Superconducting Graphene Nanodevices in the Ballistic Transport Regime

Joel I-Jan Wang [1, 2], Yu-An Chen[2], Kenji Watanabe[3], Takashi Taniguchi[3], Pablo Jarillo-Herrero[2]

[1] *Harvard School of Engineering and Applied Sciences, Cambridge, MA 02138, USA*
[2] *Department of Physics, Massachusetts Institute of Technology, Cambridge, MA 02139 USA*
[3] *National Institute for Materials Science, Namiki 1-1, Tsukuba, Ibaraki 305-0044, Japan*

Superconductivity carried by Dirac fermions can be realized through induced superconductivity in graphene [1]. Observation of novel phenomena anticipated by theories [2] calls for superconducting graphene devices with low disorder so that the transport is ballistic.

Current fabrication procedures to make graphene devices with low disorder, such as devices on suspension or ultra-flat substrates, all call for certain kinds of annealing to remove organic residues derived from the fabrication process [3],[4]. Applying these methods to superconducting devices is challenging since the transparency at the graphene/superconductor interface may be compromised.

Here we present the fabrication and characterization of superconducting graphene nanodevices with its 2-dimensional electron gases (2DEGs) encapsulated in hexagonal boron nitride (hBN) flakes. The ultra flatness and lack of dangling bond in the boron nitride substrate reduces the disorder in graphene, while the top hBN layer protects the graphene from contamination during nanofabrication. We believe that this kind of device will open the door for the study of ballistic Dirac fermions in the superconducting regime.

[1] H. B. Heersche *et al*., "Bipolar supercurrent in graphene," *Nature*, vol. 446, pp. 56-59, Mar. 2007.
[2] C. W. J. Beenakker, "Colloquium: Andreev reflection and Klein tunneling in graphene," *Rev. Mod. Phys*., vol. 80, pp. 1337-1354, 2008.
[3] Kirill I. Bolotin *et al*., "Observation of the fractional quantum Hall effect in graphene," *Nature*, vol. 462, pp. 196–199, Nov. 2009.
[4] T. Taychatanapat *et al*., "Quantum Hall effect and Landau level crossing of Dirac fermions in trilayer graphene," *Nature Physics*, vol. 7, pp. 621-625, 2011.