Electron-hole doping asymmetry in an organic Mott insulator investigated by electric-double-layer doping

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Electron-hole doping asymmetry in Mott insulators has been one of the key questions related to the origin of superconductivity near the insulating state. To investigate this, one should prepare a half-filled Mott insulator and then inject or extract electrons in the same sample. In comparison with the high-$T_c$ cuprates, the organic Mott insulator $\kappa$-(BEDT-TTF)$_2$Cu[N(CN)$_2$]Cl ($\kappa$-Cl) serves as a more appropriate material for examining the electron-hole asymmetry of doped Mott insulators because of its single electronic orbital nature. However, precise chemical doping into organic Mott insulators is generally difficult. We fabricated electric-double-layer transistor (EDLT) using $\kappa$-Cl and realized reversible ambipolar doping in the same sample [1].

According to our measurements of the transport properties and calculations of the single-particle spectral function of the Hubbard model, the effect of carrier doping into $\kappa$-Cl is summarized as follows. The band filling deviates from half filling by either electron or hole doping, resulting in restoration of the Fermi surface. However, pseudogap opens at specific points in the momentum space. A major pseudogap opens near the van Hove critical point under hole doping. Namely, the effect of doping is very asymmetric, reflecting the non-interacting band structure.

The doping asymmetry is also observed in the superconducting states. In the talk I would like to introduce the doping-induced superconductivity and its doping asymmetry, which appears by the control of electric-double-layer doping and bending strain [2].

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Fig. 1. (Upper figures) Top view of the conducting BEDT-TTF layer. Each BEDT-TTF dimer possesses one hole at half filling. (Lower figures) Optical and schematic of images of the $\kappa$-Cl EDLT.

References