Large-scale MoS_2 | Graphene for van der Waals ultrafast-photoactive circuits.

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Abstract

The widely investigated two-dimensional (2D) materials of graphene and MoS_2 and their van der Waals heterostructures show excellent prospects for emergent electronic[1], spintronic[2],[3], and opto-spintronic[4] phenomena. Using mechanical transfer techniques to realize these heterostructures poses a challenge in their large-scale realization. We demonstrate the direct growth of MoS_2 on graphene employing a confined space chemical vapor deposition growth technique. These heterostructures display interface charge transfer and sp^3 bonds as revealed by X-ray photoelectron, Raman spectroscopic techniques, and electrical transport measurements. By spatial photoconductivity measurements, we show that photoactive regions can be locally created in graphene channels covered by MoS_2 layers. In addition, time-resolved ultrafast transient absorption (TA) spectroscopy reveals accelerated charge decay kinetics in Graphene/MoS_2 heterostructures compared to standalone MoS_2 and up-conversion for below-band-gap excitation conditions. Our proof-of-concept of direct synthesis of van der Waals heterostructures paves the way for the growth of photoactive nanoelectronics and opto-spintronic devices.

References

[1] H. Mishra *et al.*, "Experimental advances in charge and spin transport in chemical vapor deposited graphene," *J. Phys. Mater.*, vol. 4, no. 4, p. 042007, Oct. 2021, doi: 10.1088/2515-7639/ac1247.
[2] I. G. Serrano *et al.*, "Two-Dimensional Flexible High Diffusive Spin Circuits," *Nano Lett.*, vol. 19, no. 2, pp. 666–673, Feb. 2019, doi: 10.1021/acs.nanolett.8b03520.
[3] J. Panda, M. Ramu, O. Karis, T. Sarkar, and M. V. Kamalakar, "Ultimate Spin Currents in Commercial Chemical Vapor Deposited Graphene," *ACS Nano*, vol. 14, no. 10, pp. 12771–12780, Oct. 2020, doi: 10.1021/acsnano.0c03376.
[4] J. F. Sierra, J. Fabian, R. K. Kawakami, S. Roche, and S. O. Valenzuela, "Van der Waals heterostructures for spintronics and opto-spintronics," *Nat. Nanotechnol.*, vol. 16, no. 8, pp. 856–868, Aug. 2021, doi: 10.1038/s41565-021-00936-x.