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구리 배선공정에서의 CVD TaN 확산방지막에 관한 연구
A study on CVD TaN as a diffusion barrier for Cu interconnects

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Tantalum nitride film was deposited by chemical vapor deposition with the aid of ion beam (ion-beam induced CVD, IBICVD), which was devised in order to obtain films with high density. The IBICVD system consists of two parts. One is the deposition chamber and the other is the ion beam source. The ion beam source is composed of the plasma tube and two grids. The upper grid is electrically floated to repel most of the electrons and attract ions from the plasma. The lower grid is biased to 1kV in order to extract and accelerate the ions. In order to extract N-, Ar- or H- ion beam, N_2, Ar or H_2 was used as a plasma gas, respectively. These ion beams are used to bombard the film surface during film growth and thereby increase the film density. The energy and flux of ion beam are measured by using a retarding-field ion energy analyzer. The ions have the energies between 115eV and 127eV. Ion current density is about 7.7~13.9mA/cm^2 as lower grid bias is changed.

TaN_x films were deposited using pentakis(diethylamido)-tantalum(PDEAT) as a precursor under the bombardments of N-, Ar- or H- ion beam. For comparison, two kinds of thermally-deposited TaN_x films were prepared. One was deposited using PDEAT as a single precursor and the other used was PDEAT as a precursor with hydrogen. In case of N_2 IBICVD, deposition rate leveled off in the whole temperature range. In case of thermal CVD, the deposition rate was controlled by the surface reaction with an activation energy of about 1.0eV. The activation energy of Ar and H_2 IBICVD was about 0.3eV. The film resistivity was decreased with increasing deposition temperature except Ar IBICVD case. It also showed that the film resistivity of IBICVD TaNx was lower than that of thermally grown TaN_x. The minimum resistivity of TaN_x films was about 600$\mu\Omega$-cm, which was deposited at 350℃ by using Ar-ion beam. In order to identify the phase of deposited films, XRD patterns of 150nm thick films were taken. The peaks appeared at around 35° and 41° in the XRD patterns can be indexed to either TaN or TaC, because two phases have same structure(rock-salt structure) and similar lattice parameter. C_{1s} XPS spectrum shows that Ta-C bond exists in the Ar IBICVD TaN_x film. It showed that almost all the carbons in the film are bonded to tantalum.

TaNx films(50nm) deposited at 325℃ were tested as diffusion barriers for copper. After 650C annealing, all the sheet resistance increases dramatically.