We have deposited the W-N diffusion barrier with pulse plasma enhanced atomic layer deposition (PPALD) method by using WF₆ and NH₃. In the conventional ALD process of W-N film, since the WF₆, N₂, NH₃, and N₂ gases are introduced into the reactor in sequential order, the N content seems not to be effectively incorporated into the W-N film from the initial growth stage of W-N since the WF₆ gas adsorbs to Si surface and forms W layer due to the fast Si catalytic reaction with WF₆, and the NH₃ gas does not effectively adsorb to the W layer, resulting in that the N content is deficient at the bottom layer of W-N on the Si. Therefore, in this work, we have provided the nitrogen atoms during the ALD cycles by PPALD method. Experimental results show that the N content is uniformly distributed into the W-N film since the H₂ and NH₃ gases dissociated by the pulse spike plasma adsorb to the Si surface first, and then react with WF₆ [1]. The resistivity of PPALD W-N is about 100–300 μΩ-cm and the deposition rate per cycle is ~0.5 Å/cycle. As a diffusion barrier for the Cu interconnect, we have investigated thermal stability Cu/PPALD W-N/Si structure after annealing at 500°C for 30 min as shown in Fig. 1. This HR-TEM reveals that 25 nm thick W-N successfully prevent Cu penetrating through the W-N at 500°C for 30 min. In this work, we will discuss the metallurgical characteristics of PPALD W-N film and the performance of diffusion barrier or the Cu interconnect depending on thickness of W-N film and annealing temperatures.

Fig. 1. Transmission electron microscope image of Cu/W-N/Si structure after annealing at 500°C for 30 min. W-N films were deposited after 100 cycles at 350°C.

Reference