Effect of Ar Purge Step Condition on PEALD-TiN Film Properties

Ju Eun Kang, Surin An, and Sang Jeen Hong
Department of Semiconductor Engineering., Myongji University, Yongin 17058, Korea
Tel.: +82-31-330-6374, E-mail: samhong@mju.ac.kr

The role of the metal diffusion barrier become more crucial for the low power consumption and high reliability in the metallization process. TiN thin film has been a conventionally preferable material for Cu diffusion barrier using atomic deposition layer (ALD). Despite of the purge steps in time-divided cyclic ALD, undesired residues of precursor and reactants remained inside the process chamber may turns into unexpected particles in the film which can jeopardize the film quality. Extending purge time can avoid the presence of the particle, but it also decreases the manufacturing throughputs due to the extended process time. Therefore, we investigated the relationship between purge time and characteristics of the TiN thin film quality. The TiN films deposited in 6-inch PEALD system with varyied purge conditions was inversigated with repect to the thickness, sheet resistance, and surface composition with ellipsometry, a 4-point probe, and X-ray photoelectron spectroscopy, respectively. The by-product production, with respect to the flow rate of the purge gas and flow time, was also investigated using Employing Chemkin simulation study.

As the longer Ar flow time, the N 1s peak of 300 sccm as the Ar flow rate and thickness decrease because the screening effect increases and it means that residual Ar atoms are intervened between the adsorbents to block the adsorption of the precursors and reactants. As shown in Fig. 1, through chemical reaction simulations, we found that the production rate of hydrocarbon increased as the Ar flow rate increased because Ar as inert gas increases the collision between chemical species in the chamber, making the production rate increase. We found that when the Ar flow rate increased, the reaction between the desorbed ligands increased to form an unstable compound (CH_3), and as the material was formed, the carbon component increased. Especially, in low Ar flow rate, the C_3H_6 production rate increased. Carbon 1s peak decreased at a lower Ar flow rate because the stable compound (C_3H_6) is easily removed from the chamber by the pump. Thus, we concluded that inducing the generation of these compounds can reduce the removal of the incorporation of materials into the thin film surface. In the past ALD process cycle optimization research, the focus has been on optimizing the flow time of precursors and by-products rather than purging. However, in this study, the effect of the purge condition on the characteristics of the TiN thin film was confirmed was proposed. This can be a novel approach to prevent by-product incorporation through purge conditions in terms of controlling the surface composition of thin films.

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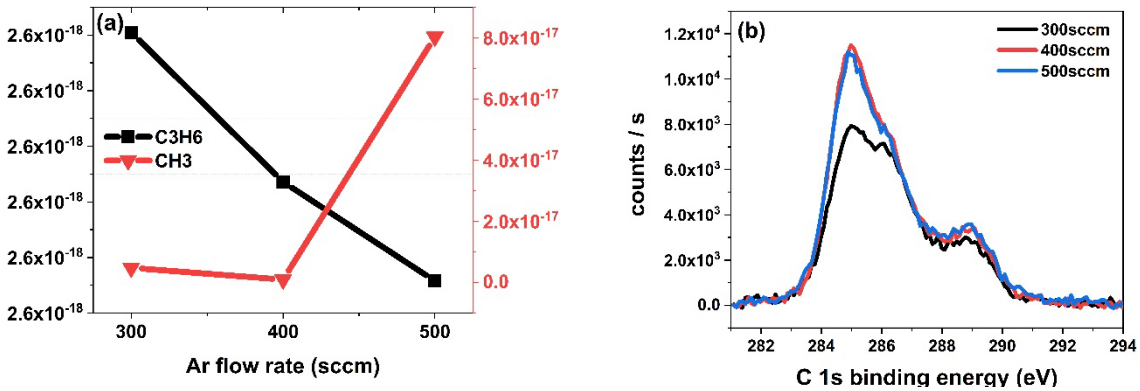

Fig. 1 Chemical reactions; (a) CH_3 and C_3H_6 production rate by Ar flow rate and (b) C 1s peak by Ar flow rate.