

A Facility for Ultra-Clean Assembly of Van der Waals Heterostructures in Ultra-High Vacuum Conditions

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Layer-by-layer assembly of van der Waals (vdW) heterostructures (HS) underpins many new discoveries in solid state physics, material science and chemistry. Most techniques for the fabrication of these so-called 'designer' materials from vdW HS rely on the use of flexible polymer-based transfer techniques. The use of these contaminating polymers in fabricating vdW HS can place limits on the cleanliness and ultimate optical/electronic properties of these devices and thus limit their potential application. With this in mind, we have developed a novel multi-chamber ultra-high vacuum (UHV) cluster tool at the National Graphene Institute for the development of ultra-clean vdW HS.

The primary aim of the facility is to develop techniques for the assembly of novel devices from 2D materials with pristine interfaces between layers. The heart of the system (Fig. 1) is the UHV assembly 'Core' chamber, consisting of a 12-axis robotic micromanipulator which allows sub-micron positioning accuracy of monolayer vdW layers at stable temperatures of up to 1000°C and chamber pressures of $\sim 10^{-10}$ mbar. Along the backbone of the system several stations are integrated for further processing and analysis of samples, including a physical vapour deposition (PVD) system and a closed-cycle low-temperature scanning probe microscope (SPM). We present a technical overview of this system, our recent results demonstrating the assembly of VdW heterostructures using a novel, polymer-free technique developed at the NGI [1] and recent upgrades to the system, including integration of a low-temperature optical cryostat and integration with external facilities.

References

- [1] W. Wang, N. Clark, M. Hamer, A. Summerfield, E. Tovari, A. Carl, S. Sullivan-Allsop, E. Tillotson, Y. Gao, F. Selles, H. de Latour, E. G. Castanon, M. Zhou, H. Bai, X. Li, A. Weston, K. Watanabe, T. Taniguchi, J. Howarth, C. Mattevi, T. H. Bointon, A. Kretinin, L. A. Ponomarenko, S. J. Haigh, R. Gorbachev. *Submitted*, (2023).

[2]

Figures

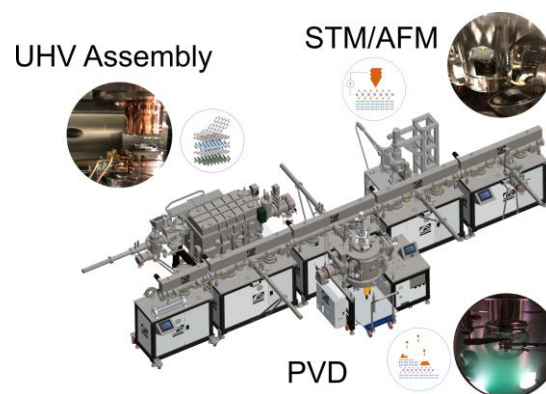


Figure 1: Overview of UHV Transfer system showing the location of assembly, PVD and SPM systems along the length of the transfer tunnel chamber [1].
