Superconductivity in two dimensions in the $AlO_x/SrTiO_3$ heterostructure

Shamashis Sengupta,[1] Miguel Monteverde,[2] Tobias Rodel,[1] Emilie Tisserond,[2] Florence Linez,[3] Anil Murani,[2] Richard Deblock,[2] Sophie Guéron,[2] Hélène Bouchiat,[2] Philippe Lecoeur,[3] Thomas Maroutian,[3] Claire Marrache-Kikuchi,[1] Andrés Santander-Syro[1] and Franck Fortuna[1]

[1] Centre de Sciences Nucléaires et de Sciences de la Matière, Univ. Paris-Sud, CNRS/IN2P3, Université Paris-Saclay, 91405 Orsay, France

[2] Laboratoire de Physique des Solides, Univ. Paris-Sud, CNRS, Université Paris-Saclay, 91405 Orsay, France

[3] Centre de Nanosciences et de Nanotechnologies, Univ. Paris-Sud, CNRS, Université Paris-Saclay, 91405 Orsay, France

shamashis.sengupta@csnsm.in2p3.fr

The realization of two-dimensional electronic gases (2DEGs) in oxide-based heterostructures has led to important discoveries [1,2] about superconductivity in low dimensions, such as the observation of pairing interactions without superconductivity [3] and density-of-states features resembling the pseudogap in cuprates [4]. Consequently, this 2DEG has emerged as a model system to study the physics of Cooper pair formation in two dimensions and to gain useful insights about complex problems, e.g., the phase diagram of high temperature superconductors.

In this talk, we will focus on: i) the facile realization of a 2DEG in $AlO_x/SrTiO_3$ using a method devised in our group that is more accessible to researchers than conventional hetero-epitaxial techniques, and ii) the phenomenon of gate-tunable superconductivity in two dimensions.

A conducting 2DEG can be realized on the bare surface of $SrTiO_3$ by the creation of oxygen vacancies [5]. The electrons populate the bands arising from Ti 3d orbitals. In a recent work *(Rodel et al., Advanced Materials, 28:1976–1980, 2016),* we have shown that the deposition in ultra-high vacuum of a thin layer of metallic Al on $SrTiO_3$ leads to the creation of the same 2DEG due to the withdrawal of oxygen atoms from the surface by the reducing agent Al (which turns into insulating AlO_x). The resulting heterostructure, $AlO_x/SrTiO_3$, is suitable for transport experiments because the layer of AlO_x protects the 2DEG in ambient conditions against the percolation of oxygen from air. From transport experiments, we have determined that the 2DEG is superconducting with a critical temperature of 320 mK. The critical parameters (temperature and field) are tunable with the gate voltage, leading to a 'superconducting dome' in the phase diagram. Phase fluctuations of the order parameter play a dominant role in the phenomenon of superconductivity in two dimensions. By continuously varying the carrier density, we have been able to tune the 2DEG across different regimes of electronic interactions that influence the phenomenon of Cooper pair condensation. We will present our results on this topic.

References:

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