Chapter 6

Conclusion and Suggestions for Future Work

6.1 Conclusion

This thesis studies the Cu CVD on TaN and TaSiN substrates as well as the effects of substrate plasma treatment (by Ar-, H_2-, or N_2-plasma) on the Cu nucleation and the Cu films property.

The Cu CVD was conducted using a liquid metalorganic compound of Cu(hfac)TMVS with 2.4%TMVS additive as the precursor at a pressure of 150mtorr over a temperature range of 140 to 240℃. The lowest film resistivity of about 2.15μΩ-cm was found for the Cu film deposited at 160℃ either on TaN or TaSiN substrates. For the films deposited at temperatures below 160℃, the film resistivity increased with decreasing deposition temperature presumably due to the higher contamination of residual impurities from the reaction by-products and the higher grain boundary density of the Cu films. For the films deposited at temperatures above 160℃, the film resistivity also increased with increasing deposition temperature presumably resulting from the higher contamination of impurities and the porous microstructure of the Cu films. The grain size, the surface roughness, and the intensity peak ratio of Cu(111)/Cu(200) reflections of the Cu films all increased with increasing deposition temperature. A post-deposition thermal annealing at 400℃ resulted in increased grain size, decreased film resistivity, reduced surface roughness, milky surface morphology, and increased peak ratio of Cu(111)/Cu(200) reflections.

The nucleation behavior of Cu films is closed related to the substrate surface condition. It was found that the substrate treatment by Ar-plasma and H_2-plasma enhanced the nucleation rate and decreased the wetting angle of the nucleated Cu grains, presumably due to the increased substrate surface energy and/or decreased interfacial energy. However, the substrate treatment by N_2-plasma decreased the nucleation rate and increased the wetting angle of the nucleated Cu grains, presumably due to the nitridation of the substrate surface and the decreased substrate surface energy and/or increased interfacial energy, respectively.

The substrate treatment by Ar- and H_2-plasma has a number of beneficial effects on the CVD Cu films, including enhanced (111)-preferred orientation, better-contacted grains, and smoother film surface. A post-deposition thermal annealing at 400℃ resulted in reducing the film resistivity to about 2.0μΩ-cm, improved surface smoothness, and increased intensity peak ratio of Cu(111)/Cu(200) reflections.

6.2 Suggestions for Future work

There are a number of Cu CVD related topics that may be worthy of suggestion for future work as follows.

1. Effects of plasma substrate treatment on via-filling of Cu CVD.
2. Integration of Cu CVD with Cu CMP process.
3. Stress-temperature behavior of CVD-Cu film deposited on plasma-treated diffusion barrier substrates.
4. Development of via-filling in bottom-up way (superfilling) using a catalytic surfactant on Cu CVD.
5. Integration of Cu CVD and low-k dielectrics, especially dual damascene process.
6. Effects of precursor additives (such as HMDS, Hhfac, H_2O, and iodine) on the characteristics of CVD Cu films.