Electronic structure of Ag thin films on Ge(001) surface

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Introduction

Ag deposited Ge(001) surface is known to show superconducting behaviors below 8K, which is supported by recently observed non-linear current – voltage characteristic in the scanning tunneling spectra.[1] It should be localized at the interface since neither Ag nor Ge is a superconductor and they do not make a bulk alloy. So far, we have studied the initial growth of Ag by using scanning tunneling microscopy (STM) at room temperature (RT).[2] On the substrate below 100K, two dimensional (2D) mono-atomic height Ag islands grow and saturate the substrate. On the substrate at RT, three dimensional (3D) islands grow. In the present work, we have studied valence band and Ge 3d core-level spectra to reveal the electronic structure of these two kinds of islands.

Experiment

All the spectra were measured at RT at beamline 18A at KEK-PF. A clean Ge(001)-(2×1) surface was obtained by the repetition of Ar^+ ion sputtering and annealing at ~970K. Ag was deposited at substrate temperature of 95K and RT. The thickness of Ag was 0.2–1.5 ML. Here, we define 1 ML to be the amount of Ag to saturate the substrate only with 2D islands.

Results and Discussion

Figure 1 shows Ge 3d spectra. A shoulder structure S derived from the upper dimer atoms on the clean surface is suppressed in the case of Ag deposition at 95K. This suggests a strong interaction between Ag and the substrate in 2D islands. In the corresponding valence band spectrum, all the surface states on the clean surface, S_1 –S_3, vanished and several new features appear as indicated by arrows in Fig. 2(b). The state A locates within the bulk band-gap and should be related to Ag 5s and/or the dangling bond state S_1 of the substrate. Ag 4d peak B does not show any bulk-like features except for the shoulder C. The state C appears above 1ML, which is ascribed to 3D islands grown on 2D islands.[2] In the case of Ag deposition at RT, both the shoulder in Ge 3d spectrum and the surface states on the clean surface remain. These suggest that the clean surface still exists, which is consistent with the STM observation.[2] The line shape of Ge 3d spectrum, however, shows a small change from that on the clean surface, suggesting a significant interaction at the interface of 3D islands and the substrate. The increment of the density of states just below Fermi level and a wide band-width of Ag 4d represented by A' and B' in Fig. 2(c), respectively, are derived from bulk-like character of each 3D island.

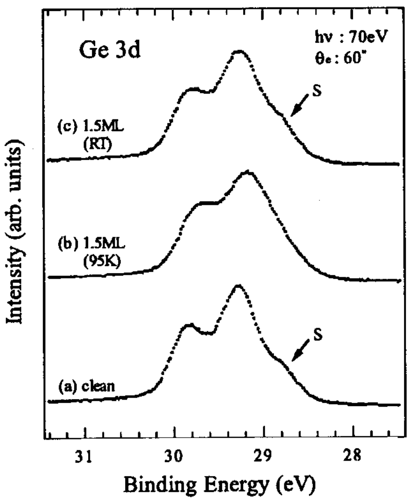

Figure 1: Ge 3d spectra for (a) clean surface, (b) 1.5ML Ag deposited on 95K substrate and (c)1.5ML Ag deposited on RT substrate. See the text in details.

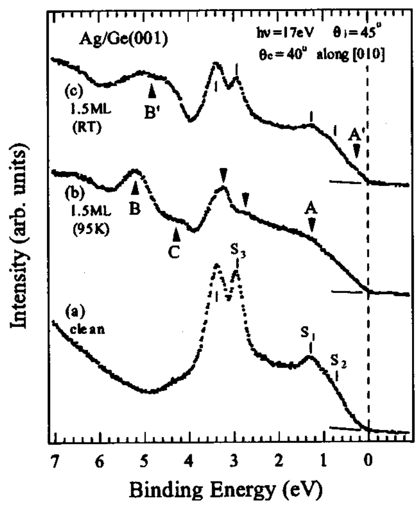

Figure 2: Valence band spectra for the same surfaces as in Fig. 1, respectively. See the text in details.

References

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