STM study of FeSe: from bulk to monolayer

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We investigated the electron-pairing mechanism in FeSe by using scanning tunneling microscopy and spectroscopy. Tunneling conductance spectra of stoichiometric FeSe crystalline films in their superconducting state revealed evidence for a gap function with nodal lines. Electron pairing with twofold symmetry was demonstrated by direct imaging of quasiparticle excitations in the vicinity of magnetic vortex cores, Fe adatoms, and Se vacancies. The twofold pairing symmetry was further supported by the observation of striped electronic nanostructures in the slightly Se-doped samples. For bi-layer FeSe, we provide strong evidence for the scenario of orbit-selective superconductivity. In monolayer FeSe, we report the direct observation of BEC-BCS crossover. The scanning tunneling spectra demonstrate the evolution from the BCS to the BEC regions in real space. In the BCS region, the superconducting gap closes and re-opens under magnetic field, which reveals a quantum phase transition from the superconducting state to the pseudogap state. The spectra are nearly independent of temperature in the BEC region. In the BEC-BCS crossover region, a pseudogap above superconducting transition temperature is observed.