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Graphene Nanoribbons for Bandgap Engineering

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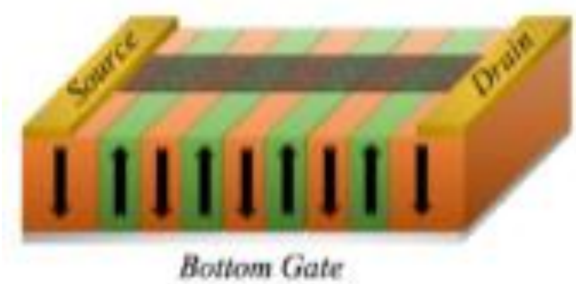
Abstract

Graphene is being touted as the wonder material of the 21st century due to its impressive electrical and mechanical properties. Whether scalable and economically viable devices that can outperform their conventional alternatives will emerge is still somewhat of an open question, but recent developments in wafer-scale production of graphene via CVD (Chemical Vapour Deposition) offer great promise. In this talk, we will look at three topics – (i) size-dependence of resistivity of graphene nanoribbons, which reveal some new phenomena, with scanning gate microscopy as a technique to explore edge effects, (ii) substrate-mediated device architectures and (iii) an AFM-based oxidative etching process used to create nanoribbons with widths down to below 10 nm.

We show that the resistivity of graphene nanoribbons scales more strongly with size than in the case of metals, mostly due to the nature of graphene's Dirac Fermions, but also due to the emergence of a bandgap for widths below around 30 nm.

We then experimentally demonstrate a graphene/ ferrolectric device, termed Ferrotronic (electronic effect from ferroelectric) device in which the band-structure of single-layer graphene is modified. The device architecture consists of graphene deposited on a ferroelectric substrate which encodes a periodic surface potential achieved through domain engineering. This structure takes advantage of the nature of conduction through graphene to modulate the Fermi velocity of the charge carriers by the variations in surface potential, leading to the emergence of energy mini-bands and a band gap at the superlattice Brillouin zone boundary. Thisrepresents a simple route to building circuits whose functionality is controlled by the underlying substrate.

In the final part, we introduce an AFM-based technique for ultra-precise oxidative lithography of graphene based on tip-induced hydrolysis.



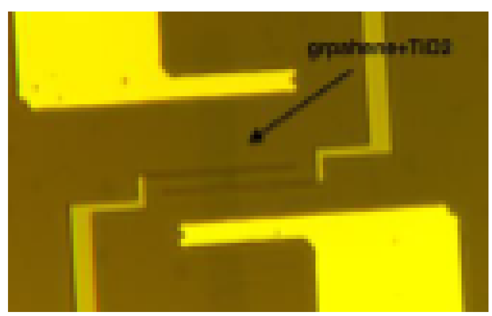


Fig1. Left: Graphene Ferrotronic device architecture where a ferroelectric substrate is periodically poled in order to create a periodic potential; Right: Graphene device for testing width-dependent resistivity.

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