

Automated processing and transfer of graphene wafers

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Abstract

The availability of graphene on various substrates is crucial for large-area applications, such as integration with silicon-based technologies, which requires high carrier mobility. While large-area graphene films with high quality and uniformity have been produced using chemical vapor deposition, they are mainly limited to metal foils. Reliable transfer techniques that prevent cracks and contamination are essential for applying 2D materials to diverse substrates. Polymer-based transfer medium is usually introduced to avoid cracks and wrinkles but introduce contamination on the graphene surface. Here, we have achieved the crack, contamination and wrinkle-free transfer of graphene films over large area: (1) we achieved the crack-free mechanical delamination of graphene from Cu surfaces by uniform oxidation of Cu and engineering of interfacial forces; (2) by controllably crosslinking the transfer medium polymer, we tuned the adhesion between the polymer and graphene, enabling all-dry transfer. Stronger adhesion ensures crack-free peeling, while reduced adhesion allows clean exfoliation of the polymer, leaving an ultraclean graphene surface. This process was achieved without using water or organic solvent. (3) we introduced an automated system for transferring CVD-grown 2D materials using robotics to engineer interfacial adhesion and strain. The system demonstrates industrial compatibility with a production capacity of up to 180 wafers per day, high-quality transfer (graphene mobilities over $14,000 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$), and consistent uniformity and repeatability.

References

- [1] Zhao, Y. et al. *Nat. Commun.* 13 (2022) 4409.
- [2] Chen, S. et al. *Adv. Mater.* 36 (2024) 2308950.
- [3] Zhao, Y. et al. *Nat. Chem. Eng.* 2 (2025) 296.

Figures

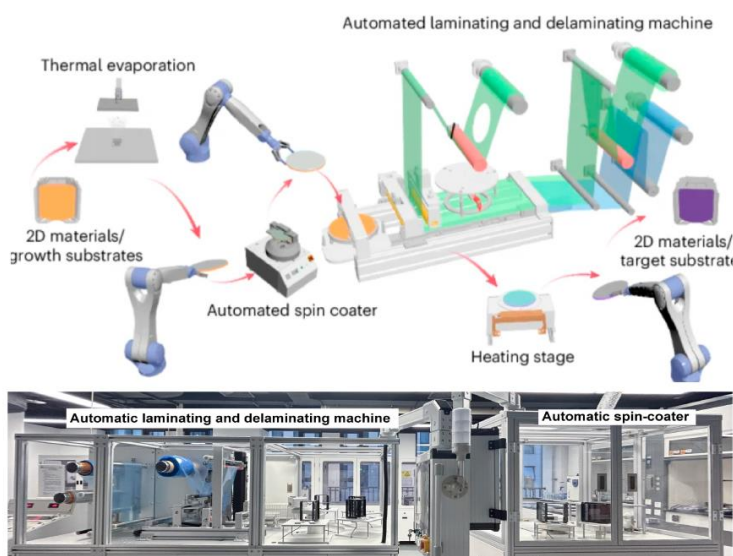


Figure 1: Automated transfer process system.