New Class of T'-structure Cuprate Superconductors

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High-temperature superconductivity has been discovered in La$_{2-x}$Ba$_x$CuO$_4$ that derives from the undoped mother compound La$_2$CuO$_4$ crystallizing in the K$_2$NiF$_4$ (so-called T) structure with oxygen octahedra surrounding the copper ions. It has been common sense that high-temperature superconductivity develops upon doping such an antiferromagnetic Mott-insulator with charge carriers. La$_2$CuO$_4$ is also the basis of the electron-doped cuprate superconductors of the form La$_{2-x}$Ce$_x$CuO$_{4+y}$, which however crystallize in the Nd$_2$CuO$_4$ (T') structure without apical oxygen above or below the copper ions of the CuO$_2$-plane. Due to the vicinity to the structural phase transition into the T-structure the study of the undoped or low doped mother compound with T'-structure is difficult. However, using the isovalent substituents Y, Sm, Eu, Gd, Tb, or Lu for La, nominally undoped La$_2$CuO$_4$ can be synthesized by molecular beam epitaxy in the T'-structure. The surprising result is that all these nominally undoped T'-compounds are superconductors with fairly high critical temperatures over 20 K. This suggests a phase diagram for this new class of electron doped cuprates, in which the Mott-insulating, antiferromagnetic ground state is not obtained.

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