ALD Fundamentals
Room On Demand - Session AF7
Growth and Characterization: Low Temperature ALD

AF7-1 Neutral Beam Enhanced Atomic Layer Deposition at Room Temperature for Si Dielectric Film, ***Ge Beibei,*** Tohoku University, Japan, China*; C. Hua Hsuan,* National Yang Ming Chiao Tung University , Taiwan*; O. Daisuke, O. Takuya, S. Seiji,* Tohoku University, Japan

Atomic layer deposition (ALD) is a synthesis thin film technique based on sequential, self-limiting reactions which has developed significantly in recent years [1]. Silicon dielectric films such as silicon dioxide (SiO_2) films and silicon nitride (SiN) films can be deposited using several ALD techniques, such as thermal ALD and plasma-enhanced ALD. The high deposition temperature and high thermal budgets have become a problem of traditional thermal ALD, the deposited films show low quality and poor step coverage [2]. PEALD could deposit at lower temperature, but inherent problems in plasma process such as plasma irradiation and charge accumulation will cause defects on films [3]. In previous report by Samukawa et al, using O_2 neutral beam could synthesize the very high quality SiO_2 film on the Si substrate at room temperature [4]. In this work, we demonstrated growth of Si dielectric thin films by neutral beam enhanced atomic layer deposition (NBEALD) at room temperature.

Thin SiO_2 and SiN films were deposited on Si substrate at 30°C using bis(diethylamino)silane (BDEAS) as Si precursor, O_2 or N_2 as the neutral beam gases. The NBEALD cycle was composed as follows: precursor absorption, purge, reactive gases injection, neutral beam irradiation and purge. In this process, neutral beam instead of plasma was used in irradiation step of ALD for providing energy on surface reactions. The thickness of NBEALD Si dielectric films was measured by spectrum ellipsometer. Film quality was investigated by X-ray photoelectron spectroscopy (XPS) to analyze the element composition. The density of the Si dielectric films was studied by x-ray reflectivity (XRR). The surface roughness of the deposited films was investigated by atomic-force microscope (AFM).

SiO_2 films with high quality in terms of chemical composition, surface roughness and mass density are equivalent to that of thermal oxidation films. For the growth of SiN film, the growth per cycle of the feed time was saturated over the 2 sec. The deposition rate was 0.32 Å/cycle. For the XPS results, SiN film showed the strong N-Si_3 peak at 397.5 eV. On the other hand, weak C-NH_2 peak at 399.7 eV, and C=O peak at 531.5 eV were observed. As a result, it suggests that the carbon contamination was amide group that comes from precursor. It can be solved to optimize the NB source power and bias power condition. Hence, N_2 neutral beam with BDEAS achieved the SiN film growth at room temperature.

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