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Graphene/hexagonal Boron Nitride/Graphene Nanopore for Electrical Detection of Single Molecules

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One challenge for graphene is to find out potential applications except for conventional electronic devices, where the specific advantages of single layer graphene are utilized. Here we report a novel design by utilizing natural self-assembly properties of graphene/ multilayered hexagonal boron nitride /graphene (G/xL h-BN/G) for single molecule detection. It has long been known that the extreme thinness together with the excellent electrical and mechanical properties of graphene have made it a very promising candidate as molecule sensor. Yet to define in-plane electrical probes which have to be aligned with the nanopore on the graphene is extremely challenging and has not been realized yet.

The novelty of our design is that we use the top and bottom graphene layers as two separate electrodes while the sandwiched h-BN layers as the insulating dielectric. In this way, we circumvent the challenge of sub-nanometer gapped electrical probe fabrication. Our theoretical investigation shows that the background current can be effectively suppressed by utilizing ABC stacking of the G/h-BN/G layers, thus making the top and bottom graphene electrodes electrically insulated. The stacking style induced vertical conducting/insulating is a quantum mechanical effect and a clear physical picture about the open/block of the conducting path is illustrated. We further demonstrate that there exists quantum mechanical interaction between electron transport through the h-BN dielectric and that through the target molecule during the molecule electrophoresis through the nanopore. Our evaluation suggests that the effect can be utilized for further enhancing the sensibility of G/h-BN/G nanopore sensors.

This theoretical study indicates that the ordered stacking of h-BN dielectric in G/h-BN/G nanopore will result in intriguing quantum interference effects, which are the stacking style-dependent vertical cross-layer conducting and the greatly enhanced molecule conductance. Such effects are demonstrated to be of promising application for single-molecule identifying.

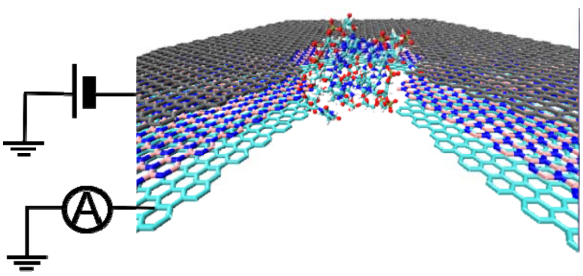

Fig1: Schematic of graphene/h-BN/graphene nanopore sensor.

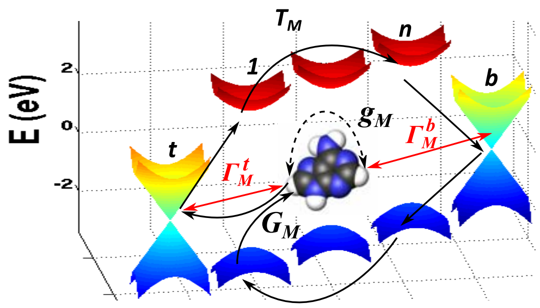

Fig2: Vertical electronic conducting mechanism when target molecule is in the nanopore.