1C/2001C009

Transformation of Fe_2O_3 nanoparticles on Si and Ge surfaces

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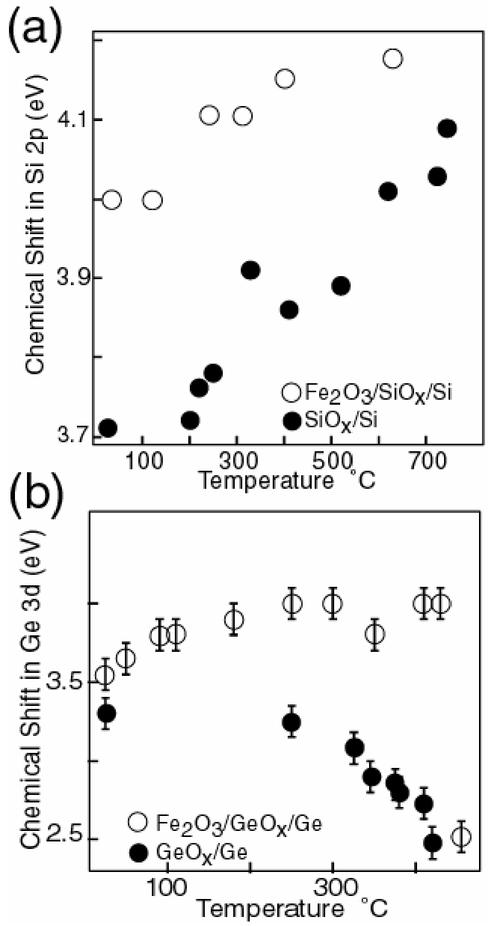
Nanoparticles have been emerging as a promising material for various applications including the functionalization of semiconductors such as silicon [1]. We recently reported that Fe_2O_3 nanoparticles undergo reduction and form nanoparticles of Fe on the surfaces of Si and Ge surfaces at vastly different temperatures (780°C and 440°C on Si and Ge respectively). We also found that the thermal decomposition pathways are distinctly different in both these systems [2]. In the present work, we followed the transformation of Fe_2O_3 nanoparticles on Si and Ge surfaces in the presence of a thin oxide layer, by monitoring the core level as well as the valence band spectra, as a function of temperature.

The nanoparticles are introduced onto Si and Ge surfaces from an ethanol suspension and loaded in to the ultrahigh vacuum chamber. The Si 2p, Ge 3d and the valence band spectra are recorded using photons of energy 130 and 90 eV respectively. The samples are annealed to a particular temperature and kept at that temperature for about 20 min. in order to ensure uniform temperature. The measurements are performed after cooling the sample to room temperature.

Figure 1 compares the variation in the chemical shifts observed in Si 2p (a) Ge 3d (b) core levels as a function of temperature, in the presence (open circles) and absence (filled circles) of Fe_2O_3. It is interesting to note that, in the presence Fe_2O_3 , the silicon oxide formed at room temperature is predominantly iO_2 like, as seen by the clear difference in the chemical shift (4.0 eV and 3.7 eV in the presence and absence of Fe_2O_3, for oxide layer of similar thickness). This suggests that Fe_2O_3 particles catalyse the formation of SiO_2. On increasing the sample temperature, the suboxide like oxide gets converted to form SiO_2 and at higher temperatures SiO molecules desorb and results in the reduction to form nanoparticles of Fe. Similarly, on a Ge surface, presence of Fe_2O_3 particles induces the conversion GeO type oxide to GeO_2, on annealing, as seen by the increase in the chemical shift in Ge 3d core level. At higher temperatures, possibly, a reverse process takes place, which is followed by the desorption of GeO leading to the reduction of Fe_2O_3 to Fe. This behaviour is entirely different form the thermal transformation of just the oxide layer on Ge.



References

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