Abstract Template

Graphene Nanoribbons Grown Within h-BN Stacks for High-Performance Electronics

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Van der Waals (vdW) encapsulation of 2D materials within hexagonal boron nitride (h-BN) stacks has proven to be a promising way to create ultrahigh-performance electronic devices. However, contemporary approaches for achieving vdW encapsulation, which involve artificial layer stacking using mechanical transfer techniques, are difficult to control, prone to contamination, and unscalable. Here, we report on the transfer-free direct growth of high-quality graphene nanoribbons (GNRs) within h-BN stacks. The as-grown embedded GNRs exhibit highly desirable features being ultra-long (up to 0.25 mm), ultra-narrow (< 5 nm), and homochiral with zigzag edges. Our atomistic simulations reveal that the mechanism underlying the embedded growth involves ultra-low GNR friction when sliding between AA′-stacked h-BN layers. Using the grown structures, we demonstrate the transfer-free fabrication of embedded GNR field-effect devices that exhibit excellent performance at room temperature with mobilities of up to ~4,600 $cm2V^{-1}s^{-1}$ and on/off ratios of up to ~10^6. This paves the way to the bottom-up fabrication of high-performance electronic devices based on embedded layered materials.