# Transport phenomena in nanostrctured graphene

**A. P. Jauho**, M. Settnes, S. R Power, A. A. Shylau, and D. H. Petersen

Center for Nanostructured Graphene CNG, Department for Micro and Nanotechnology, DTU Nanotech, Technical University of Denmark, Ørsteds Plads, Bldg 345E, 2800 Kongens Lyngby, Denmark
Antti-Pekka.Jauho@nanotech.dtu.dk

Graphene samples in the lab are not ideal: disorder, defects, or deliberate nanostructuring is always present. Here we describe three recent developments in modeling of such systems.

STM is a widely used tool to analyze mesoscopic samples: it yields direct information about the density of states. We have recently analyzed a dual-probe STM setup [1]; here current is injected from one probe, and collected by another, adjacent probe. Present technology allows probe separations below one hundred nanometers – well below dephasing lengths at low temperatures – and thus the conductance between such probes displays quantum interference phenomena. The signal, being a transport quantity, contains more information than the conventional STM measurement which reflects local properties. For example, probes separated along armchair or zigzag directions on pristine graphene yield very different results because of the underlying anisotropy of the graphene lattice. Calculations have been performed for a large number of nanostructured graphene samples: single or several defects, adsorbents, or vacancies as well as samples with edges. We envisage experiments where one probe is kept fixed while the other scans along the sample surface, and examples of such conductance maps as well as their Fourier transforms (which yield information about intra- and intervalley scattering) will be analyzed during the talk. We have also considered [2] a setup where the separation of the two probes is kept fixed but the voltage is varied; this spectroscopic mode is also shown to be very versatile.

A paradigm for creating a gap in graphene is to fabricate periodic perforations of the graphene sheet – graphene antidot lattices (GAL) [3]. The band gaps can be used as potential barriers so as to guide charge carriers [4], much in analog with photonic crystals. Here, we report on simulations of charge transport for two coupled GAL waveguides in Coulomb drag geometry [5]. The lateral geometry of our suggested device offers many technological advantages as compared to conventional stacking (where the two graphene layers are separated by a thin isolating material). We make several predictions for the temperature dependence of the measured drag signal: this displays a complex behavior due to an interplay between the available phase-space for scattering, and the screened Coulomb interaction.

Finally, we assess the role of disorder in GALs as a limiting factor for carrier confinement. Our previous work used a Kubo-formula approach to consider large samples [6], here we investigate mesoscopic devices with a Green's function formalism: transistors and GAL waveguides [7]. We have performed extensive numerical work and show that the barriers predicted for perfect GALS may in fact become leaky for disordered GALs, depending of the character of the disorder. Also, we show that the edge character of the antidots (armchair, zigzag, disordered) plays an important role in the transmission properties of GAL wave guides. We believe that our numerical work will give important guidelines for the optimization of devices based on GAL waveguides.

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## References

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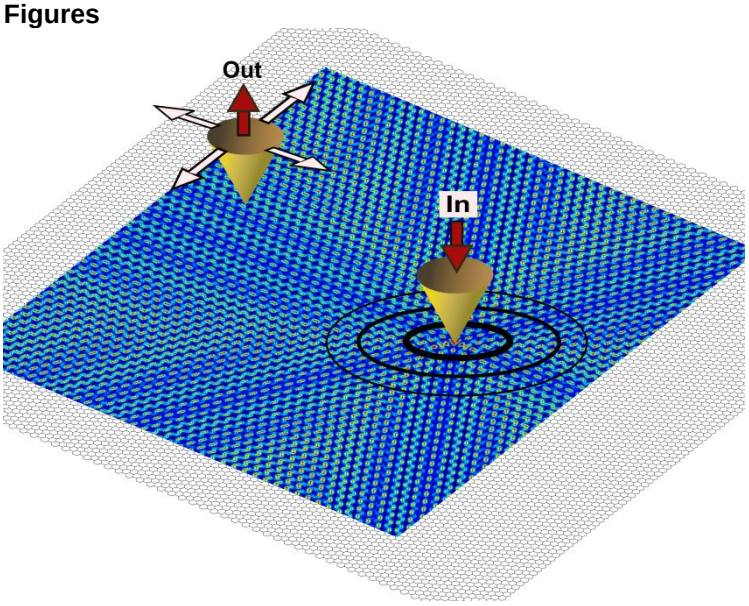
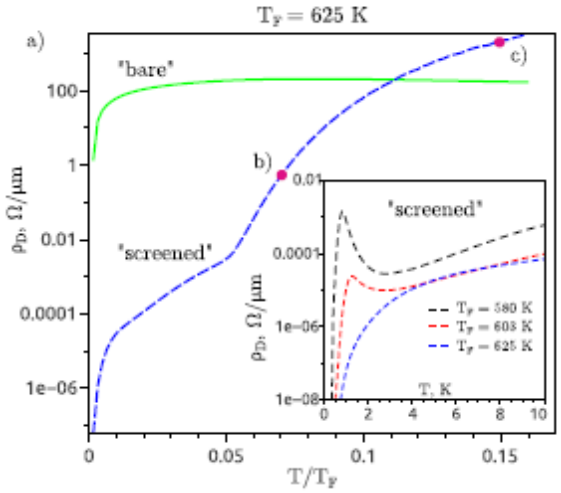
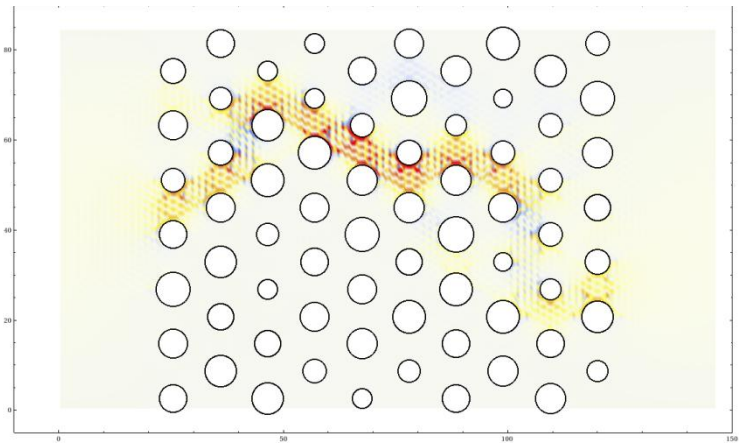
**Figures**




Dual probe STM setup on pristine graphene. The conductance is constant along armchair probe separations, and oscillatory along zigzag separations




Temperature dependence of drag resistance. Shown are results for unscreened case (“bare”), and RPA screened Coulomb interaction. Inset shows a drag enhancement which can occur at low temperatures for certain parameters.



An example of a ”leaky” GAL barrier (current path shown as a color map). Disorder (varying antidot size) opens pinholes through a GAL structure which would be impenetrable for antidots of equal size.