Epitaxial Graphene Surface Preparation for Atomic Layer Deposition of Al₂O₃


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High-k dielectrics such as Al₂O₃, HfO₂, Ta₂O₅, and TiO₂, are required for realizing graphene-based top-gated electronic devices and for scaling field effect transistors to sizes < 100 nm. Atomic layer deposition (ALD), a method based on two self-limiting surface half-reactions, is a preferred technique to deposit high-quality, conformal, stoichiometric dielectric films with precise thickness control. Unfortunately, direct deposition of oxides on pristine or non-functionalized graphene by ALD, using H₂O-based precursors, is hindered by the highly hydrophobic and chemically inert nature of graphene, resulting in no coverage or non-uniform coverage [1-4]. Here, a simple ex-situ graphene surface treatment based on wet chemistry is developed to render the otherwise chemically inert graphene surface more suitable for thin dielectric deposition. Using this approach, 30 nm thick Al₂O₃ films are deposited, using trimethylaluminum and triply-distilled H₂O as precursors, onto epitaxial graphene grown on the Si-face of silicon carbide. The resulting films show excellent morphology and uniformity over large (~8 mm²) areas (i.e., the entire sample area), as determined by atomic force microscopy and scanning electron microscopy. X-ray photoelectron spectroscopy revealed a nearly stoichiometric film with markedly reduced impurity content. Moreover, capacitance-voltage measurements reveal an extracted dielectric constant of ~7.3 and a positive Dirac voltage shift of ~ 1V. The mobility of free carriers in the graphene layer, as determined by van der Pauw Hall measurements (1000-1200 cm² V⁻¹ s⁻¹), was not affected by either the surface pre-treatment or the deposited dielectric although in each case, the sheet charge density changed.

References