Expanding the Toolbox for Superconducting Film Investigations

H. Zhou¹, Y. Yacoby², V.Y. Butko¹, G. Logvenov¹, I. Božović¹, R. Pindak¹
¹Brookhaven National Laboratory; ²Hebrew University

Using a combination of unique tools to build and analyze films just nanometers thick, a group of researchers has shown that subtle changes in a material’s structure can dramatically alter its interfacial superconducting properties.

The group synthesized ultrathin films of the material La₂₋ₓSrₓCuO₄ (LSCO), using a unique layer-by-layer molecular beam epitaxy system. The 6 atomic-layer structural unit cells of this material exhibit metallic (M), insulating (I), or superconducting behavior depending on the Sr concentration (x). It was previously discovered that an M-I bilayer film comprised of both metallic and insulating LSCO unit cells exhibits superconductivity at the interface between them.

X-ray diffraction and an improved phase retrieval technique (developed by the group) were used to study the distance of the out-of-plane (apical) oxygen atoms from the copper-oxygen plane, a characteristic known to effect the transition temperature of high-temperature superconductors. The distance stays the same in single-phase metallic or superconducting LSCO films but unexpectedly increased in the bilayer M-I LSCO films.

Their findings stress the importance of studying the superficial and deep structural features of superconducting films, which transport electricity with zero resistance and are envisioned, some day, for use in applications like ultrafast, power-saving electronics.

The measured electron density in two atomic planes of the M-I interfacial superconducting bilayer LSCO film showing the positions of the atoms in two metallic (M) and three insulating (I) unit cells Left: in the (100) plane, the white lines highlight the projected shapes of the CuO₆ octahedra, in particular the elongation near the surface; Right: in (110) plane, the white lines highlight the projected profiles of the La-apical O planes, in particular the enhanced corrugation near the surface.


Work performed on Advanced Photon Source Beamline 33-ID