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Photoemission Momentum Microscopy of Graphene on Ir (111)

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Abstract : Graphene reveals a unique electronic structure that predetermines many intriguing properties such as massless charge carriers, optical transparency and high velocity of fermions at the Fermi level, opening a wide horizon of future applications. Hence, a detailed investigation of the electronic structure of graphene is crucial. The method of choice is angular resolved photoelectron spectroscopy ARPES. Here we present experiments using time-of-flight (ToF) momentum microscopy, being an alternative way of ARPES using full-field imaging of the whole Brillouin zone (BZ) and simultaneous acquisition of up to several 100 energy slices. Unlike conventional ARPES, k-microscopy is not limited in simultaneous k-space access. We have recorded the whole first BZ of graphene on Ir(111) including all six Dirac cones. As excitation source we used synchrotron radiation from BESSY II (Berlin) at the U125-2 NIM, providing linearly polarized (both polarizations p- and s-) VUV radiation. The instrument uses a delay-line detector for single-particle detection up the 5 Mcps range and parallel energy detection via ToF recording. In this way, we gather a 3D data stack I(E,kx,ky) of the full valence electronic structure in approx. 20 mins. Band dispersion stacks were measured in the energy range of 14 eV up to 23 eV with steps of 1 eV. The linearly-dispersing graphene bands for all six K and K' points were simultaneously recorded. We find clear features of hybridization with the substrate, in particular in the linear dichroism in the angular distribution (LDAD). Recording of the whole Brillouin zone of graphene/Ir(111) revealed new features. First, the intensity differences (i.e. the LDAD) are very sensitive to the interaction of graphene bands with substrate bands. Second, the dark corridors are investigated in detail for both, p- and s- polarized radiation. They appear as local distortions of photoelectron current distribution and are induced by quantum mechanical interference of graphene sublattices. The dark corridors are located in different areas of the 6 Dirac cones and show chirality behaviour with a mirror plane along vertical axis. Moreover, two out of six show an oval shape while the rest are more circular. It clearly indicates orientation dependence with respect to E vector of incident light. Third, a pattern of faint but very sharp lines is visible at energies around 22eV that strongly remind on Kikuchi lines in diffraction. In conclusion, the simultaneous study of all six Dirac cones is crucial for a complete understanding of dichroism phenomena and the dark corridor.

Keywords : band structure, graphene, momentum microscopy, LDAD
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