UV-Assisted Bandgap Engineering of Single-Layer Oxidized Graphene and Integration into Heterostructures for Advanced Devices.

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Abstract : Graphene oxide (GO) is a versatile two-dimensional material with promising applications in nanotechnology due to its tunable chemical and electronic properties. However, its inconsistent structure and lack of precise control over functionalization limit its integration into advanced electronic and optoelectronic devices. This study introduces a novel and scalable approach for fabricating single-layer oxidized graphene (SOG) using Xe_2 excimer UV irradiation under ambient conditions. This method achieves uniform SOG with ~20% oxygen content in under 45 seconds, significantly reducing processing time compared to traditional chemical methods. Scanning tunneling microscopy (STM) reveals the formation of ordered epoxy superstructures (C_7O) with intrinsic bandgaps of ~0.25 eV, a breakthrough in understanding the atomic-scale structure of oxidized graphene and its electronic properties. The integration of SOG into both vertical and lateral heterostructures with single-layer graphene (SLG) further highlights its potential in advanced devices. Vertical graphene/SOG heterostructures exhibit strong interlayer coupling, inducing a p-doping effect in graphene and enhancing charge transport, while lateral heterojunctions formed through UV-assisted patterning provide seamless continuity and precise modulation of current flow. These heterostructures maintain the pristine electronic properties of SLG while leveraging the tunable barrier characteristics of SOG, making them ideal for field-effect transistors (FETs) and other nanoelectronic applications. Advanced characterization techniques, including Raman spectroscopy, X-ray photoelectron spectroscopy (XPS), and density functional theory (DFT) calculations, confirm the structural integrity, chemical composition, and tunable electronic properties of SOG and its heterostructures. By addressing key challenges in GO synthesis, such as defect control and uniform oxygen distribution, this study paves the way for scalable fabrication methods that enhance device performance. The results establish SOG as a transformative material for next-generation quantum devices, optoelectronics, and energy systems. This work provides a comprehensive framework for exploiting SOG's unique properties, offering new opportunities for innovation in nanotechnology and 2D material applications.

Keywords : bandgap engineering, graphene oxide, heterostructures, UV irradiation
Conference Title : ICMSE 2025 : International Conference on Materials Science and Engineering
Conference Location : Seattle, United States
Conference Dates : September 06-07, 2025