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Multidimensional Hetero-integration of Graphene and h-BN towards Nano-electronics

Ideal graphene nanoribbons (GNRs) have been shown to exhibit extreme chirality dependence as metals or semiconductors. Therefore, the capability to precisely produce GNRs with defined chirality at the atomic level is required in order to engineer their band gap and electrical properties. It is obvious that earlier approaches have fundamental limitations for further electronic investigation. Electronics always require scalable transfer-free approaches for growing GNRs and conducting band gap engineering. Controlled fabrication of oriented GNRs embedded on hexagonal boron nitride (h-BN) has the capability to overcome the above difficulties. With proper control, the band gap and magnetic properties can be precisely engineered. Most desired features for GNRs can be automatically attained using this approach.

Here, we demonstrate the successful growth of GNRs directly on hexagonal boron nitride (h-BN) substrates with smooth edges and controllable widths via templated growth using chemical vapour deposition (CVD). The applicability of graphene for future digital devices is often questioned due to its intrinsic gapless nature. Nanoribbons offer a potential solution, but both the width and edges must be precisely controlled. By employing the in-plane epitaxy of graphene in nano-trenches of h-BN, we have realized ZZ-oriented graphene nanoribbons with a controlled width and smooth edges. The GNRs feature a tunable band gap, enabling sub-10-nm GNR FETs with on-off ratios greater than 10^4. Our results demonstrate that it is possible to resolve the fundamental gapless limitation of graphene, paving the way for the realization of graphene-based digital electronics that can operate at room temperature.

References

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Figures

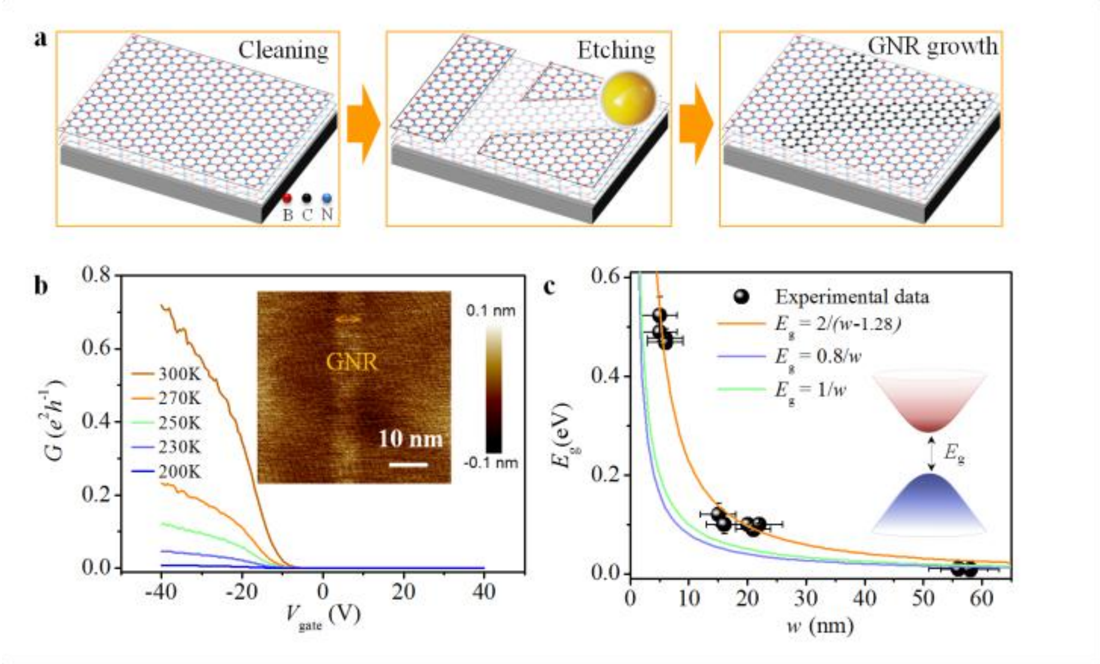

Figure 1: (a) Formation of GNRs in h-BN trenches; (b) Electronic transport through a narrow ribbon with a width of ∼5 nm. Its conductance can be completely switched off, even at 300 K;(c) Band gap Eg extracted from experimental data for GNRs versus their ribbon width (w).