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Probing electric properties at the boundary of planar 2D heterostructure

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The quest for novel two-dimensional (2D) materials has led to the discovery of hybridized 2D atomic crystals. Especially, planar 2D heterostructure provides opportunities to explore fascinating electric properties at abrupt one-dimensional (1D) boundaries reminiscent to those seen in the 2D interfaces of complex oxides. By implementing the concept of epitaxy to 2D space, we developed a new growth technique to epitaxially grow hexagonal boron nitride (hBN) from the edges of graphene, forming a coherent planar heterostructure [1]. At the interface of hBN and graphene, a polar-on-nonpolar 1D boundary can be formed which is expected to possess peculiar electronic states associated with the polarity of hBN and edge states of graphene Scanning tunneling microscopy and spectroscopy (STM/S) measurements revealed an abrupt 1D zigzag oriented boundary, with boundary states about 0.6 eV below or above the Fermi level depending on the termination of the hBN at the boundary [2]. The boundary states are extended along the boundary and exponentially decay into the bulk of graphene and hBN. Combined STM/S and first-principles theory study not only disclose spatial and energetic distribution of interfacial state but also reveal the origin of boundary states and the effect of the polarity discontinuity at the interface By probing electric properties at the boundary in the atomic scale, planar 2D heterostructure is demonstrated as a promising platform for discovering emergent phenomena at the 1D interface in 2D materials. This research was conducted at the Center for Nanophase Materials Sciences, which is a DOE Office of Science User Facility. 1 L. Liu and J.Park et al., *Science* **343**, 163 (2014). 2 J. Park and JK Lee et al., *Nature Commun.* **5**, 5403 (2014).