

# From Growth to Integration: A Roadmap for Ultra-High Vacuum Transfer of Graphene Nanoribbons

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Graphene nanoribbons (GNRs) exhibit remarkable electronic and magnetic properties that arise from quantum confinement and atomically precise edge structures. The ability to tailor their band gap and access spin-polarized edge states makes them highly attractive for nanoelectronic, quantum, and spintronic applications<sup>1</sup>. However, translating these fundamental properties into real devices requires a reliable way to transfer the ribbons from their metallic growth substrates onto electrostatically gateable platforms, without compromising their structural or electronic integrity.

In this work, we outline a practical roadmap for transferring GNRs synthesized via on-surface synthesis (OSS) in ultra-high vacuum (UHV). We explore wet<sup>2</sup>, semi-dry, and fully dry transfer approaches to integrate armchair-edged GNRs into gated device architectures<sup>3,4</sup>. For zigzag-edged GNRs, whose reactive edge states demand strictly UHV-compatible handling, we develop several stamp-based pickup strategies, including polymer-assisted, gold-mediated, and 2D material-supported methods, implemented using an automated UHV transfer setup and an adapted KISS approach<sup>5</sup>. We further implement conformal contact assisted transfer to improve interfacial contact and preserve ribbon alignment. Further, we also explore electrostatic force assisted schemes that enable non-contact pickup and drop through controlled biasing of stamp material. To reduce strong GNR-Au interactions, we employ intercalation with AuCl and CrCl<sub>3</sub> to facilitate reliable ribbon decoupling and transfer.

Together, these efforts provide a scalable pathway toward integrating atomically precise GNRs into functional device platforms.

## References

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