Coupling of Quantum Hall Effect and Superconductivity Using Al/InAs Junction on Cleaved Edge Surface

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Hybrid systems comprising superconductor (SC) and quantum-Hall (QH) chiral edge channels have attracted renewed attention as an alternative route to exotic quasiparticles with non-Abelian statistics. Since they require strong magnetic fields, so far type II superconductors have been used exclusively [1]. On the other hand, at zero magnetic field, superconducting hard gap properties have been reported for low-temperature grown epitaxial Al/InAs [2], although there are no reports on their application to SC-QH hybrid systems due to their small critical magnetic field. In this study, we fabricate an Al SC and InAs two-dimensional electron gas (2DEG) junction on the wafer cleaved edge surface and demonstrate Andreev reflection in the QH regime.

The sample, thinned to 300 μm by polishing to obtain a flat cleaved edge surface, comprises a InAs quantum well with AlGaSb barriers grown on an *n*-type GaSb substrate. After cleaving the wafer in an ultra-high vacuum chamber, we deposited Al/Pt/Al (6/1/2 nm) on the cleaved surface with the sample holder cooled with liquid nitrogen. The thin Pt layer enhances the critical field [3]. With this structure, the magnetic field applied perpendicular to the 2DEG is parallel to the SC thin film, where a large critical magnetic field of a few T is expected [3]. We form a short SC/semiconductor junction by patterning a top gate defining the 2DEG channel region, with a 3-μm aperture above the SC/semiconductor interface, and depleting the 2DEG underneath [Fig. 1(a)].

Figure 1(b) plots R_d (= dV_d/dI), where I is the current passing through the junction and V_d is the voltage of the downstream edge channel with respect to the junction, as a function of dc bias (V_{dc}) and magnetic field (B_z). The data reveal a superconducting gap, which appears as a region of reduced R_d around zero bias and remains open up to 4.8 T. The reduced R_d within the superconducting gap is a manifestation of hole reflection into the downstream edge channels. From this result, we demonstrated the coupling of SC and QH edge channels by using Al and InAs. In the presentation, we discuss the Andreev reflection probabilities at $B_z = 0$ and $B_z \neq 0$ by analyzing the data using the Blonder-Tinkham-Klapwijk and Landauer-Büttiker models, respectively.

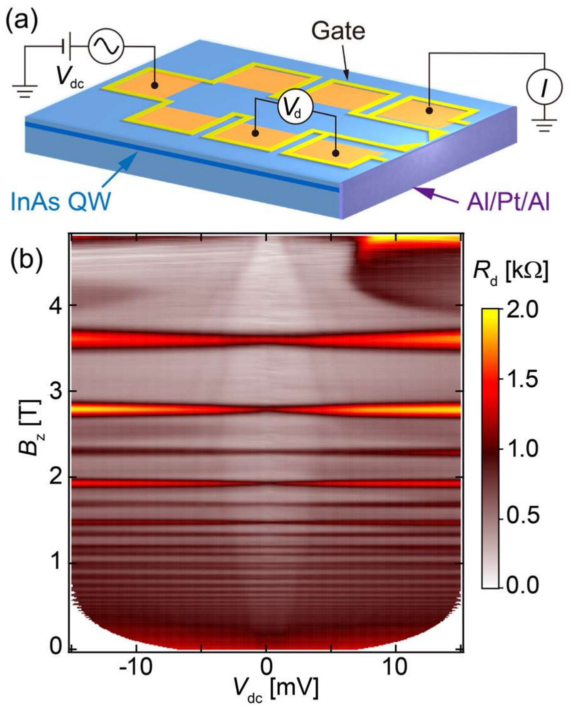

Fig.1. (a) Schematic image of the device and measurement setup. (b) R_d vs V_{dc} and B_z showing Andreev reflection in the quantum Hall regime.

References

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