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Influence of strain on thin film growth of Si on the Ge (111) surface

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Introduction

We have studied about the influence of the strain on the quasi two-dimensional electron gas (2DEG) state formed on the√3×√3-Ag structure, because the dispersion of the 2DEG state could be modified with the lattice strain introduced by hetero-epitaxial growth such as the Ge/Si(111) or the Si/Ge(111). Since the lattice constant of Si is about 4 % smaller than that of Ge, the compressive strain is induced in the Ge layer grown on the Si(111) and the tensile strain is induced in the Si layer on the Ge(111) such as a Ge/Si(111) and a Si/Ge(111). We have investigated that the electronic states of the compressive and tensile √3×√3-Ag structure on the Ge/Si(111) and Si/Ge(111) measured with a scanning tunnelling microscope (STM) and an angle resolved ultraviolet photoelectron spectroscopy (ARUPS), and reported that the relation between the strain and the effective mass of the 2DEG shows that the tensile strain makes the effective mass heavy [1, 2]. Since the results are based on the relation in the film thickness with in 1BL, we have tried to investigate the relation over 1 BL.

Experimental

The STM observations were performed in our laboratory (U-STM, ULVAC), and the ARUPS observations were performed in BL-18A (Institute for Solid State Physics, University of Tokyo). The STM images were taken in the constant-current mode with a tunnel current I_t, of 50 pA and several sample bias voltages V_s, at room temperature (RT). All ARUPS spectra were measured with the polarized light with the photon-energy of 21.2 eV at low temperature (about 120 K). The angular resolution was less than 0.3°, which corresponds to 0.010 Å^{-1} indicated by a wave number, and the energy resolution was less than 0.05 eV.

Results

The relation between the strain and the effective mass of the 2DEG shows that the tensile strain makes the effective mass heavy. However, the mass in the √3×√3-Ag structure on the Si/Ge(111) decreases over 2 % of the tensile strain as shown in Fig. 1.

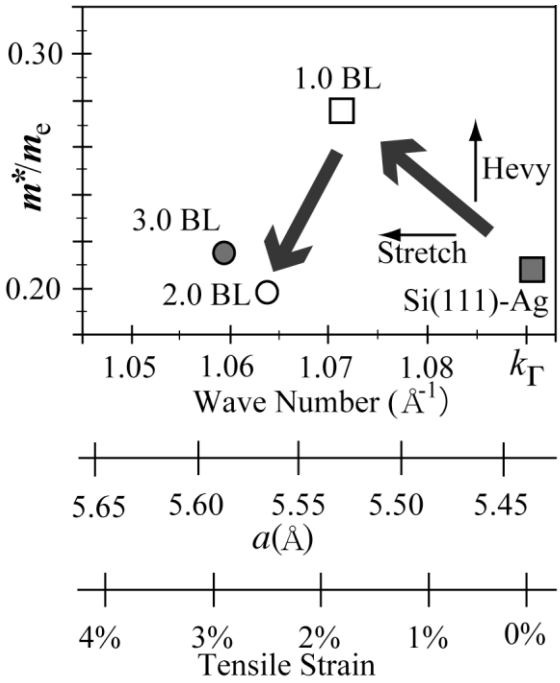

Fig. 1. Relation between the strain and the effective mass of the 2DEG in the √3×√3-Ag structure on the Si/Ge(111) .

The result is incompatible with the liner relation between the strain and the effective mass with in the thickness of 1 BL [2]. For this reason, we assume that the increase of lattice constant in the Si(111) layer over the 2BL is due to the intermixing of Ge atoms into the Si layer and the tensile stress in the Si layer is relaxed by the intermixing. We will make clear the intermixing by using Core-Level Photo electron Spectroscopy.

References

[1] I. Mochizuki, R. Negishi, and Y. Shigeta, J. Appl. Phys., **106**, 013709 (2009).
[2] I. Mochizuki, R. Negishi, and Y. Shigeta, J. Appl. Phys., **107**, 084317 (2010).

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