

Electronic band dispersion of Pt-induced nanowire on Ge(001) surface studied by angle-resolved photoemission spectroscopy

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Self-assembled nanowires have attracted a great deal of interests as not only potential applications in nano-devices, but also fundamental understandings of one-dimensional properties. Recently, van Houselt et al. reported [1] that Pt-induced nanowires, fabricated on a Ge(001) surface [2], undergo a Peierls-type structural phase transition with scanning tunneling microscopy/spectroscopy. We found out that the structural phase transition is derived from a height difference between the topmost Ge dimer atoms [3], using reflection high-energy positron diffraction. On the other hand, the electronic structure of the Pt-induced nanowire is still unrevealed. In this study, we investigated the electronic band dispersion of the Pt/Ge(001) surface using angle-resolved photoemission spectroscopy (ARPES).

A well-defined Ge(001)-(4×2)-Pt surface with single-domain was prepared on the vicinal Ge(001) substrate tilted in $[\bar{1}10]$ direction (2° OFF, n type, $R < 0.3 \Omega\text{cm}$). Three quarters of the total amount of the Pt were deposited on the clean Ge(001) surface kept at 720 K, and then, the another quarter of that was deposited at 620 K. The total amount of the Pt was 1.2 monolayer (ML), where 1 ML corresponds to 6.3×10^{14} atoms/cm². ARPES measurements were performed with a polarized radiation of $h\nu = 25$ eV at beamline BL-19A of the KEK Photon Factory (Institute for Solid State Physics, University of Tokyo).

Figure shows the ARPES spectra along $[110]$ direction obtained at 64 K [4]. In this experimental condition, the data only include the signals parallel to the nanowire direction. Below the Fermi energy (E_F), the parabolic band appears as indicated by the white arrow. From peak-fittings for the energy distribution curves with Lorentz functions and an exponential background, we found that the position of the bottom of the band corresponds to the binding energy of 0.5 eV at the wave vector (k) of $-0.4 \text{ \AA}^{-1}$. The parabolic band also appears at $k = 0.4 \text{ \AA}^{-1}$, corresponding to the $\bar{J}$ points of the surface Brillouin zone (SBZ). These valence band features have not been mentioned in the past [3]. This is because the parabolic bands are not observed clearly in the first-SBZ due to the superposition of intense Ge-bulk bands and the other surface states.

we also observed the change in the electronic band dispersion together with the phase transition [4] (not shown here). The photoelectron intensity of the edge of the parabolic band crossing to the E_F seems to decrease below the phase transition temperature, whereas that crosses obviously to the E_F at room temperature.

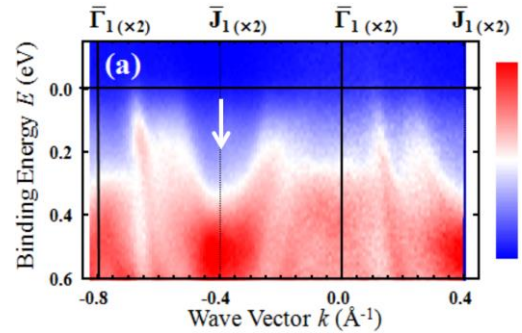


Figure ARPES spectra obtained from vicinal Pt/Ge(001) surface. The color-bar in the right side represents the photoelectron intensity. The solid and dotted vertical lines indicate $\bar{\Gamma}_1$ and $\bar{J}_1$ points of the SBZ, respectively. The horizontal line is E_F .

References

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