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Superconductor-Insulator Transitions and Enhancement of Superconductivity by a Parallel Magnetic Field in 2-D Superconductors

In conventional materials, the origin of superconductivity is well understood. However, novel electronic phases and quantum phase transitions can be induced when these materials are subject to dimensional confinement, disorder, external magnetic field, and paramagnetic impurities. Many of these electronic states and phase transitions are poorly understood and controversial. We have carried out a systematic examination of the superconductor-insulator transitions (SITs) in ultrathin amorphous Pb films as a function of disorder (film thickness), perpendicular magnetic field, and paramagnetic impurities. The films are quench-condensed in an ultrahigh vacuum at low temperature in a modified dilution refrigerator and all electrical measurements are performed *in situ*. We are able to directly compare the nature of the SITs tuned by all three parameters[1]. In the same films, a parallel magnetic field is found to enhance superconductivity, increasing the mean-field T_C by as much as 13% at 8 T. The T_C enhancement is shown to follow a non-monotonic thickness dependence and is progressively suppressed and extinguished by incremental deposition of paramagnetic impurity on the film. We report a similar albeit weaker T_C enhancement in the superconductor found at the heteroepitaxial interface of 8 u.c. $LaAlO_3$ and TiO_2 terminated $SrTiO_3$. The possible origin of the parallel magnetic field enhanced superconductivity will be discussed[2].

1. J.S. Parker, D. Read, A. Kumar, and P. Xiong, Europhys. Lett. 75, 950 (2006).
2. H.J. Gardner, A.Kumar, L. Yu, P. Xiong, M.P Warusawithana, L. Wang, O. Vafek, and D. G. Schlom, Nature Physics 7, 895 (2011).

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