Superconducting oxides interfaces

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The achievement of high-quality epitaxial interfaces involving transition metal oxides offers a unique opportunity to design artificial materials that host novel electronic phases. The discovery of a high mobility two-dimensional electron gas (2-DEG) confined in a quantum well at the interface between two insulating oxides $LaAlO_3$ and $SrTiO_3$ is perhaps one of the most prominent examples in the field[1]. Unlike more conventional semiconductor based quantum wells, conducting electrons at $LaAlO_3/SrTiO_3$ fill 3d-bands, which gives a favourable ground for the emergence of complex electronic phases. In particular, 2D superconductivity [2,3] and strong Rashba spin orbit coupling [4] have been reported in such interfaces. More recently, the discovery of a superconducting 2-DEG in (111)-oriented $KTaO_3$-based heterostructures injected new momentum into the realm of oxide interfaces [5,6]. In this system, the superconducting T_c can exceed 2K, nearly an order of magnitude higher than that observed in $SrTiO_3$-based interfaces. Additionally, the increased mass of Ta compared to Ti leads to significantly enhanced spin-orbit effects, as recently demonstrated [7]. Consequently, $KTaO_3$-based 2-DEGs have the potential to enable the realization of topological superconducting phases—a concept originally proposed for SrTiO3-based 2-DEGs but hitherto unattainable due to the limitations of the relevant energy scales.

A key feature of these electronic systems lies in the possibility to control their carrier density by electric field effect, which results in gate-tunability of both superconductivity and Rashba spin-orbit coupling. In this talk, I will review complementary dc and microwave transport measurements conducted on $SrTiO_3$ and $KTaO_3$-based interfaces employing both back-gate and top-gate configurations. I will discuss, in particular, gate-induced multigap superconductivity [8,9] and the role of phase fluctuations within the Berezinskii-Kosterlitz-Thouless model [10]. I will also present the realization of field effect devices whose physical properties, including superconductivity and Rashba spin-orbit coupling, can be tuned over a wide range of electrostatic doping, and discuss the potential of oxides interfaces for the realization of mesoscopic devices [11].

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