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Y. L. Gan1, M. von Soosten1,2, Y. Zhang1,3, H. R. Zhang3, D. Krishnan4, Z. Zhong5, W. Niu1, D. J. Carrad2, K. Norrman1, D. V. Christensen1, N. Gauquelin4, T. S. Jespersen2, B. G. Shen3, J. Verbeek2, J. R. Sun3, N. Pryds1 and Y. Z. Chen1*

1Department of Energy Conversion and Storage, Technical University of Denmark, Risø Campus, 4000 Roskilde, Denmark
2Center for Quantum Devices, Niels Bohr Institute, University of Copenhagen, Universitetsparken 5, 2100 Copenhagen, Denmark
3National Laboratory for Condensed Matter Physics and Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China
4EMAT, University of Antwerp, Groenenborgerlaan 171, 2020 Antwerp, Belgium.
5Key Laboratory of Magnetic Materials and Devices, Ningbo Institute of Materials Technology and Engineering, Chinese Academy of Sciences, Ningbo, 315201, China

*E-mail: yuga@dtu.dk; yunc@dtu.dk;

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The two-dimensional electron liquid (2DEL) formed at the LaAlO3/SrTiO3 (LAO/STO) interface is related to the electrons located in 3d-orbit of Ti. Due to electron-electron interactions, the ground state of the system, which is either superconducting or magnetic, is sensitive to external electric field that changes the carrier density by tuning the shape and width of the potential well [1]. On the other hand, a charge-transfer-induced modulation doping can be made by inserting a LaMnO3 (LMO) buffer layer into LAO/STO interface which not only significantly suppresses the carrier density but also boosts the mobility of these carriers [2]. Herein, we report unforeseen tunability of the phase diagram of the metallic LAO/STO interface by introducing an electron sink of ferromagnetic LaMnO3 insulator into the LAO side. This is done without formation of lattice disorder and without changing the polarity of the system, LaAl1-xMnxo3/STO (0≤x≤1). By deliberately increasing the Mn-doping level, x, the interfacial 2DEL undergoes a Lifshitz transition [3] at x=0.225 with a critical carrier density of nC=2.8×1013 cm-2, where a peak value of ~250 mK of superconducting transition temperature is observed. Moreover, the LaAl1-xMnxo3 turns ferromagnetic at x≥0.25. Remarkably, at a doping level of x=0.3, just before the metallic interface becomes insulating, we observed signatures of both ferromagnetism and superconductivity in the same 2DEL where the dxy electrons is dominated.

References: