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Electronic structure and electronic order in lightly doped cuprates studied by STM

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Although the mechanism of superconductivity in the cuprates remains elusive, it is generally agreed that at the heart of the problem is the physics of doped Mott insulators. A crucial step for solving the high temperature superconductivity puzzle is to elucidate the electronic structure of the parent compound and the behaviour of doped charge carriers. In this talk we report recent scanning tunnelling microscopy studies of the atomic-scale electronic structure and electronic order in the parent and lightly doped cuprates in the antiferromagnetic insulating regime. In the parent compound, the full electronic spectrum across the Mott–Hubbard gap, or more precisely the charge transfer gap, is uncovered by scanning tunnelling spectroscopy. The size of the charge transfer gap shows strong variations for different cuprate families, and may have important implications to the maximum transition temperature that can be achieved at optimal doping. Defect-induced charge carriers are found to create broad in-gap electronic states that are strongly localized in space. In lightly doped insulating Bi-2201 compound, we find that the main effect of charge doping is to induce a spectral weight transfer from the high energy Hubbard band to the low energy in-gap states. At sufficiently high doping, a sharp energy gap reminiscent of the pseudogap starts to form near the Fermi level, and is accompanied by the emergence of a checkerboard-like charge order. Our results demonstrate that the first ordered phase in the doped Mott insulator is a charge ordered insulator, which will gradually evolve into the superconducting state upon further doping.