Graphene Nanostructures

Graphene has attracted considerable interest for fundamental studies and potential applications in future electronics due to its high electronic qualities. However, two-dimensional graphene sheet is a semimetal with a zero bandgap which prevents it from being used for effective FETs at room temperature. Theoretical study predicted an appreciable band gap opening with the formation of sub-10 nanometer graphene nanoribbons (GNRs). In the first part of the talk, I will demonstrate a rational approach to fabricate GNRs with sub-10 nm width by employing chemically synthesized nanowires (NWs) as the physical protection mask in oxygen plasma etch. Our study shows a linear scaling relation between the resulted GNR widths and mask nanowire diameters with variable slopes for different etching condition. GNR FETs were fabricated and room temperature on-off ratio over 100 was demonstrated. Moreover, a new graphene nanostructure- graphene nanomesh (GNM) was fabricated as a mimic of highly dense GNRs network. We show that GNMs with variable periodicities and neck widths down to 5 nm can be prepared using block copolymer lithography. Using the GNMs as semiconducting channel, we have fabricated room temperature FETs that can deliver large current nearly 100 times greater than individual GNR devices, whilst with a comparable on-off ratio that is tunable by varying the neck widths. In the second part of the talk, I will discuss our efforts using high-k dielectric nanostructures as top-gate dielectrics for high mobility graphene transistors. Here the dielectric-graphene integration is achieved through a physical assembly approach, and therefore minimizes potential damage to monolayer of carbon lattice. Single crystalline Al2O3 nanoribbons were synthesized with excellent dielectric properties. Using such nanoribbons as the gate dielectrics, top-gated graphene transistors have been demonstrated with the highest carrier mobility (> 20,000 cm2/V•s) reported to date. This method opens a new avenue to integrate high-k dielectrics on graphene with the preservation of the pristine nature of graphene and high carrier mobility, representing an important step forward to high performance graphene electronics.