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Coherent quantum transport in hybrid Superconductor-2DEG-Superconductor planar Josephson junctions

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The study of hybrid superconductor-semiconductor (S-Sm) structures have received renewed interest because of the recently reported detection of Majorana fermions at the S-Sm interface in nanowire and topological insulator based devices.

Here, we report the experimental results on proximity induced superconductivity in a high-mobility two-dimensional electron gas (2DEG) in InGaAs heterostructures. Eight symmetric S-Sm-S Josephson junctions were fabricated on a single InGaAs chip.

The superconducting electrodes were made of Niobium (Nb) and the quantum transport of junctions were measured using a lock-in technique at temperature 40 mK. The subharmonic energy gap structures (SGS) were observed at $V=2\Delta_{Nb}/ne$ on dV/dI (V) due to Andreev reflections at the S-Sm interfaces. The SGS features suppressed significantly with increasing temperature and magnetic field, leading to a shift of the SGSs toward zero bias.

The differential conductance dI/dV versus magnetic field B curves show a maxima at zero B and decreases by increasing B. When decreasing the magnetic field to below +0.4 T, there is hysteresis in B accompanied by periodic oscillations of conductance with a periodicity of ~15 mT between +0.05 and 0 T. The same effect could also be seen for negative fields. Both the hysteresis and periodic oscillation effects are strongly temperature dependent.

Our observation paves the way for development of coherent circuits applicable in novel quantum multiplexers and processors.