Influence of topological edge states on the properties of Al/Bi_2Se_3/Al hybrid Josephson devices

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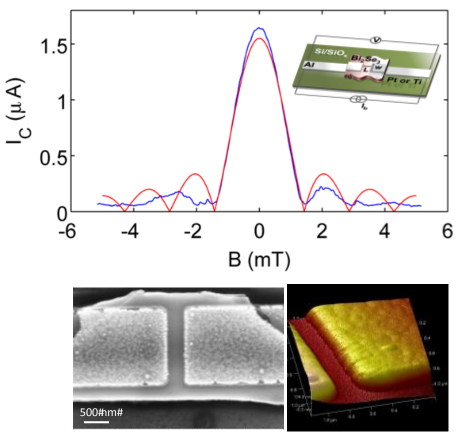
PHYSICAL REVIEW B, 89, 134512 (2014)

The understanding of how superconductivity propagates in unconventional barriers has progressively become more and more comprehensive, taking advantage of the possibility of manufacturing a larger variety of interfaces and materials. The recent introduction of topological insulators represents a milestone for this study. The standards of proximity effect in these types of structures have to be settled for a neat identification of possible new entities.

In this work we present a systematic study of transport properties of superconductor-topological insulator-superconductor coplanar Josephson junctions. These devices are characterized by a ballistic coherent transport through the topological edge states of the barrier, which is expected to generate unconventional proximity effects and, possibly, to signal the presence of Majorana bound states. A comparative study of Shubnikov–de Haas oscillations and scanning tunneling spectroscopy gave an experimental signature compatible with a two-dimensional electron transport channel with a Dirac dispersion relation.

A reduction of the size of the Bi_2Se_3 flakes to the nanoscale is an unavoidable step to drive Josephson junctions in the proper regime to detect possible distinctive features of Majorana fermions.



(Top) Critical current as a function of the external magnetic field in a Al/Bi_2Se_3/Al Josephson junction at 300 mK. The red line is the reference curve appropriate for a small junction with uniform critical current density. The inset shows a sketch of the device. (Bottom left) scanning electron microscopy image of the device, and (Bottom right) atomic force microscopy of the same device. The morphology of the Bi_2Se_3 barrier is clearly visible, showing an atomically flat surface.

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