

Structural and electrical properties of ultra-thin Al₂O₃ films grown by seed-layer-free atomic layer deposition on epitaxial graphene

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The atomic layer deposition (ALD) is the method of choice to deposit uniform and ultra-thin films of high- κ dielectrics on graphene (Gr) for micro- and optoelectronic applications. Because of the lack of out-of-plane bonds in the sp² Gr lattice, nucleation in the ALD process typically requires the pre-functionalization of Gr surface or the deposition of a seed-layer, which can adversely affect the Gr carrier mobility. In this work, we demonstrate the possibility of growing highly uniform thin layers of Al₂O₃ by a seed-layer-free thermal ALD process on the surface of monolayer (1L) epitaxial Gr (EGr) on 4H-SiC(0001). Experimental results and DFT calculations indicated that this peculiar growth mechanism is related to the presence of the carbon buffer layer of EGr/SiC interface.

The morphological, structural and electrical properties of the grown Al₂O₃ films have been investigated in details by different characterization techniques. Uniform and pinhole-free Al₂O₃ films with ~12 nm thickness have been observed by atomic force microscopy and cross-sectional transmission electron microscopy. Raman spectroscopy, carried out on the EGr before and after the Al₂O₃ deposition, indicated a negligible effect of the ALD process on the doping, strain and defectivity of EGr. Nanoscale current map by conductive atomic force microscopy showed highly uniform insulating properties of the Al₂O₃ on 1L EGr, with a breakdown field >8 MV/cm. These results can have important impact in epitaxial graphene device technology.