Electrostatic Tuning of the Supercondutor-Insulator Transition*

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Application of the field effect transistor principle to achieve electrostatic doping of materials can provide the opportunity to bring about fundamental modifications of the electronic and magnetic properties of materials through controlled and reversible changes of the carrier concentration. This can be done without modifying the level of disorder, as would occur when chemical composition or thickness is altered. As well as providing a basis for new devices, electrostatic doping can in principle serve as a tool for studying quantum critical behavior by permitting the ground state of a system to be tuned in a controlled fashion. An electric-field effect device geometry that uses a mechanically thinned single crystal of strontium titanate as both the substrate and gate insulator has been used to effect significant charge transfer into ultrathin elemental films of metals. This device has been used to change the superconducting transition temperature of a film as well as to induce superconductivity in an insulating film. It has been possible to characterize the insulator-to-superconductor transition using finite size scaling. The results of the analysis are consistent with the (2+1) dimensional XY model. The appearance of superconductivity appears to be correlated with the crossover between strongly and weakly localized behavior. Application of a parallel magnetic field to a film in which superconductivity has been induced electrostatically, drives the system into an insulating state, which is substantially more insulating than the original unbiased film.

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