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Elemental 2D Materials Beyond Graphene

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Two-dimensional (2D) materials, which possess atomic or molecular thickness and infinite planar lengths, are regarded as a novel family of materials that have a great potential to transform modern electronics due to their unique nanostructures and electronic states, especially since the discovery of graphene, which possesses amazing functionalities such as high electron mobility and the quantum Hall effect at room temperature. Silicene, germanene, blue phosphorene, new allotropes of silicon, germanium and phosphorous, in 2D one-atom-thick honeycomb structures, could have the potential for promising applications in electronics, photonics, and the other related areas because they not only demonstrates essentially the same electronic properties as graphene, such as linear dispersion of the electron band and high Fermi velocity, but they also possess an energy gap at the Dirac point, stronger spin-orbital coupling (SOC) and inherent compatibility with the current semiconductor industry.
In this talk, I will review our recent work on silicene, germanene, and blue phosphorene. By molecular beam epitaxial deposition, we successfully synthesized large-scale silicene, germanene and blue phosphorene layers on various substrates. The atomic honeycomb structures have been clearly demonstrated by scanning tunneling microscopy (STM). Their phonon properties and distinct electron-phonon coupling effects have been revealed by in-situ Raman spectroscopy. Electronic structures of silicene, germanene and blue phosphorene were demonstrated by scanning tunneling spectroscopy (STS) and angle-revolved photoemission spectroscopy (ARPES). The electronic dispersion, band gap, Fermi velocity, and surface reactive sites at the nano scale and atomic scale on the surfaces of these 2D elemental materials have been studied in details. We also successfully tuned their electronic properties by physical and chemical modulations.

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