Transmission electron microscopy study of annealed platinum films made by ion beam induced deposition

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Gallium ion beam deposited Pt(IBID-Pt) film is widely used for nanofabrication and TEM sample preparation. Using TEM, the authors previously characterized microstructure details for the Pt films deposited on Si substrate, including the sub-film damage layers. Also suggested was a scenario on the film formation where the order of combining strength among Pt, Si and C atoms plays a crucial role. [1]

When IBID-Pt films are annealed at high temperature, the involving atoms would interact with each other vigorously, which is an additional process to examine our assumptions regarding the inter-atom actions. Here we performed the in-situ TEM study of the films annealed at room temperature to 750°C.

The diffusion of atoms over the sectioned specimen surface being added to the diffusion in volume, the in-situ TEM study shows two pronounced behaviors of Pt atoms: (1) Pt in contact with Si diffuse into Si, crystalline or in amorphous phase, to form Pt-Si compounds. (2) Pt far from Si, separates themselves from the carbon matrix of the film to agglomerate into PtSi-particles. Any distinct behavior of Ga still could not be observed except that it always comes with Pt in proportion as revealed in TEM analysis (EDS).

It is revealed that the in-situ annealing experiment enforces our scenario for the IBID-Pt film formation on Si substrate along with the assumptions it bases on. Further it is informative in the application where a made nanostructure needs some annealing on purpose. We will introduce the results of the annealing experiments and re-discuss our scenario. Further the annealing experiments of Pt films in volume, compatible to those in the in-situ TEM, will also be presented.

[1] Byong Chon Park, Yun Chang Park, Hwack Joo Lee and Young Heon Kim, "Transmission Electron Microscopy study of damage layer formed through ion beam induced deposition of platinum on silicon substrate", J. Vac. Sci. Technol. B 28(6), C6F31-C6F37.

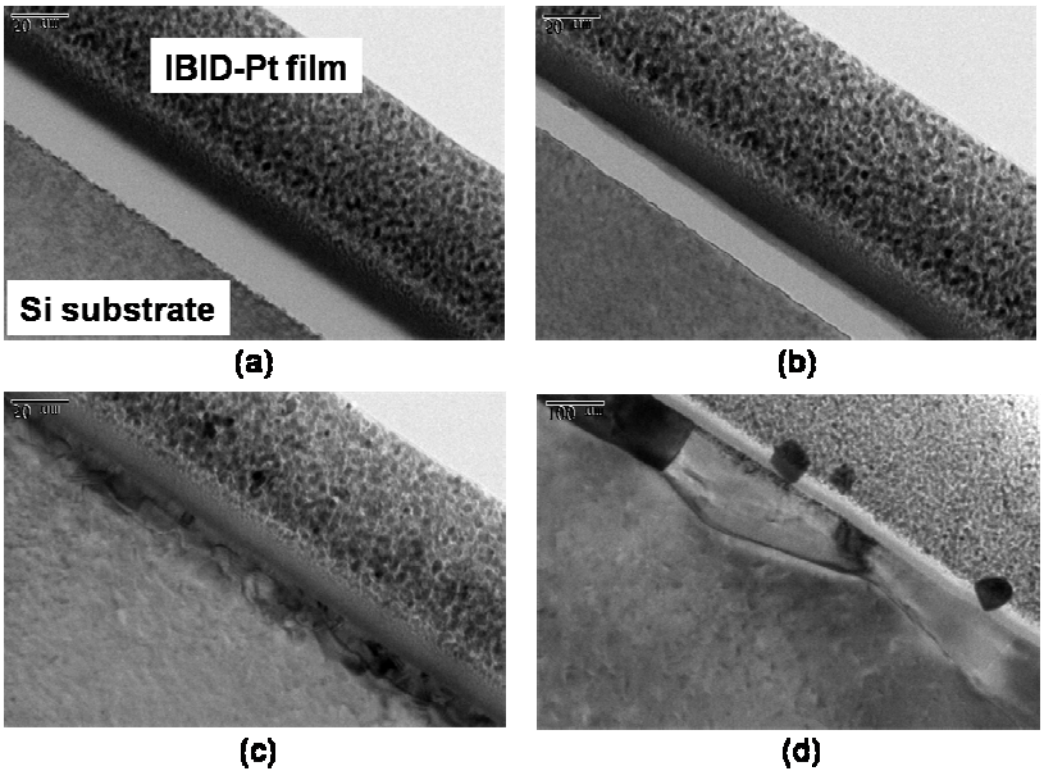

Figure 1: Annealing of sectioned IBID-Pt film in in-situ TEM: The change of the microstructure as the specimen temperature is increased from room temperature to 750 °C. Each of four TEM pictures are taken when the specimen is at the range of (a) 25-300 °C (b) 300-450 °C (c) 450-600 °C (d) 600-750 °C. In (b) Pt is diffusing into the amorphous Si. In (c) Pt diffused into amorphous Si begins to form PtSi compund. In (d) PtSi compound grows into the crystal Si; Pt particles inside the IBID-film gets out of film to form PtSi particles at the outside of the film. When left further at 750 °C, PtSi particles on the Pt-film increases in number and then gathers to form larger particles though not shown here.

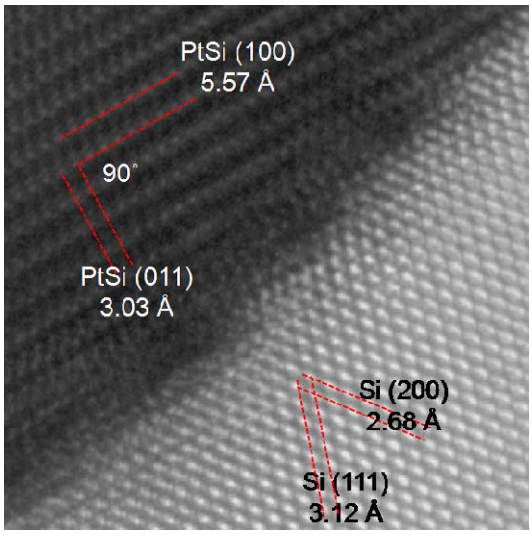

Figure 2: PtSi compound as formed in Si region as the result of in-situ TEM annealing

Figure 3: SEM picture depicting PtSi particles formed outside of the sectioned surface after in-situ TEM annealing (picture plane parallel to the film surface)