Fermi level depinning in two-dimensional materials using flourinated bilayer graphene

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Two-dimensional (2D) materials, such as graphene and transition-metal dichalcogenides (TMDs), have drawn tremendous attention recently due to their promising advantages including atomic thickness and smooth channel-to-dielectric interface without dangling bonds [1]. However, while the absence of bandgap in graphene results in a high off-current of the field effect transistor, the large contact resistance of metal/TMD junctions makes it difficult to inject charge carriers to the channel [2, 3].

In this report, we first demonstrate the energy gap opening in bilayer graphene (BLG) *via* a mild fluorination using SF_6 gas. Raman scattering and X-ray photoelectron spectroscopy measurements indicate that only the top layer of BLG is fluorinated with the covalent C-F bonding at the surface, while the bottom layer remains intrinsic. The current-voltage characteristics of the fluorinated bilayer graphene (FBLG) transistor show a nonlinear behaviour. The fluorination induces an asymmetry between the top and bottom graphene layers due to differences in carrier concentrations and/or disordered lattice structure, leading to an opening of a gap between valence and conduction bands of BLG [4]. The calculated energy gap is from 70 to 100 meV, which is in a similar range of molecular doped BLG [5].

As a proof of concept, we fabricate and investigate transport properties of the metal/FBLG/MoS_2 transistors using contact metals with different work functions. The extracted Schottky barrier heights (SBH) at the metal/MoS2 junctions are almost similar for all metals, manifesting the strong Fermi level pinning. By insertion of FBLG, the SBH dramatically reduces for the low-work function metals, resulting in higher on-current of the transistor. In addition, it alleviates the line-up effect of the work function of the metal at the interface, leading to a better pinning factor.

Our results define a straightforward method to generate thin dielectrics for de-pinning the Fermi level at the interface of metal/TMD and as well as for various applications in advanced electronics and optoelectronics.

References

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