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Deterministic Integration of MoS2-Graphene Heterostructures for Future Chip-Scale 2D Electronics

Two-dimensional (2D) van der Waals heterostructures offer a powerful materials-by-design approach for beyond-CMOS electronics, enabling atomically sharp junctions, clean interfaces, and heterogeneous integration on silicon platforms. Among these, MoS_2–graphene heterostructures combine graphene's high conductivity and tunable work function with the semiconducting bandgap of MoS_2, providing a versatile platform for low-resistance contacts, ultrathin channels, and 2D–2D junction devices relevant to future chip technologies. Here, we report the fabrication and spectroscopic verification of a MoS_2–graphene vdW heterostructure assembled on SiO_2/Si using a viscoelastic stamping technique. This approach enables deterministic placement and alignment of exfoliated 2D layers while minimizing solvent exposure and interfacial contamination, which are critical for reproducible device integration. Optical microscopy confirms successful overlap of graphene and MoS_2 flakes. Raman spectroscopy reveals the simultaneous presence of characteristic graphene G (~1576 cm^{-1}) and 2D (~2708 cm^{-1}) bands, along with MoS_2 E12g(~377 cm^{-1}) and A1g(~402 cm^{-1}) modes, confirming few-layer MoS_2 and high-quality graphene in the heterostructure. Building on these results, we will advance MoS_2–graphene 2D–2D junctions through spectroscopic mapping, interface engineering, and correlation of Raman signatures with electrical and optoelectronic performance. This platform enables scalable integration of 2D materials for chip-scale technologies, including low-power electronics, RF contacts, photodetectors, and heterogeneous integration on Silicon.

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