



Induced superconductivity in magnetic topological insulator – superconductor hybrid devices

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Magnetic topological insulators (MTIs) coupled to superconductors (SCs) represent a promising platform for realizing Majorana zero modes (MZMs), key building blocks for fault-tolerant topological quantum computing. MTIs combine broken time-reversal symmetry with helical Dirac surface states in a single material. Unlike approaches with semiconductor nanowires and non-magnetic topological insulators, which require external magnetic fields, MTI-based devices promise operation without external magnetic field. However, experimental progress has been limited by the difficulty of fabricating high-quality MTI nanostructures and by the challenge of inducing superconductivity in the presence of ferromagnetic order.

This study addresses these limitations by developing a novel selective deposition technique that enables the controlled, fully in-situ growth of magnetic topological insulator nanostructures and their integration in superconducting devices. This approach enables nanoscale device fabrication while preserving clean interfaces, essential for proximity-induced superconductivity. Proximity-induced superconductivity in magnetic TI was realized for nano scaled Josephson Junctions (< 120 nm in width and < 70 nm in length). The junctions show signatures of multiple Andreev reflections, indicating highly transparent SC–MTI interfaces. Magnetic-field-dependent measurements reveal asymmetric Fraunhofer interference patterns with $I_c(B) \neq I_c(-B)$, with I_c being the critical current. A theoretical analysis points to an interpretation, that the observed behavior is a signature of a proximitized magnetic Dirac system. Together, these results establish a complete experimental toolbox for magnetic topological insulator-superconductor hybrid devices, laying the foundation for future studies of topological superconductivity in MTI systems.



Dr. Detlev Grützmacher is a distinguished scientist in the field of semiconductor nanoelectronics. He earned his PhD in Physics from RWTH Aachen University with special honours and subsequently held a postdoctoral position at IBM's T.J. Watson Research Center in New York. From 1993 to 2006, he was a scientist and project leader at the Paul Scherrer Institute in Switzerland, where he led research on silicon nanosystems. Since 2006, he has served as Director of the Peter Grünberg Institute for Semiconductor Nanoelectronics at Forschungszentrum Jülich, Germany. He has also held several leadership roles within the Jülich Aachen Research Alliance (JARA), including Scientific Director of JARA-FIT and, since 2019, Co-Director of JARA-FIT. His research focuses on semiconductor nanotechnology, nanoelectronics, and future information technologies.

