Experimental Signatures of Gate-Tuneable One-Dimensional Edge Channels in Bi2Se3 Josephson Junctions

Feike van Veen
Femke Witmans, Jara Vliem, Daniel Vanmaekelbergh, Chuan Li, Alexander Brinkman
University of Twente, Drienerlolaan 5, 7522 NB Enschede, The Netherlands

f.vanveen@utwente.nl

Abstract (Century Gothic 11)

The quantum spin Hall (QSH) effect exhibits helical edge channels allowing for a quantized conductance that can be utilized in the development of quantum computing [1]. In a previous study, an enhanced density of states has been probed at the edges of ultrathin colloidal Bi2Se3 nanoplatelets (NPLs) with scanning tunnelling spectroscopy, which was attributed to surface hybridization [2]. Here, we study the transport properties of the edge modes in these Bi2Se3 NPLs in Nb - Bi2Se3 - Nb Josephson Junctions (JJ)s and confirm strong signatures of a 1D contribution in the superconducting transport properties of 6 nm thick Bi2Se3 JJs. We reveal experimental evidence of a thickness dependence as is described by theoretical frameworks [3]. Also, we can deplete the NPLs into an insulating regime by applying a back-gate voltage, hereby destroying the supercurrent, allowing for an 'on' or 'off' mode of the JJ. Additionally, we have performed spectroscopy on sub-gap Andreev bound states, in thicker samples we have observed persistent supercurrents up to at least 1 T in parallel field. These observations contribute to understanding and development of topological JJs and shed new light on previous studies focussing on superconductivity induced in QSH states.

References

[1] Hasan, M. Z. et al., Rev. Mod. Phys. 82, 3045–3067 (2010).
[2] Moes, J. R. et al. Nano Lett. 24, 5110-5116 (2024)
[3] Asmar, M. M. et al, Phys. Rev. B 97, 075419 (2018)

Figures

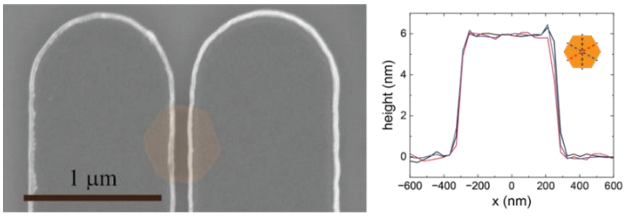

Figure 1: Left: False coloured SEM of one of the measured devices. Orange shows the hexagonal Bi2Se3 NPL, the left and right white-edged features are Nb leads. Right: height profile of the NPL shown on the left

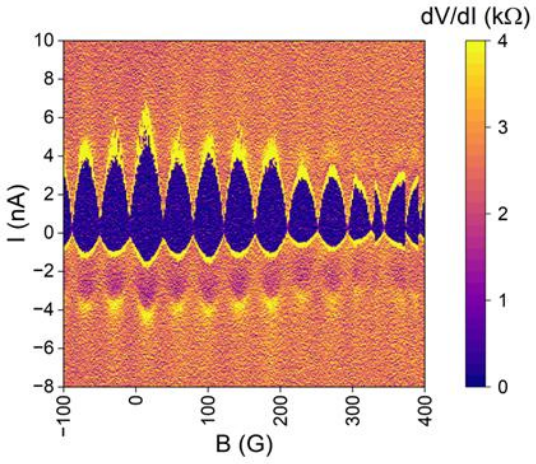

Figure 2: Numerical differential resistance versus magnetic field and sourced current. A SQUID-like oscillatory dependence is observed, indicative of edge states running at the perimeter of the device.