evaluated including Al_2O_3, HfO_2, ZrO_2, Ta_2O_5, Nb_2O_5, TiO_2, $SrTiO_3$ (STO), and $Ba_{0.5}Sr_{0.5}TiO_3$ (BST). Among them, TiO_2-based materials including STO and BST have advantage of high dielectric constant but also have low electrical barrier height and high leakage current problem. On the other hand, high dielectric constant over 50 was reported in hexagonal Ta_2O_5 films using Tantalum halide precursor such as $TaCl_5$ [1)] or TaF_5 [2)]. The barrier height of Ta_2O_5 dielectric material will be expected to have larger value than those of TiO_2-based dielectrics, because of high band gap of Ta_2O_5 over TiO_2. Even though TaN was widely known to have higher work function than TiN, little was reported about electrical properties of TaN/Ta_2O_5/TaN capacitor.

In this study, Ta_2O_5 films were fabricated using Atomic Layer Deposition (ALD) method on TaN and TiN electrodes**.** $TaCl_5$ and O_3/H_2O were used as Ta_2O_5 precursor and oxidants, respectively. The growth temperature range of the films was 300~375℃ and rapid thermal annealing (RTA) process was carried out to crystallize the Ta_2O_5 films after dielectric deposition. Structural properties of Ta_2O_5 dielectric layer and electrical properties of metal / insulator / metal (MIM) capacitor with TaN/Ta_2O_5 combination such as capacitance, leakage current density and dielectric constant were compared with TiN/ Ta_2O_5 stack. The crystal structures and impurities were analyzed using transmission electron microscope (TEM) and time of flight secondary ion mass spectrometry (TOF-SIMS).

References

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