SIGNATURES OF MAJORANA ZERO MODES IN NANOSCALED (Bi$_x$Sb$_{1-x}$)$_2$Te$_3$/Nb JOSEPHSON JUNCTIONS

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Topological Insulators (TIs) are semiconductors with a band gap in the bulk, but metallic states at the surface. At the surface a band inversion induced by strong spin-orbit interactions leads to the so-called Dirac states. Majorana excitations are predicted to arise in topological insulator (TI) surface states in proximity to conventional s-wave superconductors (SC). Here, topologically protected Majorana Zero Modes (MZMs) promise to obey non-Abelian exchange statistics and therefore to facilitate fault-tolerant quantum computing [1].

Josephson Junctions were fabricated s-wave superconductor (Nb) and 3-dimensional topological insulators, typically Bi$_x$Sb$_{2-x}$Te$_3$ alloys, as test vehicles on the search for Majorana modes. Induced superconductivity in Josephson junctions with weak links of 3D TI films is expected to be mediated partly by Majorana bound states.

In Bi$_x$Sb$_{2-x}$Te$_3$ alloys the band gap and the position of the Fermie level at the sample surface can be controlled by the composition. However, a serious problem is the large bulk carrier concentration and the high sensitivity towards surface oxidation. Thus in-situ fabrication of the TI/SC interface as well as TI surface passivation is required to obtain a high contact transparency and a high mobility in the surface layer, respectively. The Molecular beam epitaxy process presented in this work combining selective growth and stencil lithography [2] assures these necessities. The in-situ prepared Josephson junctions show a high interface transparency and large $I_cR_N$ products of 325 µV, indicating a strong proximity effect and a large superconductive gap. The Shapiro response of radio frequency measurements indicates the presence of gapless Andreev bound states, the so called Majorana bound states, proofed a high interface transparency and showed signatures of gapless Andreev bound states, so-called Majorana bound states.

The in-situ fabrication process can be adapted to complex layouts, first experiments for the in-situ processing of nanowire devices and qubit structures will be presented. Thus the process paves the way towards networks of in-situ grown Majorana devices for the proposed topological qubit layouts.


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