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Highly transmissive InSb nanoflag Josephson junctions

High-quality III–V narrow bandgap semiconductor materials with strong spin–orbit coupling and large Landé g-factor provide a promising platform for next-generation applications in the field of high-speed electronics, spintronics, and quantum computing. InSb offers a narrow bandgap, high carrier mobility, and small effective mass and, thus, is very appealing in this context. In fact, this material has attracted tremendous attention in recent years for the implementation of topological superconducting states. An attractive pathway to obtain two-dimensional (2D) InSb layers is the growth of freestanding single-crystalline InSb nanoflags [1].

We have demonstrated fabrication of ballistic Josephson-junction devices based on these InSb nanoflags with Ti/Nb contacts that show a gate-tunable proximity-induced supercurrent and a sizable excess current [2]. The devices show clear signatures of subharmonic gap structures, indicating phase-coherent transport in the junction and a high transparency of the interfaces.

The high quality of the devices has allowed the observation of the Josephson diode effect in these Josephson junctions [3]. Indeed, when an in–plane magnetic field is applied, the devices are driven into a non-reciprocal transport regime, where we observe an asymmetry between the positive and negative critical current. The asymmetry is modulated by the angle between the in-plane field and the current direction, and strongly depends on temperature. Our experimental evidence demonstrates that these devices can work as Josephson diodes, with dissipation–less current flowing in only one direction.

Under microwave irradiation, we observe half-integer Shapiro steps that are robust to temperature, suggesting their possible nonequilibrium origin [4]. Our results demonstrate the potential of ballistic InSb nanoflags Josephson junctions as a valuable platform for understanding the physics of hybrid devices and investigating their nonequilibrium dynamics.

References

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