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Encapsulation and real life reproducibility of graphene devices

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As many graphene-based electronic and optoelectronic device concepts begin to make the transition from the research laboratory into real world applications it is imperative that factors such as long term stability and large area reproducibility are addressed. Graphene is inherently highly sensitive to environmental factors such as ambient air, lithography resists and polymers used in the transfer process which cause unintentional, generally p-type, doping and hysteretic behavior in field effect devices. Many of the graphene field devices need ambi-polarity. To overcome these issues device encapsulation and passivation is required. Atomic layer deposition (ALD) of oxides provides two-fold benefits. Firstly, Al_2O_3 act as a moisture barrier which adds long term stability and protection of devices from humidity and other atmospheric effects. Secondly, the ALD process has been shown to effectively passivate charge trap sites such as silanol (SiOH-) groups at the SiO_2—graphene interface which are responsible for much of the observed unintentional doping and hysteretic device behavior. We have developed two different routes to enhance the nucleation of ALD oxides on hydrophobic graphene surface. In first approach an ex-situ nucleation layer of 2 nm Al film was deposited with appropriate amount of oxygen control by e-beam evaporation. While in second route an *in-situ* nucleation was created by pulsing water precursor in the ALD chamber. In both the methods highly-air stable and reproducible GFETs are obtained. We have shown continuous hundreds of DC measurements in ambient which do not show any hysteresis and shifts of Dirac points with negligible doping concentration in graphene channel. It paves the way to speed up the production of graphene devices for real life applications.

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Graphene and boron nitride-based nanocomposites with enhanced thermal properties

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Polymer composites with a high thermal conductivity are always desired for different applications. Improved thermal conductivity of polymers can be obtained via dispersion of metal particles in a polymer matrix. However a good dispersion and thermal coupling cannot be achieved. We have designed and developed a formulation with enhanced thermal conductivity of silicone and epoxy-based resin systems using graphene and boron nitride-based nanomaterials synthesized in our laboratories. The nanocomposites are characterized thoroughly and excellent thermal conductivity improvement was observed. A detailed data analysis with different characterization techniques will be discussed and demonstrated.

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