Spectroscopic-Imaging STM Studies of Superconducting Gap in Unconventional Superconductors

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Information on the superconducting gap is crucially important to elucidate mechanisms of superconductivity. While the superconducting gap of conventional phonon-mediated superconductor is constant everywhere on the Fermi surface, that of unconventional counterpart depends on momentum and may change its sign. Spectroscopic technique which has both momentum selectivity and phase sensitivity is thus indispensable. We use spectroscopic-imaging scanning tunneling microscopy (SI-STM) for this purpose. In SI-STM, tunneling spectrum is acquired at every pixel of the atomic-resolution STM topograph and thus atomically-registered spectroscopic images are obtained at many excitation energies. Each tunneling spectrum reflects quasi-particle density of states from which one can identify the superconducting gap. Fourier-transformed spectroscopic images provide us with the momentum-resolved information and the relative sign of the superconducting gap can be inferred from the magnetic-field dependence through the coherence-factor effect. We confirmed that these features work well for a cuprate with a d-wave gap. We also performed SI-STM on an iron-based superconductor Fe(Se,Te) and obtained the results which suggest the $s_{\pm}$-wave gap. Another advantage of SI-STM is a high spatial resolution which allows us to study the effects of impurities. We discuss the defect states in a clean iron-based superconductor LiFeAs in relation to the superconducting-gap structure.

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