

Annealing-Induced Superconductivity in In/Bi₂Te₃

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Combining a conventional superconductor with a topological insulator (TI) provides a promising route to inducing superconducting (SC) correlations in a material with strong spin–orbit coupling and spin-polarized topological surface states. In/Bi₂Te₃ heterostructures are suitable for investigating this interplay. However, fabrication of devices with well-defined geometries requires lithographic processing, during which elevated temperatures may alter the In/Bi₂Te₃ interface. In particular, annealing may promote In intercalation into the van der Waals (vdW) gaps, giving rise to superconductivity distinct from that of elemental In.

Here, we investigate annealing-induced modifications of In/Bi₂Te₃ using low-temperature transport measurements and scanning tunnelling microscopy and spectroscopy (STM/STS). Hall-bar devices were fabricated from exfoliated Bi₂Te₃ flakes and coated with a 70 nm thick In layer deposited at 100 K. Complementary STM/STS measurements were performed on *in situ*-cleaved Bi₂Te₃ surfaces covered with a sub-monolayer of In.

No SC transition is observed in the transport channel prior to annealing. After annealing, however, the resistance decreases below 1.75 K, and the transition is suppressed by a magnetic field of 0.67 T. The transition exhibits Berezinskii–Kosterlitz–Thouless-like behaviour, indicative of two dimensional SC. Moreover, both the transition temperature and critical field differ from those of a reference elemental In film, suggesting that the observed SC cannot be attributed solely to an unmodified In layer. This motivates a local investigation of the structural and electronic changes induced by annealing.

At room temperature, deposited In forms nanoscale islands on the Bi₂Te₃ surface. STS measurements performed near these islands reveal distance-dependent spectral shifts of up to 80 meV relative to the Fermi level while preserving signatures of the topological surface states. Following annealing, the islands disappear and are replaced by non-native defects exhibiting bias-dependent contrast. Spectra acquired near these defects show local energy shifts of up to 100 meV, indicating a substantial modification of the near-surface electronic structure. These observations suggest that annealing promotes the incorporation of In beneath the surface and could be consistent with its intercalation into the vdW gaps.

Together, the results suggest that annealing produces an inhomogeneous, two-dimensional SC region associated with In-modified Bi₂Te₃, rather than an unmodified elemental In layer. Intercalation into the vdW gaps provides a possible microscopic explanation, although direct structural confirmation is still required.

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