A new quasi-2D superconductor that bridges a ferroelectric and an insulator

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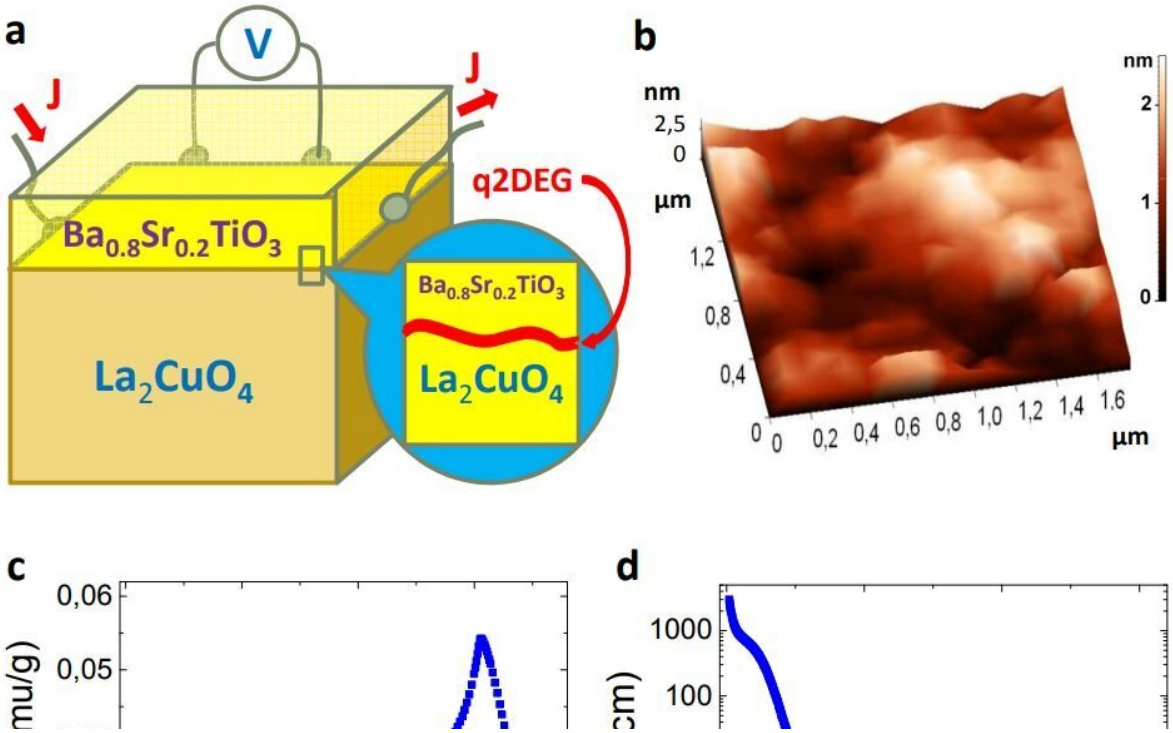

The schematic structures of $Ba_{0.8}Sr_{0.2}TiO_3/La_2CuO_4$ (a) with q2DEG (shown in red); AFM image of the La_2CuO_4 single crystal surface without the film (b) illustrates the inhomogeneity of the interface. The temperature dependence of the magnetic susceptibility (c), and the temperature dependence of the resistivity (d) of La_2CuO_4 single crystal (without ferroelectric film). Credit: Dmitrii P. Pavlov et al., arXiv:1804.05519 [cond-mat.supr-con]

Researchers at the Zavoisky Physical-Technical Institute and the Southern Scientific Center of RAS, in Russia, have recently fabricated quasi-2-D superconductors at the interface between a ferroelectric $Ba_{0.8}Sr_{0.2}TiO_3$ film and an insulating parent compound of La_2CuO_4. Their study, presented in a paper published in *Physical Review Letters*, is the first to achieve superconductivity in a heterostructure consisting of a ferroelectric and an insulator.

The idea of forming a quasi-2-D superconducting layer at the interface between two different compounds has been around for several years. One past study, for instance, tried to achieve this by creating a thin superconducting layer between two insulating oxides ($LaAlO_3$ and $SrTiO_3$) with a critical temperature of 300mK. Other researchers observed the thin superconducting layer in bilayers of an insulator (La_2CuO_4) and a metal ($La_{1.55}Sr_{0.45}CuO_4$), neither of which is superconducting in isolation.

"Here we put forward the idea that thin charged layer on the interface between ferroelectric and insulator is formed in order to screen the electric field," Viktor Kabanov and Rinat Mamin, two researchers who carried out the study, told Phys.org via email. "This thin layer may be conducting or superconducting depending on the properties of the insulator. In order to get a superconducting layer, we chose La_2CuO_4 – an insulator that becomes a high T_c superconductor when it is doped by carriers."

The heterostructure fabricated by Kabanov, Mamin and their colleagues consists of a ferroelectric magnetron sputtered on the surface of the parent compound of high T_c superconductor La_2CuO_4. At the interface between these two components, the researchers observed the appearance of a thin superconducting layer, which attains its superconductivity at temperatures below 30K.

The researchers detected the layer's superconducting properties by measuring its resistivity and via the Meissner effect. They found that a finite resistance is created when applying a weak magnetic field perpendicular to the interface, which confirms the quasi-2-D quality of the layer's superconductive state.

"The key advantage of our technique is the relative simplicity of the creation of the heterostructure, because the requirements for the roughness of the surface are not so stringent," Kabanov and Mamin said. "On the other hand, the changing the polarization in the ferroelectric allows to control the properties of the conducting layer."

Kabanov, Mamin and their colleagues are the first ever to observe superconductivity on the interface between a ferroelectric and an insulator. In the future, their approach and the superconductors they fabricated could inform the design of new electronic devices with a ferroelectrically controlled superconductivity.

"As far as plans for the future are concerned, we would like to learn how we can control the superconducting properties of the interface by rotating the polarization of the ferroelectric," Kabanov and Mamin said. "Another idea is to try to control the properties of the interface by laser illumination. This is basically the direction we are working on now."

More information: Dmitrii P. Pavlov et al. Fabrication of High-Temperature Quasi-Two-Dimensional Superconductors at the Interface of a Ferroelectric Ba0.8Sr0.2TiO3 Film and an Insulating Parent Compound of La2CuO4, *Physical Review Letters* (2019). DOI: 10.1103/PhysRevLett.122.237001

Jian-Feng Ge et al. Superconductivity above 100 K in single-layer FeSe films on doped SrTiO3, *Nature Materials* (2014). DOI: 10.1038/nmat4153

High-temperature interface superconductivity between metallic and insulating cuprates. arXiv:0810.1890 [cond-mat.supr-con]. arxiv.org/abs/0810.1890