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Exploring the tipping point of high temperature superconductors by La_2CuO_4

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The majority of the mother compounds of high-temperature superconductors are antiferromagnetic insulators and the appearance of superconductivity is associated to doping. However, doping is not an exclusive trigger for superconductivity and we demonstrate this on the most fundamental high-temperature superconductor, namely La_2CuO_4. In La_2CuO_4 the copper ions are octahedrally coordinated and this structure is associated with its prototype K_2NiF_4 or T-structure. Nonetheless, within the 214 cuprates, also other structural polymorphs have been reported, i.e., the T*-phase, where copper ions are square-pyramidal coordinated. Moreover, the Nd_2CuO_4 or T'-type cuprates with square-planar copper coordination, are well known and commonly associated with electron-doped cuprates. The present phase diagram of cuprate superconductors may not be called "intrinsic" as it is based on hole-doping into the T-phase, whereas electron-doping is performed in T'-phase cuprates. It is of the utmost importance to lift this asymmetric scenario and consider a situation where La_2CuO_4 could be isomerized into either phase. We have grown La_2CuO_4 thin films by molecular beam epitaxy and stabilized all three isomers. Since the T-phase is the thermodynamic stable polymorph, its growth parameters can be varied widely [1]. The T*- and T'-phase are found to be stable only for distinct substrates and growth conditions [2]. While the T- and T*- phases are insulating, the T'-phase is not, but superconducting at 25 K [3]. Our results suggest that structural arguments govern the metal-insulator transition observed for La_2CuO_4 isomers. Moreover, our results emphasize the asymmetry in the electronic phase diagram of cuprate superconductors which is driven by structural differences as the T-phase is clearly in an antiferromagnetic-insulating ground state whereas the T'-phase is superconducting even without doping.

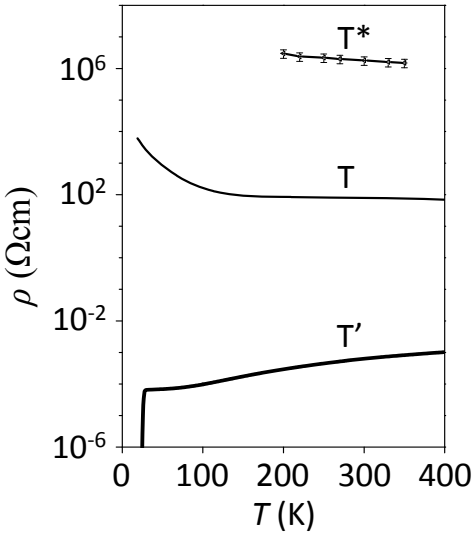

Figure 1. Electronic transport behavior of three La_2CuO_4 isomers as a function of temperature. While T- and T*- La_2CuO_4 are insulators, the T'-phase is a superconductor.

[1] H. Sato *et al.* Phys. Rev. B **61**, 12447 (2000).
[2] H. Yamamoto *et al.* J. Crystal Growth (2013).
[3] Y. Krockenberger *et al*. to be published (2013).