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Engineering a Band Gap Opening in Dirac Cones on Graphene/Tellurium Heterostructures

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Abstract : Graphene, in its pristine state, is a semiconductor with a zero band gap and massless Dirac fermions carriers, which conducts electrons like a metal. Nevertheless, the absence of a bandgap makes it impossible to control the material's electrons, something that is essential to perform on-off switching operations in transistors. Therefore, it is necessary to generate a finite gap in the energy dispersion at the Dirac point. Intense research has been developed to engineer band gaps while preserving the exceptional properties of graphene, and different strategies have been proposed, among them, quantum confinement of 1D nanoribbons or the introduction of super periodic potential in graphene. Besides, in the context of developing new 2D materials and Van der Waals heterostructures, with new exciting emerging properties, as 2D transition metal chalcogenides monolayers, it is fundamental to know any possible interaction between chalcogenide atoms and graphene-supporting substrates. In this work, we report on a combined Scanning Tunneling Microscopy (STM), Low Energy Electron Diffraction (LEED), and Angle-Resolved Photoemission Spectroscopy (ARPES) study on a new superstructure when Te is evaporated (and intercalated) onto graphene over Ir(111). This new superstructure leads to the electronic doping of the Dirac cone while the linear dispersion of massless Dirac fermions is preserved. Very interestingly, our ARPES measurements evidence a large band gap (~400 meV) at the Dirac point of graphene Dirac cones below but close to the Fermi level. We have also observed signatures of the Dirac point binding energy being tuned (upwards or downwards) as a function of Te coverage.

Keywords : angle resolved photoemission spectroscopy, ARPES, graphene, spintronics, spin-orbitronics, 2D materials, transition metal dichalcogenides, TMDCs, TMDs, LEED, STM, quantum materials
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