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Electronic Structure and Morphology of Graphene Layers on SiC

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Recent years have witnessed the discovery and the unique electronic properties of graphene, a sheet of carbon atoms arranged in a honeycomb lattice. The unique linear dispersion relation of charge carriers near the Fermi level ("Dirac Fermions") lead to exciting transport properties, such as an unusual quantum Hall effect, and have aroused scientific and technological interests. On the way towards graphene-based electronics, a knowledge of the electronic band structure and the morphology of epitaxial graphene films on silicon carbide substrates is imperative. We have studied the evolution of the occupied band structure and the morphology of graphene layers on silicon carbide by systematically increasing the layer thickness. Using angle-resolved photoemission spectroscopy (ARPES), we examine this unique 2D system in its development from single layer to multilayers, by characteristic changes in the π band, the highest occupied state, and the dispersion relation in the out-of-plane electron wave vector in particular. The evolution of the film morphology is evaluated by the combination of low-energy electron microscopy and ARPES. By exploiting the sensitivity of graphene's electronic states to the charge carrier concentration, changes in the on-site Coulomb potential leading to a change of π and π^* bands can be examined using ARPES. We demonstrate that, in a graphene bilayer, the gap between π and π^* bands can be controlled by selectively adjusting relative carrier concentrations, which suggests a possible application of the graphene bilayer for switching functions in electronic devices. This work was done in collaboration with A. Bostwick, J. L. McChesney, and E. Rotenberg at Advanced Light Source, Lawrence Berkeley National Laboratory, K. Horn at Fritz-Haber-Institut, K. V. Emtsev and Th. Seyller at Lehrstuhl für Technische Physik, Universität Erlangen-Nürnberg, and F. El Gabaly and A. K. Schmid at National Center for Electron Microscopy, Lawrence Berkeley National Laboratory.