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Chemical potential and tunneling in bilayer graphene using double bilayer graphene heterostructures[1]

EMANUEL TUTUC, The University of Texas at Austin

Vertical heterostructures consisting of atomic layers separated by insulators can open a window to explore the role of electron interaction in these materials, otherwise not accessible in single layer devices. We describe here one such heterostructure, consisting of two bilayer graphene flakes separated by a hexagonal boron-nitride dielectric. Using the top layer as a resistively detected Kelvin probe we map the chemical potential of the bottom bilayer graphene as a function of electron density, perpendicular magnetic field, and transverse electric field. At zero magnetic field the chemical potential reveals a strongly non-linear dependence on density, with an electric field induced energy gap at charge neutrality. The data allow a direct measurement of the electric field-induced bandgap at zero magnetic field, the orbital Landau level energies, and the broken symmetry quantum Hall state gaps in high magnetic fields [1]. In samples where the two layers are rotationally aligned the interlayer tunneling current measured as a function of interlayer bias reveals a gate-tunable negative differential resistance thanks to momentum conserving tunneling [2]. Remarkably, the resonance width has a weak temperature dependence in the range 1.5 K to 300 K.

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[1] K. Lee *et al., Science* **345**, 58 (2014).
[2] B. Fallahazad *et al.*, *Nano Letters* ASAP, DOI: 10.1021/nl503756y (2014).

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