Ultra-thin Graphene/Polymer Layered Composite Membranes for NEMS applications

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Single layer chemical vapor deposited (CVD) graphene has shown great promise in enabling Micro and Nano-electromechanical Systems (MEMS/NEMS) that can outperform current silicon-based state of the art. However, current methods in forming single layer graphene MEMS devices result in low yields due to capillary effects acting on the suspended material during the graphene transfer process. In addition, the suspended membranes that survive often suffer from a distorted topography due to transfer polymer residue thereby limiting the in-plane span as well as poor device fabrications reproducibility.

We present the fabrication and mechanical characterisation of a suspended graphene/parylene-C bilayer composite membrane that tackles the prevailing challenge of constructing high yield, environmentally robust suspended devices whilst preserving the superlative mechanical properties of graphene. The fabrication method enables the construction of suspended membrane structures that can be multiplexed over entire wafers with 100% yield. Furthermore, we measure the elastic properties of heterostructure membranes with different polymer thicknesses ranging from 15 nm to 200 nm using a micro-blister inflation technique. We can tune the elastic modulus of the membrane between that of graphene (173±55 Nm^{-1}) and parylene-C (2.8±0.2 GPa) [1]. The graphene-polymer structure can be finely tailored to obtain a highly robust mechanical structure that proves to be an excellent candidate for large scale integration in NEMS applications such as pressure and touch sensors [2].

References

[1] Berger C, Dirschka M, Vijayaraghavan A, Nanoscale, 8 (2016), 17928-17939
[2] Berger C, Phillips R, Vijayaraghavan A, *Submitted* (2017)

Figures

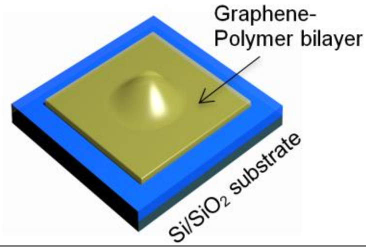

Figure 1: A schematic representation of a graphene-polymer bilayer blister formed by pressurizing a microcavity etched into a silicon oxide substrate.

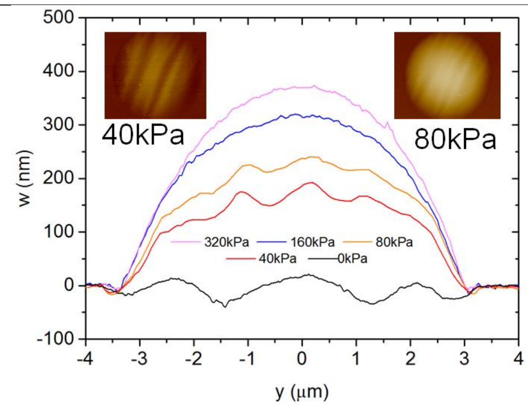

Figure 2: The cross-sections of a 21 nm thick graphene-polymer bilayer composite membrane at different blister pressures. The two insets show an AFM height map at 40 kPa and 80 kPa.