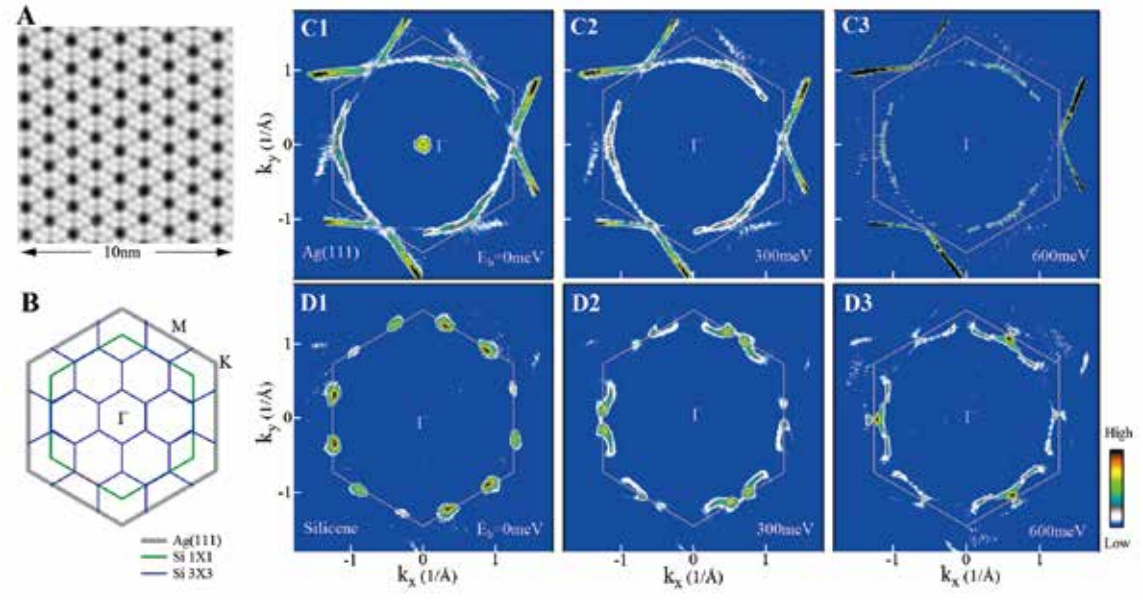
A New Form of Interaction-Induced Dirac Cones Discovered in Silicene/Ag(111) System

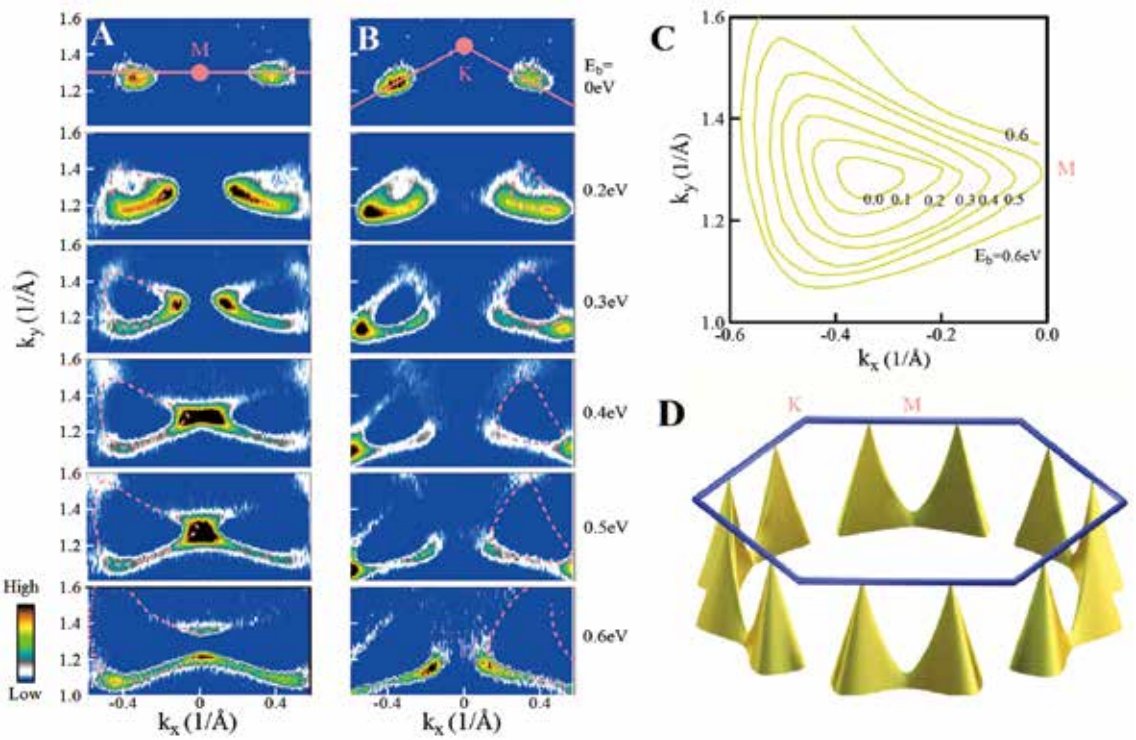
Silicene, analogous to graphene, is a one-atom-thick two-dimensional crystal of silicon which is expected to share many of the remarkable properties of graphene. The buckled honeycomb structure of silicene, along with its enhanced spin-orbit coupling, endows silicene with considerable advantages over graphene in that the spin-split states in silicene are tunable with external fields. Although the low-energy Dirac cone states lie at the heart of all novel quantum phenomena in a pristine sheet of silicene, the question of whether or not these key states can survive when silicene is grown or supported on a substrate remains hotly debated.

