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Core level spectroscopy study for cluster-like Si deposited on graphite and insulating sapphire

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In the coming nanotechnology age, Si-assembled nanostructures will be the key components for fabrication of many nanodevices. Due to technological and research importance, study of Si-epitaxy on inert substrates, such as semi-metallic graphite [1] and insulating sapphire [2] has attracted much attention in recent years. For example, scanning tunneling microscopy measurement was performed to observe the Si nanowires on graphite [1]. However, electronic structures of Si nanowires and Si-clusters on HOPG are not known.

Recently we have carried out a core level photoemission and photoabsorption experiment for different Si thin films deposited on Highly Oriented Pyrolitic Graphite (HOPG) and insulating Sapphire (Al_2O_3). The in-situ measurements were performed at BL27A, Photon Factory. Si was deposited on the substrates at room temperature by using electron deposition method. After Si deposition, sample was transferred to analysis chamber, and Si 1s photoemission spectra and photoabsorption spectra at Si 1s near edge were measured.

In Figs. 1(a), 1(b) and 1(c), several Si 1s photoemission spectra are shown. The excitation energy was hν =2.2 keV. Figures 1(a) and 1 (b) show spectra for Si films on HOPG. The thicknesses of Si films are 0.3 Å and 5.5 Å, respectively.

In Fig. 1(b), there is only one component, "A". However, in the case of thinner film, i.e., 0.3 Å film in Fig. 1(a), there are more three components along with component "A". The relative binding energies for four components (A, B, C and D) are 0, 1.45, 2.85 and 4.25 eV, respectively.

The presence of several components in the photoemission spectra confirms the existence of a range of Si morphologies consisting of clusters and nanowires. Compared with other films, such as 0.4 Å, 2.3 Å and 4.5 Å, we identified two relatively stable Si phases corresponding to components "A" and "C". The binding energy difference between A and C is about 2.85 eV. Comparing with a previous result [3], we describe the component "C" originates from a cluster forming with an average of 10 Si atoms. According to Ref. 1, we predict that this 10-atom Si-clusters is polymerized, and become Si nanowires. At further deposition, the bulk-like component (A) starts to dominate, and finally remains for thicker films. Similar with thin Si on HOPG, thin Si on Sapphire in Fig. 1(c) also shows four different components, and their relative binding energy positions are also same to Si/HOPG. However, component C is more intense than others. From this photoemission measurement, it is understood that the morphology of Si corresponding to component "C" is a stable when Si is very thin grown on both HOPG and Sapphire.

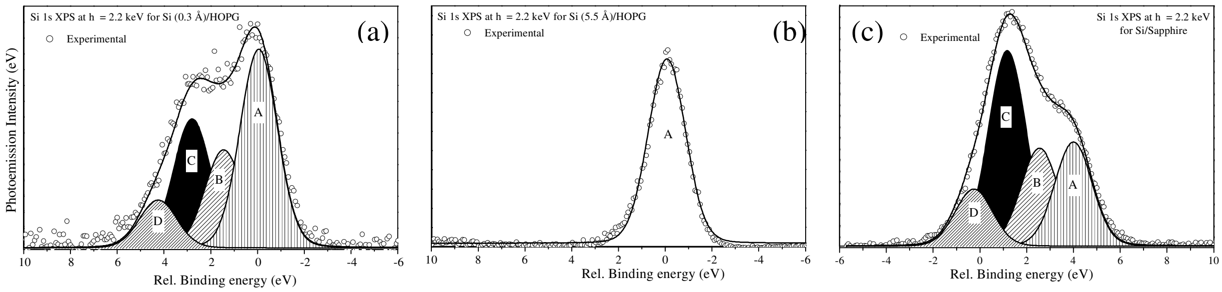

Figure 1. (a) Si1s photoemission spectra for a thin Si on HOPG. Four peaks are fitted to the experimental spectrum. (b) Si1s photoemission spectrum for thicker Si film on HOPG. Only a single component is observed. (c) Si1s photoemission spectra for a thin Si on Sapphire. Similar with thin Si on HOPG, four components are found.

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