Andreev reflection spectroscopy for $Fe_{1+y}Te_{1-x}Se_x$ in nano-scale metal-superconductor junctions

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We have developed a distinct experimental method to study the Andreev reflection in uniquely designed nano-scale metal-superconductor junctions, and applied such a method to investigate a multi-band superconductor $Fe_{1+y}Te_{1-x}Se_x$. We report the observation of more than four superconducting (SC) gaps in $Fe_{1+y}Te_{1-x}Se_x$ from Andreev reflection spectra, along with negative differential conductance dips due to the pair breaking related to the largest SC gap. We propose that the observed number of SC gaps be related to the multiple disjoint Fermi surfaces. The evolution of the SC gaps is further investigated as a function of both temperature and magnetic field. For the largest SC gap, the Andreev reflection signal persists above bulk Tc, suggesting the possible existence of phase-incoherent Cooper pairs. We expect our experimental approach to be widely applicable for the study of various types of superconductors in future.