Hot pick-up assembly of high quality, self-cleaning van der Waals heterostructures

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We present a technique for the batch fabrication of heterostructures with consistently high performance and yield, supported by a large set of data from 22 mono-, double- and trilayer graphene encapsulated devices [1]. We measured maximum/average) room temperature carrier mobilities of 110000/43000) cm2/Vs, 36000/21000) cm^2/Vs and 26000/16000) cm^2/Vs, for single, bi- and trilayer, respectively, with 250 of all 280 fabricated contacts functioning, using off-the shelf graphene and hexagonal boron nitride from commercial suppliers.
The systematic use of temperature control allows tuning of the adhesion forces and mechanical properties of the support polymer, and letting the interfaces purge themselves of contamination. Multiple drop-down of stacks on a single wafer, allow processing of tens of devices in a single lithography process.
TEM microscopy of encapsulated, suspended stacks shows exceptionally low roughness and absence of contamination.
Assembly of the heterostructures at elevated temperatures reduces contamination at the interfaces, allowing even pick-up of electron beam lithography pre-patterned 2D materials, which opens up for complex architectures with multiple patterned layers. This method was successfully used to encapsulate MoS_2 in multi-terminal devices showing room temperature mobility of above 200 cm^2/Vs per layer.

References

[1] F. Pizzocchero, L. Gammelgaard, B. S. Jessen, J. M. Caridad, L. Wang, J. Hone, P. Bøggild, T. J. Booth, Nat. Comm, 7 (2016) 11864

Figures

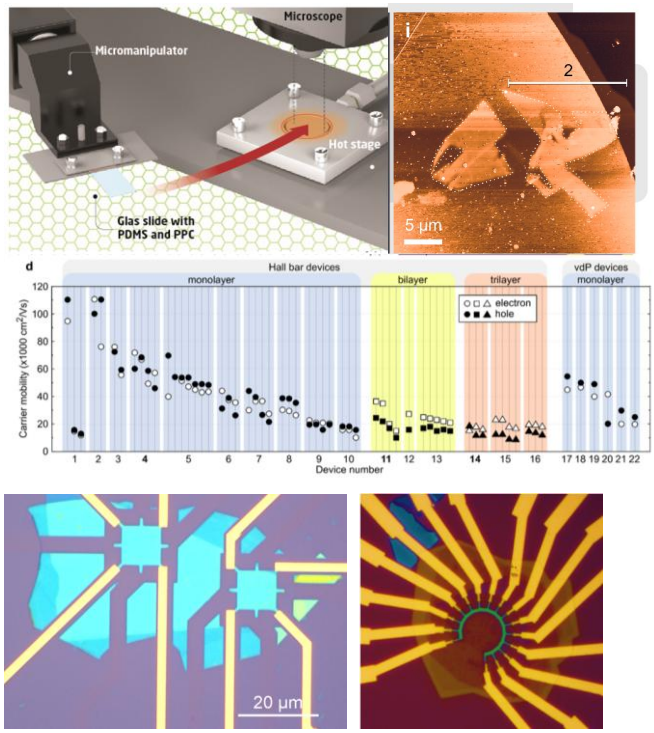

Figure 1: The hot-pickup technique allows complex patterned layers to be assembled nearly without bubbles and contamination, and batch fabricated with consistent, reliable high performance.