ABSTRACT

Title of Dissertation: TUNNELING AND RAMAN SPECTROSCOPIES OF THE ELECTRON-DOPED HIGH-TEMPERATURE SUPERCONDUCTORS

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This thesis consists of spectroscopic studies of the electron-doped high temperature cuprate superconductors $Pr_{2-x}Ce_xCuO_{4-\delta}$ (PCCO) and $Nd_{2-x}Ce_xCuO_{4-\delta}$ (NCCO).

Point contact and high barrier tunneling spectroscopies were employed to study the evolution of the superconducting gap (Δ) with cerium doping. Point contact spectroscopy of low barrier junctions reveals that the gap changes from *d*-wave in under-doped PCCO to a nodeless gap in over-doped PCCO. This transition in pairing symmetry occurs just above optimal doping.

High barrier tunnel junctions were prepared on optimally doped PCCO and NCCO crystals for tunneling into the *ab*-planes. The spectra are not consistent with either a clean *s*-wave gap or a clean monotonic $d_{x^2-y^2}$ gap, and can be explained by a non-monotonic *d*-wave gap.

A normal state gap near zero voltage bias is observed in the tunneling spectra for dopings between x = 0.13 and x = 0.19 when superconductivity is suppressed

by magnetic fields larger than the upper critical fields (H_{c2}). The normal state gap appears to coexist with the superconducting gap. The normal state gap vanishes at a temperature close to the superconducting transition temperature for optimally doped samples.

Raman spectroscopy was employed to systematically study the electronic properties of PCCO and NCCO crystals and films across the superconducting phase diagram. Polarization and doping dependence of the 2Δ coherence peaks in the superconducting state show a change in the superconducting gap from non-monotonic d-wave at optimal doping to either a dirty d-wave or a dirty s-wave in the over-doped samples.

By analyzing coherence effects, we find that all coherent carriers in the non-superconducting state condense to form the superfluid. Carriers that are doped beyond optimal doping are incoherent and do not contribute to the coherent Raman response in the normal and superconducting states.

We systematically studied the effects of temperature and magnetic field on the coherence peaks in the Raman spectra for various dopings. Compared to the optimally doped crystals, H_{c2} decreases by more than an order of magnitude in the most over-doped crystal. The implications of these observations are discussed.