Transport studies in selectively grown topological insulator multiterminal Josephson junctions

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The combination of an ordinary s-type superconductor with three-dimensional topological insulators creates a promising platform for fault tolerant topological quantum computing circuits based on Majorana braiding [1]. The backbone of the braiding mechanism are three-terminal Josephson junctions [2]. It is crucial to understand thetransport in these devices for further use in quantum computing applications. Generally, hybrid devices with multiple connections leads to rich physics in terms of transport properties, with a huge parameter space to be probed [3]. We present low-temperature measurements of three-terminal $Bi_{0.8}Sb_{1.2}Te_3$ Josephson junctions fabricated, basedon a combination of selective area growth and shadow mask evaporation. This approach allows for the in-situ fabrication of Josephson-junctions with an exceptional interface quality, important for the study of the proximity-effect. The transport properties of the junction are mapped out as a function of bias current and magnetic field. The bias current maps show several interesting transport phenomena, i.e. multiple Andreev reflections. Superconducting features in the bias maps indicate the successful fabrication of a fully coupled three-terminal junction. The multiterminal junctions properties appear to be in good agreement with a resistively and capacitively shunted junction network model. However, the transport measurements reveal the influence of intrinsic asymmetries due to the shape of the underlying nanoribbon. In addition, the properties of the single Josephson junctions forming the multi-terminal devices are investigated. This includes experiments to investigate the in-plane magnetic field dependence of the critical current, the diode effect and the Shapiro response. The results indicate the successful fabrication of a fully coupled multi-terminal Josephson junction in contrast to previous studies on the supercurrent in multi-terminal devices based on topological insulators [4]. The devices represent a further step towards proving the proximity effect in surface states and topological superconductivity in the search for Majorana bound states.

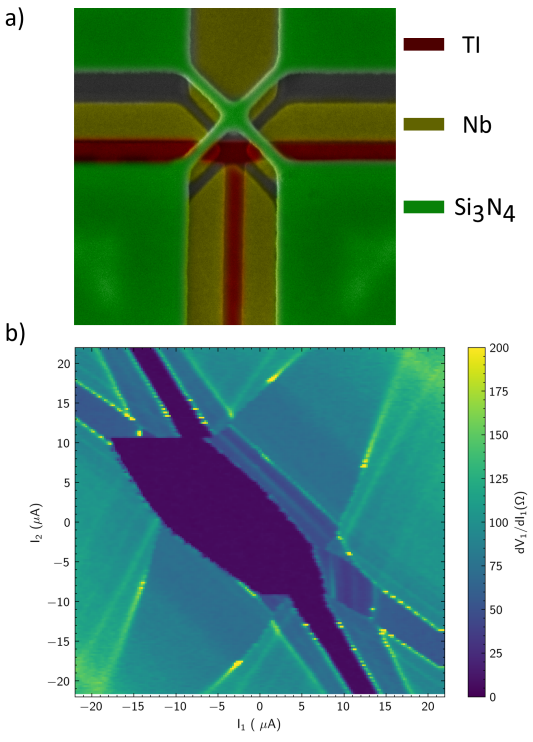

Fig. 1. **a)** Scanning electron micrograph of a multi-terminal Josephson junction. **b)** Bias map of the device shown in a) indicating a fully coupled three-terminal Josephson junction.

References

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