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IN IVB-1

STM/STS Study on 4a×4a Electronic Charge Order in Superconducting $Bi_2Sr_2CaCu_2O_{8+\delta}$

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We performed low-bias STM/STS measurements on Bi2212 crystals with various doping levels to study a nondispersive 4a×4a electronic charge order, which has recently been reported for lightly doped $Ca_{2-x}Na_xCuO_2Cl_2$ (Na-CCOC) and Bi2212 crystals with zero temperature pseudogap (ZTPG). The nondispersive charge order with a periodicity of ~4a has also been reported by Howald et al. for superconducting Bi2212, though they claimed the charge order is incommensurate. We confirmed the development of the nondispersive 4a×4a charge order with internal structure with a periodicity of 4a/3 over a wide range of doping level, including the d-wave superconducting regime. The 4a×4a charge order was clearly observed within a paring gap, while it tends to fade out outside the paring gap. We demonstrate that low doping favors the development of the electronic 4a×4a charge order, and pinning centers are also necessary for stabilizing the static 4a×4a electronic charge order. Furthermore, we point out that crystals exhibiting intense 4a×4a charge order show inhomogeneous STS spectra exhibiting both pseudogap and d-wave gap, while the crystals with weak charge order do homogeneous spectra with a typical d-wave gap with sharp coherence peaks. The origin of the nondispersive 4a×4a electronic charge order will be discussed in terms of a wide variety of unusual electronic orders proposed for the underdoped region of high-T_c cuprates.

keywords : STM/STS, 4a×4a superstructure, Bi2212, inhomogeneity of STS spectra