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ABSTRACT

Atomic Segregation Epitaxy of Germanene on Ag(111)

J. Yuhara

Nagoya University, Chikusa-ku, Nagoya, Aichi, 464-8603, Japan

Since 2012, following the epitaxial growth of silicene—a two-dimensional (2D) honeycomb lattice composed entirely of Si atoms—germanene (Ge), stanene (Sn), and plumbene (Pb) have been synthesized successively [1,2]. Theoretically, the lattice size of free-standing germanene is estimated to range between 0.392 and 0.405 nm [3]. In 2018, germanene was synthesized on Ag(111) via atomic segregation epitaxy (ASE), matching the germanene ($3\sqrt{21}\times3\sqrt{21}$)R10.9° superstructure with the Ag(111) ($7\sqrt{7}\times7\sqrt{7}$)R19.1° supercell [4]. The growth of germanene on Ag(111) using molecular beam epitaxy has also been intensively investigated and identified to exhibit a surface alloy phase [5], stripe and quasi-freestanding germanene [6], and the germanene ($2\sqrt{13}\times2\sqrt{13}$)R16° superstructure with the Ag(111) ($\sqrt{109}\times\sqrt{109}$)R24.5° supercell [7]. In the present study, all the aforementioned germanene have been prepared through low-temperature annealing, starting with the $7\sqrt{7}$ germanene prepared by ASE. The structural phase transition and electronic structure of germanene on Ag(111) have been studied using low-energy electron diffraction, scanning tunneling microscopy, photoemission spectroscopy, and angle-resolved photoemission spectroscopy.

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