Domain-resolved electronic structure of AgTe-intercalated graphene on SiC

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Intercalation at the interface of zero-layer graphene (ZLG) and SiC(0001) decouples the graphene from the SiC substrate, producing quasi-freestanding monolayer graphene (QFMLG). This enables tuning of graphene's electronic properties by controlling its charge carrier density and doping, while stabilizing novel intercalant-derived interfacial phases for both fundamental studies and potential device applications [1]. For instance, contrary to its bulk metallic nature, silver (Ag) intercalation stabilizes a two-dimensional (2D) Ag interlayer which is semiconducting due to quantum confinement [2]. Tellurium (Te) has an intrinsically chiral structure and exhibits topological features such as Weyl nodes [3]. Its intercalation offers tunable spin-orbit coupling (SOC) and thickness-dependent band-gap opening in graphene [4]. Studies of epitaxial AgTe monolayers on Ag(111) demonstrate that such interfacial alloy phases can host SOC manifested as orbital-driven Rashba-type spin-splitting [5], topologically non-trivial quantum spin Hall edge states and other emergent quantum phenomena [6]. AgTe intercalation could thus, combine these effects and produce a chemically and electronically rich interface with phase-dependent electronic properties that are protected under and potentially induced into graphene.

Competition between Ag and Te in a nominally AgTe-intercalated ZLG/SiC(0001) system currently stabilizes multiple intercalation regions, namely, Te-rich, AgTe alloy and Ag-rich intercalated domains, with distinct interlayer band dispersions and graphene doping levels. The Te-rich region exhibits semiconducting interlayer bands, and so does the Ag-rich region. However, the AgTe alloy region shows metallic interlayer bands. In different intercalation regions the graphene also exhibits different doping levels, with near charge-neutrality in the Te-rich region, moderate n-doping in the AgTe region and strong n-doping in the Ag-rich region (cf. Fig. 1). Collectively, these observations indicate that nominal AgTe intercalation produces a heterogeneous interface in which local stoichiometry critically determines both the interlayer electronic structure and the charge transfer into graphene. The coexistence of semiconducting and metallic interlayers, combined with spatially varying graphene doping underscores the pronounced sensitivity of the electronic properties of the system to subtle differences in intercalant composition and preparation parameters. Such phase-dependent electronic behavior establishes AgTe intercalation as a versatile platform for modulating electronic properties in graphene-based heterostructures, offering a route to design alloy interfaces with tailored quantum functionalities.

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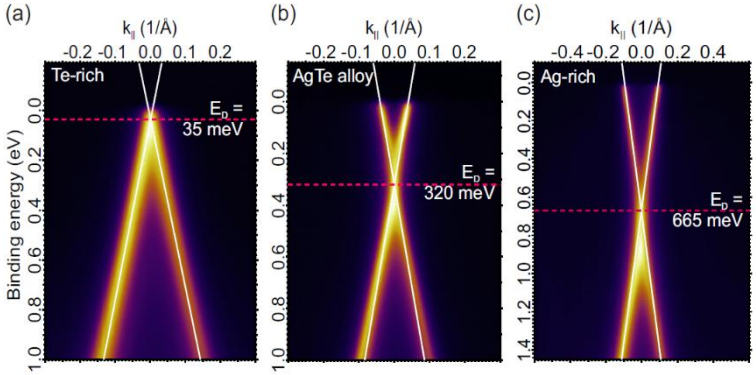

Fig. 1: Angle-resolved photoemission spectroscopy (ARPES) measurements of the graphene Dirac cone acquired (hv = 40 eV) at the $\overline{K}$-point perpendicular to the $\overline{\Gamma K}$ direction of the graphene Brillouin zone, in the (a) Te-rich, (b) AgTe alloy and (c) Ag-rich domains respectively.