Controlled Partial Gallium Intercalation in Epitaxial Graphene Hall Bars A 2D Normal-Superconductor Junction

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Two-dimensional (2D) systems provide unique opportunities to tune electronic properties via proximity effects, allowing the controlled emergence of distinct electronic phases [1]. Intercalation of Gallium beneath epitaxial graphene on SiC forms a two-dimensional Gallium layer (2DGa) that induces superconductivity while decoupling the buffer layer from the substrate, converting it into quasi-freestanding bilayer graphene (QFBLG) [2]. The SiC/2DGa/QFBLG heterostructure has been shown to exhibit superconductivity with a critical onset temperature of $T_c \approx 3.5$ K, where the superconducting path is confined within the 2DGa layer [3]. High-quality samples are realized using polymer-assisted sublimation growth (PASG) [4], ensuring well-defined interfaces and reproducible electronic properties.

We introduce a device concept for the fabrication of Hall bar structures featuring a spatially defined normal-to-superconductor transition within a single 2D material system. The concept exploits the anisotropic diffusion of liquid gallium along SiC terrace directions, driven by the liquid metal intercalation technique (LiMIT) [3], to realize controlled partial intercalation of epitaxial graphene Hall bars. Orienting the Hall bar geometry perpendicular to the preferential $[1\bar{1}00]$ diffusion direction and controlling the intercalation process allows us to intercalate one half of the Hall bar, while leaving the other half as pristine epitaxial graphene. Consequently, a lateral junction forms at the boundary separating the 2DGa/QFBLG and monolayer epitaxial graphene region.

Precisely positioning and characterizing this interface yields a reproducible platform for investigating confined 2D superconductivity, proximity-induced effects at lateral junctions, possible Andreev reflection processes, and the interplay of structural inhomogeneity and electronic transport across the junction.

References:
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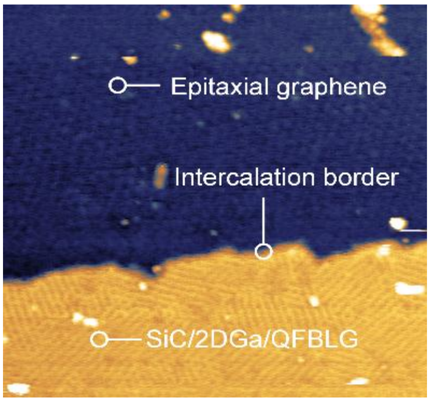

Fig. 1: Scanning tunneling microscopy (STM) image of the transition from Ga-intercalated QFBLG (yellow) to pristine epitaxial graphene (blue).