High Mobility Free-Standing InSb Nanoflags for Quantum Technologies

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High-quality III-V narrow band-gap semiconductor materials with strong spin-orbit coupling and large Landé g-factor provide a promising platform for next-generation applications in the field of optoelectronics, spintronics, and quantum computing. Indium antimonide (InSb) offers a narrow band gap, high carrier mobility, and a small effective mass, and thus perfectly fits to this scope. In fact, it has attracted tremendous attention in recent years for the implementation of topological superconducting states supporting Majorana zero modes. However, high quality heteroepitaxial two-dimensional (2D) InSb layers are very difficult to realize owing to the large lattice mismatch with other widespread semiconductor substrates. A solution to this problem is to grow free-standing single-crystalline 2D InSb nanostructures, so-called nanoflags [1,2]. Indeed, this geometry allowed us fabricating Hall-bar devices with suitable length-to-width ratio and 10/190 nm Ti/Au contacts, enabling precise electrical characterization. As shown in Figure 1a, we demonstrate a high electron mobility of ~29,500 $cm^2/(Vs)$ and a mean free path of 500 nm at 4.2 K [2]. We have also successfully fabricated ballistic Josephson junction devices with 10/150 nm Ti/Nb contacts that show gate-tunable proximity-induced supercurrent (~50 nA at 300 mK, see Figure 1b) [3]. The devices also show clear signatures of subharmonic gap structures, indicating phase-coherent transport in the junction. Our study places InSb nanoflags in the spotlight as a versatile and convenient 2D platform for advanced quantum technologies.

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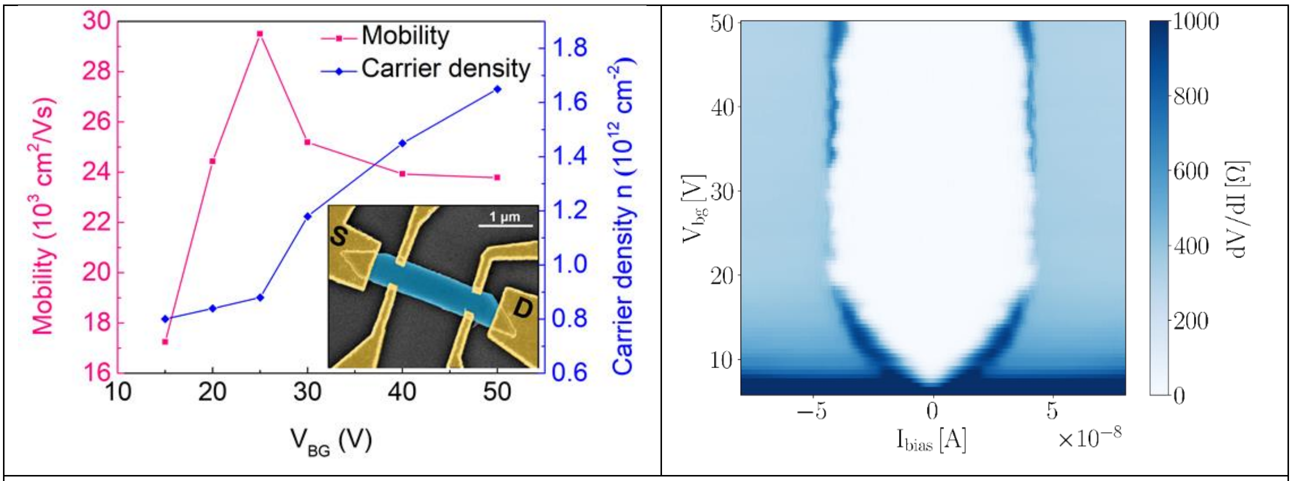

Figure 1: (a) Mobility and charge carrier density obtained from Hall measurements. Inset shows the SEM image of an InSb nanoflag Hall-bar device. (b) Differential resistance *dV/dI* of an InSb-based Josephson junction versus current bias I_{bias} and backgate voltage V_{bg}.

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[2] I. Verma, S. Salimian, V. Zannier, S. Heun, F. Rossi, D. Ercolani, F. Beltram, and L. Sorba: *High Mobility Free-Standing InSb Nanoflags Grown on InP Nanowire Stems for Quantum Devices*, ACS Applied Nano Materials, in press.

[3] S. Salimian, M. Carrega, I. Verma, V. Zannier, D. Ercolani, F. Beltram, L. Sorba, and S. Heun, unpublished.

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