Changes in the electrochemical behavior of silicon after platinum deposition and ionic bombardment

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The electrochemistry of silicon has been studied in great detail, in particular in the context of anodic etching and the formation of geometrically well-defined pores. Little is known, however, about the electrochemical behavior of silicon when it is totally or partially covered with a metal film, such as platinum, despite the importance of platinum silicide in the microelectronics industry. Only recently has there been a study on the relationship between charge-transfer at the Pt/Si interface and the surface electrochemistry.[1]

We present the results of an investigation into the electrochemistry of silicon with varying coverages of platinum. Rather than depositing different amounts of platinum onto silicon wafers, we instead produced continuous films, and used ionic bombardment to strip varying amounts of the metal from the surface, as shown in Figure 1. This gives us access to a complete range of coverage, and furthermore changes the roughness of the surface and induces the formation of platinum silicide.

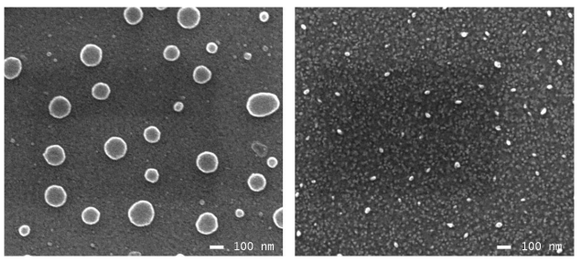

Fig. 1 – Scanning electron microscope images of Pt/Si films after different levels of helium ion bombardment.

Figure 2 shows the Pt / (Pt + Si) ratio, determined by XPS, of Pt/Si films subjected to different doses of ion bombardment, starting from a fresh, completely covered film, up to a mixed surface with little platinum left. A transition is clearly visible at which point the film breaks up and the silicon becomes detectable. AFM measurements show that this transition coincides with a maximum in the roughness of the film and, according to XPS measurements, with the formation of a platinum silicide phase at the surface, as explained in Figure 3.

Previous work has shown that the electronic structure of silicon can vary dramatically depending on the type of surface preparation. Effective dopant concentrations, flat-band potentials, or reverse dark currents for example, strongly depend on whether the surface has been mechanically or mechanochemically polished, or chemically etched.[2,3] Ion bombardment can be thought of as another possible pre-treatment process, the effects of which are discussed in the context of electrochemistry.

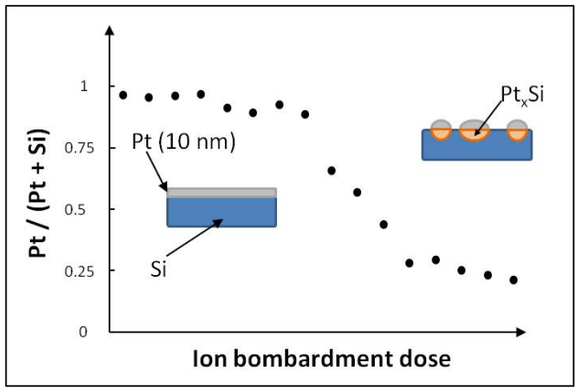

Fig.2 – Pt/(Pt+Si) surface ratio determined by XPS measurements of Pt/Si surfaces subjected to nitrogen ion bombardment

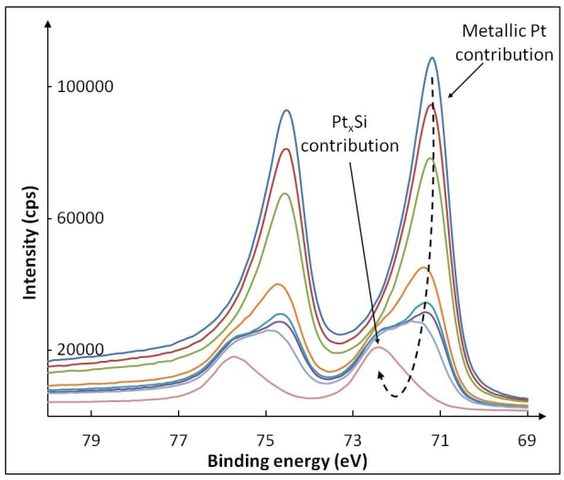

Fig. 3 – XPS Pt4f spectra of samples subjected to increasing doses of helium ion bombardment. The dashed arrow shows the transition from Pt/Si on an as-deposited sample to Pt_xSi as the ion dose increases. The +1 eV energy shift under ion bombardment is characteristic of the formation of a mixed Pt_xSi phase.[4]

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