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Promotion of radical nitriding reaction of silicon using gold nanoparticles

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1. Introduction

The catalytic effect of gold nanoparticles has been drawing attention in recent years.[1,2] We have applied catalytic properties of gold nanoparticles to plasma surface reactions to reduce damage to the plasma irradiated surface and to utilize it for the formation of high-quality ultra-thin films. To further reduce damage, this time we evaluated the reaction activity under radical irradiation with ions removed from the plasma.

2. Experiment and results

In an ultrahigh vacuum chamber, Au is vapor-deposited for 2 minutes on a Si (100) substrate with an oxide film by electron beam evaporation. Figure 1 shows the AFM image of Au nanoparticles. Next, nitrogen plasma of 30 mTorr was generated in the attached chamber, and the sample was irradiated for 5 minutes with radicals passed through 30 mesh/inch SUS 304 single mesh.

Figure 2 shows the RF power dependence of atomic composition by XPS. At an element ratio of Au of 20 W, it was equivalent to unirradiated and sputtering of nanoparticles could be suppressed by mesh. At 40 W, the element ratio of N exceeds 10%, showing a value exceeding the case of direct plasma irradiation.

Figure 3 compares Si2p spectra at 20 W RF power. The presence of Au nanoparticles gives a peak near 103 eV of SiON, and it can be seen that Si - N bonds can be formed with the aid of catalytic activity of Au nanoparticles.

3. Summary

The effect of the presence or absence of surface coating of gold nanoparticles on radical nitriding of silicon was evaluated by XPS. Si2p signal indicating the formation of SiON could be detected only when gold nanoparticles were coated.

From now on, it is necessary to elucidate which active particles (N, N_2^*, photons etc.) supplied from plasma contribute to the activation of gold nanoparticles.

References

[1] X. Chen, H.-Y. Zhu, J.-C. Zhao, Z.-F. Zheng, and X.-P. Gao, Angew. Chem. **120**, 5433 (2008).
[2] S. Bhaviripudi, E. Mile, S.A. Steiner, A.T. Zare, M.S. Dresselhaus, A.M. Belcher, and J. Kong, J. Am. Chem. Soc. **129**, 1516 (2007).

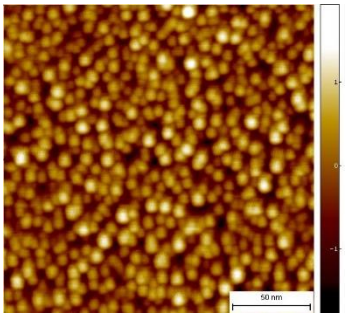

Figure 1 nc-AFM image of Au nanoparticles formed on SiO_2/Si(100) substrate.

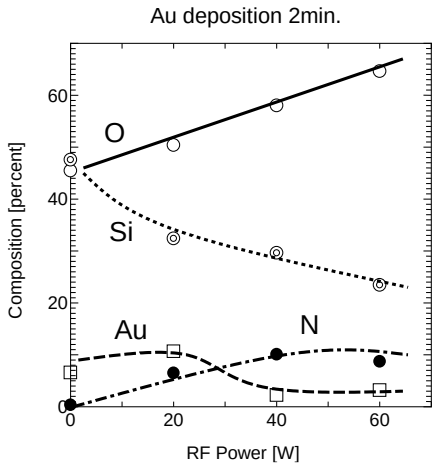

Figure 2 Power dependence of surface composition after nitrogen radical irradiation for 5 minutes.

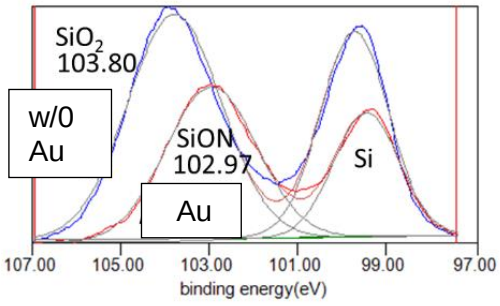

Figure 3 Changes in Si2p XPS spectrum after nitrogen radical irradiation for 5 minutes depending on the presence or absence of nanoparticles.