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Optimization of in-situ growth of Al/InAs hybrid systems for the development of Andreev quantum computation

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Hybrid systems consisting of semiconductor channels and superconducting elements allow the formation of Andreev qubits and are therefore among the novel material platforms which could pave the way to scalable quantum computation. A key ingredient to achieve high coherence time and strong qubit-qubit coupling is the establishment of a clean superconductor / low-D semiconductor interface and highly transparent channels. To this aim, InAs 2D electron gases (2DEGs) are the ideal semiconductor systems due to their vanishing Schottky barrier; however, their exploitation is limited by the non-availability of commercial lattice-matched substrates.

We show that in-situ growth of superconducting aluminum on near-surface InAs metamorphic 2DEGs can be performed by Molecular Beam Epitaxy on GaAs substrates with state-of-the art quality, despite the 7% InAs/GaAs lattice mismatch. 2DEGs down to 10nm from the surface showed record-high low-T electron mobilities, and well-developed Quantum Hall and Quantum Point Contact features.

Al growth resulted in crystalline thin films with the coexistence of different crystallographic domains. Resistivity as a function of temperature was comparable to the best Al layers on GaAs and superconducting proximity effect was observed in a Josephson junction. The observed phenomenology opens the way to the exploitation of Andreev physics on our platforms.

Primary authors: Ms MAGDHI, Kirti (Consiglio Nazionale delle Ricerche, Istituto Officina dei Materiali); BENALI, Abdennacer (Consiglio Nazionale delle Ricerche, Istituto Officina dei Materiali); SÜTŐ, Mate (Department of Physics, Budapest University of Technology and Economics and Nanoelectronics "Momentum"Research Group of the Hungarian Academy of Sciences); TÓVÁRI, Endre (Department of Physics, Budapest University of Technology and Economics and Nanoelectronics "Momentum"Research Group of the Hungarian Academy of Sciences); MAKK, Péter (Department of Physics, Budapest University of Technology and Economics and Nanoelectronics "Momentum" Research Group of the Hungarian Academy of Sciences); PROK, Tamás (Department of Physics, Budapest University of Technology and Economics and Nanoelectronics "Momentum"Research Group of the Hungarian Academy of Sciences); CSONKA, Szabolcs (Department of Physics, Budapest University of Technology and Economics and Nanoelectronics "Momentum"Research Group of the Hungarian Academy of Sciences); BIASIOL, Giorgio (Consiglio Nazionale delle Ricerche, Istituto Officina dei Materiali)

Presenter: Ms MAGDHI, Kirti (Consiglio Nazionale delle Ricerche, Istituto Officina dei Materiali)

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