Contribution ID: **175** Type: **Oral Presentation**

Atomic and electronic structure investigation of germanene grown on Al2O3(0001)

Friday, 29 June 2018 10:00 (20 minutes)

Germanene is considered as a potential alternative to graphene and has technological potential owing to its unique electronic characteristics. The buckled structure of germanene, combined with strong spin-orbit coupling, is predicted to exhibit new topological phenomena such as the quantum spin Hall and anomalous Hall effects. Recent efforts have been directed to identify suitable substrates that allows the growth of ultra-thin layers, while still preserving the desired 2D characteristics. So far, germanene has been successfully grown on metal substrates, such as Pt(111), Au(111), Ag(111) and Al(111). However, mixing of germanium-substrate atoms often leads to the formation of an ordered 2D surface alloy that prevents the experimental realization of the predicted characteristics. In this study, we have chosen an insulating Al2O3(0001) substrate for growing germanene. We experimentally investigated the room temperature growth of monolayer to few layers of Ge on the Al2O3(0001) surface under ultra-high vacuum conditions. The atomic structure investigated using Low Energy Electron Diffraction (LEED) shows that the as-grown germanene does not deviate from the 1 x 1 structure of Al2O3(0001). The measured Ge 2p and 3d core level spectra indicate intermixing of Ge and O, which is prominent at monolayer Ge thickness. Post-deposition annealing significantly influences the fraction of the Ge-O interface component. Valence band spectra depict prominent changes with Ge deposition above one monolayer as electronic states within the band gap of Al2O3(0001) are introduced. Our study paves the way to further understand and realize the electronic structure of germanene on insulating substrates.

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Session Classification: Physics of Condensed Matter and Materials

Track Classification: Track A - Physics of Condensed Matter and Materials