Recent Progress Towards Wafer-scale Graphene MEMS

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In this talk, I will chart the progress we have made towards wafer-scale and commercial fabrication of graphene-based MEMS devices and the challenges that still lie ahead.

The major breakthrough that enables this is the development of the graphene-polymer heterostructure (GPH) membrane [1-3], which overcomes the challenges associated with defects and contamination intrinsic to CVD graphene growth and transfer. GPH membranes were shown to result in 100% yield of intact suspended graphene drums and high-performance pressure sensors that can operate in both suspended and 'touch' mode.

Recently, we have undertaken the modelling of such GPH membranes by solving the Föppl–von Kármán (FvK) equations using an object-oriented, multi-physics finite-element library [4]. This is required because GPH membranes can not be modelled simply by the traditional assumptions of 'purely out-of-plane bending' or 'purely in-plane stretching'.

I will then talk about the integration of the GPH membrane with a commercial MEMS fabrication process known as PiezoMUMPS [5], resulting in high-performance graphene capacitive pressure sensors and resonators, where all but the final step of the graphene transfer is fabricated in a commercial MEMS fab. I will discuss the final missing piece of the puzzle, a wafer-scale implementation of the 'strained transfer' technique, which will enable GPH MEMS devices to become a commercial reality.

References

[1] C. Berger, Nanoscale, vol. 9, no. 44, pp. 17439, 2017.
[2] C. N. Berger, Nanoscale, vol. 8, no. 41, pp. 17928, 2016.
[3] C. Berger, *2D Mater.*, vol. 5, no. 1, 2018.
[4] K. Smith et al, Submitted, 2022
[5] K. Smith et al, Submitted, 2022

Figures

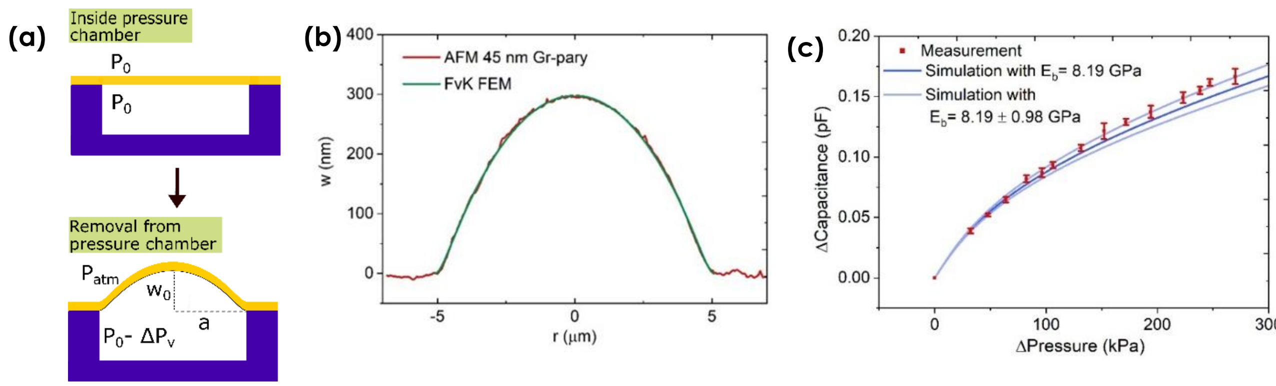

Figure 1: (a) 2-d schematic cross-section depicting the micro-blister inflation testing procedure with a single cavity and actuating membrane with significant parameters labelled. **(b)** 2-d topographical line profile of inflated 45 nm thick GPH micro-blister pressurized to ΔP= 116 kPa, compared to the FEM solution to FvK equations **(c)** Change in device capacitance against change in external pressure compared to that predicted by FEM simulation.