Towards enhanced spin-orbit coupling in epitaxial graphene via Pb intercalation

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The design of noval quantum phases by combining low dimensional materials poses the next evolution step of electronics. Intercalated epitaxial graphene on SiC embodies a van-der-Waals heterostack with well-defined lattice arrangement. Stabilizing monolayers of heavy elements in proximity to graphene, potentially enhances the spin-orbit interaction (SOI) in graphene. Using Pb as intercalant, we reliably decouple and neutralize graphene by minimizing the substrate influence. At the interface coexisting striped and hexagonal superstructures emerge from local strain and density variations in the Pb monolayer. [1] Multiprobe transport measurements, assisted by finite element simulations, revealed a temperature dependent resistance. This emergent behavior was attributed to a gap opening in graphene in the order of 3-5 meV. [2] Tip–sample spacing dependent spectroscopy supports this finding by a clearly reduced density of states at the Dirac point. The desired enhanced intrinsic SOI competes with Rashba-SOI and modulations of the sublattice potential by the Pb superstructure. Although the nature of this gap was not revealed yet, it has potential to stabilize a quantum spin Hall state.

References:
[1] M. Gruschwitz et al., Adv. Mater. Interfaces 12, 21 (2025) e00617
[2] M. Gruschwitz et al., Phys. Rev. B 109 (2024) 245430

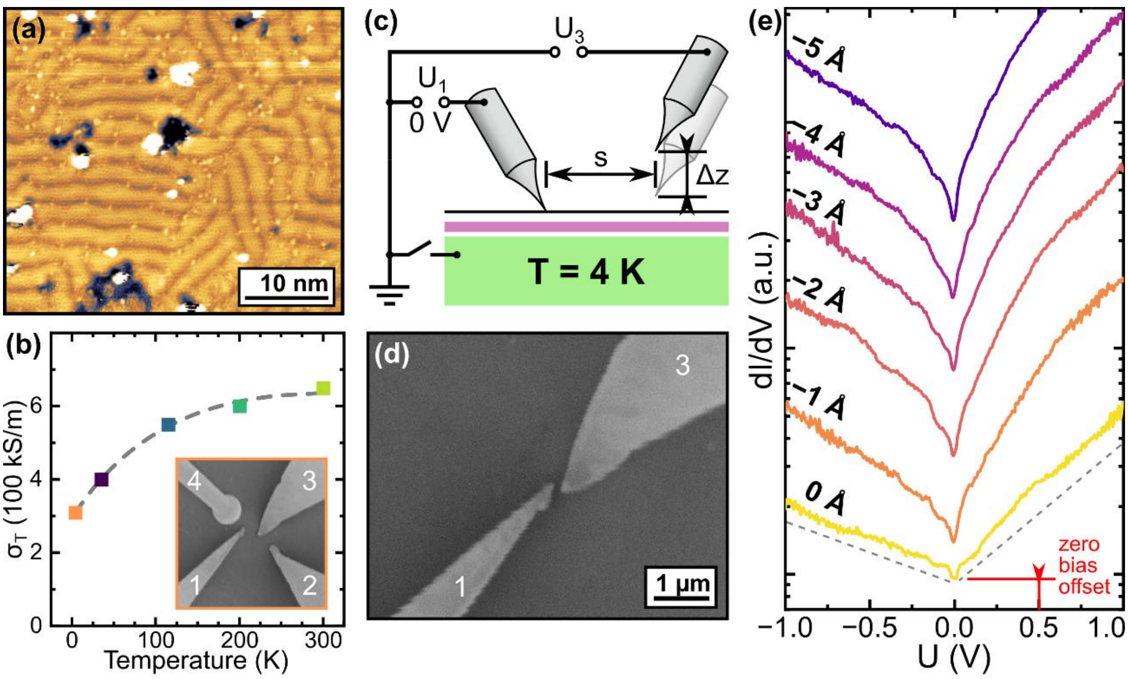

Fig. 1: Overview of transport measurements on Pb intercalated epitaxial graphene. Extended intercalated phases reveal a mixture of stripe and hexagonal Pb interface structures (a). (b) Temperature dependent local four-probe transport measurements indicated a small gap opening in the graphene layer. This gap opening was confirmed by tunneling spectroscopy (e) in a two probe setup with varied tunneling gap sizes (c). The second probe for local grounding suppresses non-local contributions in the tunneling spectra (d).