

Electron Transport and Tunneling Field-Effect Transistors in Graphene-based Heterostructures

Emanuel Tutuc^a, Seyoung Kim^a, Kayoung Lee^a, Babak Fallahazad^a, Kyoungwah Kim^a, and Jiamin Xue^a

^aMicroelectronics Research Center, The University of Texas at Austin, U.S.A., etutuc@mer.utexas.edu

Recent years have witnessed an increased interest in atomic layer semiconductors, such as graphene and transition metal dichalcogenides. These semiconductors possess unique properties such as massless fermions in graphene monolayer, tunable band-gap in graphene bilayers, or large effective mass ($\sim 0.5m_e$) in transition metal dichalcogenide layers. In this presentation we discuss the realization of atomic layer heterostructures using a layer-by-layer transfer approach [Fig. 1], and a set of electron transport experiments aimed at probing the electron-electron interaction in graphene.

Using graphene double layers consisting of two graphene layers separated by a thin dielectric, we probe the frictional drag resulting from the inter-layer interaction, as a function of layer densities and temperature, and discuss the results in the context of existing theoretical studies [1, 2].

A second topic presented is a technique that allows a direct measurement of the Fermi energy in an electron system, using a double layer heterostructure. The underlying principle of the technique is that an interlayer bias applied to maintain one of the layers at charge neutrality is equal to the Fermi energy of the opposite layer [3]. Using this technique we probe the Fermi energy in monolayer and bilayer graphene as a function of density, and identify the band structure and exchange-correlation contributions to the Fermi energy.

Third, we discuss the realization and characterization of tunneling field-effect transistors in graphene double layers separated by hexagonal boron nitride (hBN).

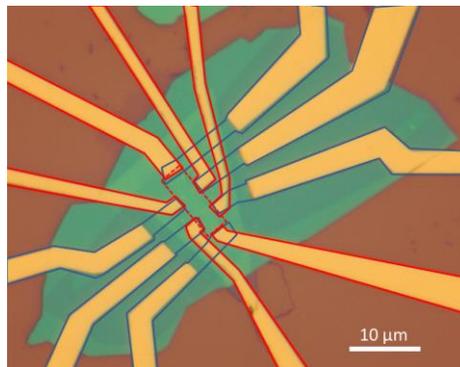


Fig. 1: Optical micrograph of a graphene double layer heterostructure on an hBN substrate, and separated by an hBN layer. The blue (red) contour marks the bottom (top) layer.

References

- [1] S. Kim, I. Jo, J. Nah, Z. Yao, S. K. Banerjee, E. Tutuc, “Coulomb Drag of Massless Fermions in Graphene”, *Physical Review B* 83, 161401-161404 (2011).
- [2] S. Kim, E. Tutuc, “Coulomb drag and magnetotransport in graphene double layers”, *Solid State Communications* 152, 1283 (2012).
- [3] S. Kim, I. Jo, D. C. Dillen, D. A. Ferrer, B. Fallahazad, Z. Yao, S. K. Banerjee, E. Tutuc, “Direct measurement of the Fermi energy in graphene using a double-layer heterostructure”, *Physical Review Letters* 108, 116404 (2012).