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The Genuine Challenge of High-Tc Superconductivity: Physics and Nano-engineering of Heteroepitaxial Films

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Abstract. Despite dozens of theories, and two decades of intensive research, high-Tc superconductivity (HTSC) remains one of the most challenging problems in physics. The slow progress is largely due to the fact that most physicists (and funding agencies) have underestimated the materials complexity. Cuprate samples, and specifically heteroepitaxially grown films, have to be fully mastered (atomically flat interfaces and total control of the stoichiometry), before one can truly address the core physics questions. That is exactly what Ivan Bozovic has done, so I will briefly discuss some of the main results on MBE-grown heteroepitaxial films: the evidence for the midgap states, implications of the giant proximity effect, the role of the c-axis phonons ... Moreover, following Bozovic's original proposal, we have systematically performed direct ARPES on *in-situ* grown thin (<30nm) cuprate films. Specifically we probe low energy electronic structure and properties of high-Tc superconductors under different degree of epitaxial (*compressive vs tensile*) **strain**. In overdoped and underdoped in-plane compressed 10nm thin $La_{2-x}Sr_xCuO_4$ (LSCO) films (the strain is induced by the choice of substrate) we almost double Tc to 40K, from 20K and 24K, respectively, yet the Fermi surface (FS) remains essentially 2-dimensional (and appears as if we performed an effective 'overdoping'). In contrast, ARPES data under ***tensile*** strain show the measured dispersion that is 3-dimensional, yet Tc drastically decreases. It seems that the in-plane compressive strain tends to push the apical oxygen far away from the CuO_2 plane, enhances the 2-dimensional character of the dispersion and increases Tc, while the tensile strain seems to act exactly in the opposite direction and the resulting dispersion is 3-dimensional. We have established the shape of the FS for both cases, and all our data are consistent (also with other ongoing studies, like EXAFS). Our data essentially rule out all oversimplified 2-dimensional mean field models. Last but not least, I will critically discuss future prospects in the high-Tc superconductivity research and nano-engineering.

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