PULSE PLASMA ENHANCED ATOMIC LAYER DEPOSITION OF TUNGSTEN NITRIDE DIFFUSION BARRIER FOR COPPER MULTI-LEVEL INTERCONNECT.

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We have deposited the W-N diffusion barrier with pulse plasma enhanced atomic layer deposition (PPALD) method by using WF_6 and NH_3. In the conventional ALD process of W-N film, since the WF_6, N_2, NH_3, and N_2 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 WF_6 gas adsorbs to Si surface and forms W layer due to the fast Si catalytic reaction with WF_6, and the NH_3 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 H_2 and NH_3 gases dissociated by the pulse spike plasma adsorb to the Si surface first, and then react with WF_6 [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^{o}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^{o}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.

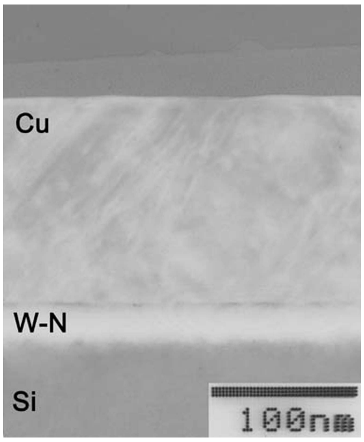

Fig. 1. Transmission electron microscope image of Cu/W-N/Si structure after annealing at 500^{o}C for 30 min. W-N films were deposited after 100 cycles at 350^{o}C.

Reference

1. D.J. Kim, H.S. Sim, Y.T. Kim, and S-I.Kim, Jpn. J. Appl. Phys. 40, 1214 (2001)