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**Nanoscale Imaging of the Pair Formation in High-Temperature Superconductors**[1]

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In the quest for a microscopic theory for the superconductivity in cuprates, one hotly debated issue is the temperature at which Cooper pairs first form. Do pairs form at the critical temperature Tc or do they form at higher temperatures lacking phase rigidity? To answer the question, we have developed new techniques, based on the scanning tunneling microscope, to visualize the process of the pair formation on the atomic scale. The magnitude of the low-temperature superconducting gap measured in Bi-2212 shows a large nanoscale spatial variation. These superconducting gaps evolve smoothly with temperature and close locally over a range of temperatures above the superconducting transition temperature Tc [1]. Our results provide evidence that pairing first occurs in nanoscale regions above the bulk superconducting transition temperature. Using the ability to track the same atomic position while changing the temperature, we have examined the evolution of the electronic states from well below Tc to above the temperature at which the pairs first form. Our technique allows us to investigate another fundamental question on the pairing mechanism: Is pairing mediated by a bosonic excitation, as in conventional BCS superconductors, or is pairing with d-wave symmetry an unavoidable consequence of the strong Coulomb repulsion in these compounds? We quantitatively analyze the temperature evolution of the gap and the local electron-boson coupling for various atomic sites with different pairing strengths [2]. We observe that the gap magnitude variation is not determined by the electron-boson coupling but instead it is strongly correlated to variations present in the normal (ungapped) electronic states.

[1] Gomes KK, Pasupathy AN, Pushp A, Ono S, Ando Y, Yazdani A, Nature 447, 569 (2007).
[2] Pasupathy AN, Pushp A, Gomes KK, Parker CV, Wen J, Xu Z, Gu G, Ono S, Ando Y, Yazdani A, Science 320, 196 (2008).

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