The high-resolution angle-resolved photoemission study on monolayer (3×3) silicene grown on Ag(111) substrate, performed by Prof. ZHOU Xingjiang's group at the Institute of Physics, Chinese Academy of Sciences, provide key insights into this important issue. They observed a new form of Dirac cones in (3×3) silicene/Ag(111) system: the presence of six pairs of Dirac cones on the edges of the first Brillouin zone of Ag(111), other than six Dirac cones at the K points of the primary silicene(1×1) Brillouin zone as expected for a pristine silicene.

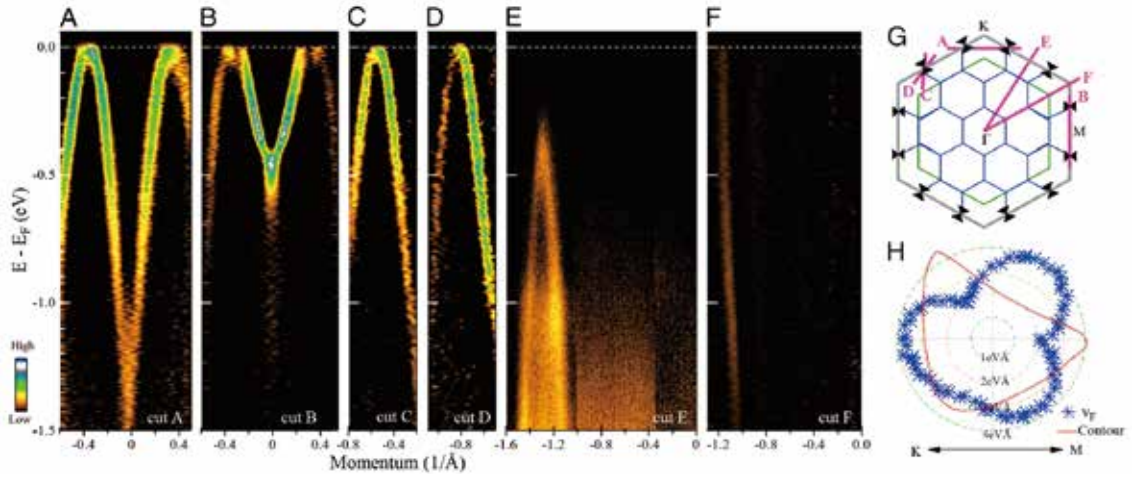
The results show clearly that the unusual Dirac cone structure originates neither from the pristine silicene nor from the Ag(111) substrate, but from the interaction of silicene (3×3) and the Ag(111) substrate. The study provides the first direct evidence on the existence of a new form of Dirac cones in silicene/Ag(111) system; meanwhile it resolves the controversy on whether Dirac cones exist in the silicene/Ag(1111) system. It also identifies the first case of a new type of Dirac Cone generated through the interaction of two



Constant energy contours of silicene(3×3)/Ag(111) showing the existence of six pairs of Dirac cones. (Image by Institute of Physics)



Evolution of the Dirac cones in silicene(3×3)/Ag(111) with binding energy, and the corresponding structures of Dirac cones. (Image by Institute of Physics)



Band structures of silicene(3×3)/Ag(111) along different momentum cuts, and the anisotropy of the Fermi velocity. (Image by Institute of Physics

different constituents. The observation of Dirac cones in silicene/Ag(111) opens a new materials platform for investigating unusual quantum phenomena and novel applications based on two-dimensional silicon systems.

This study, entitled "Direct Evidence of Interaction-Induced Dirac Cones in Monolayer Silicene/Ag(111) System", was published in *PNAS* 113 (51), 14656–14661 (2016). It was supported by the National Natural Science Foundation, the Ministry of Science and Technology of China, and the Chinese Academy of Sciences.

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