Highlights

Metallic supercurrent field-effect transistor

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A static electric field cannot penetrate deeply in a normal metal because of the screening effect. For this reason, the electric properties of normal metal are not changed by the application of an electric field. Under the same conditions one would expect that metallic superconductor properties are not affected either. Against this belief, we show that a static electric field generated by contactless lateral voltage gates can be used to control the critical current and induce the superconducting-to-normal metal transition in a superconducting metallic wire. The behavior of the supercurrent as a function of the electric voltage applied shows a flat region followed by a sudden drop when high voltages (about tens of Volt) are applied. This behavior is present at different working temperature and, despite the fact that the flat region increases with temperature, the voltage at which the critical current is suppressed is temperature independent. The effect is independent on the polarity of the voltage applied and it is present in different materials. All the experimental evidences seem to suggest that the phenomenon is general and does not depends on the details of the device. These results are interesting both for their fundamental and practical aspects. No theoretical model at the moment predicts or explains these effects and a deeper understanding is needed. From a more applicative point of view, they represent an asset for the realization of all-metallic superconducting field-effect electronics and leading-edge quantum information architectures.

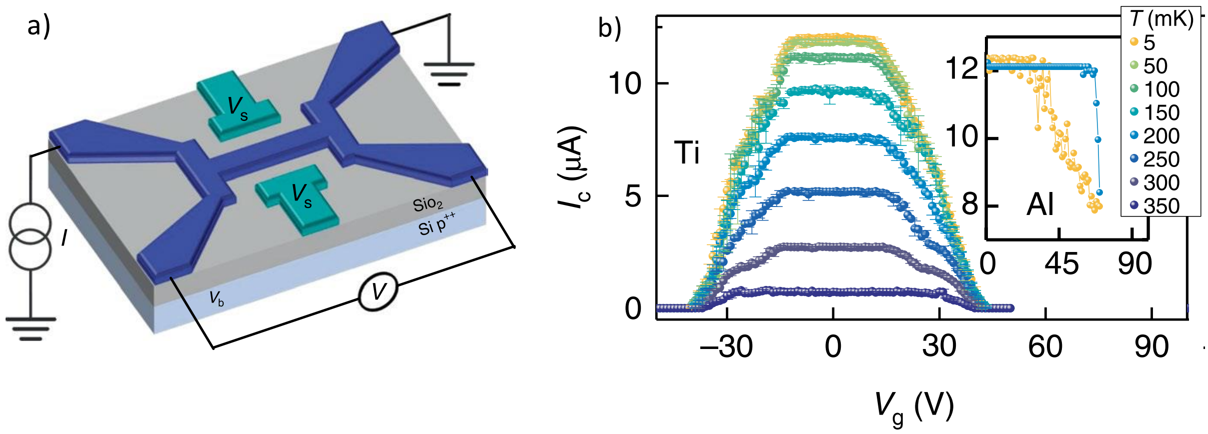

Fig. a): The schematic of the superconducting wire (blue) subject to the electric voltage V_s generated by the lateral gates (green) and a back gates V_b. b) Critical current of the superconducting wire as a function of the voltage applied and for different temperatures. The critical current shows a flat region and a fast drop but the critical voltage at which the supercurrent is suppressed remains constant in temperature. Wires made of different material (Titanium in the main figure and Aluminum in the inset) show both the supercurrent suppression.