Graphene based electromechanical sensors

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In this talk, I will present two kinds of electromechanical sensors developed in my group based on graphene, a pressure and touch sensor, and a biosensor.
NEMS pressure sensor: Graphene is an ideal membrane material for nano-electro-mechanical systems, combining low mass, high stiffness, high elasticity and high electrical conductivity. But large-scale fabrication of suspended graphene membranes has posed a challenge due to defects and wrinkles that occur during growth and transfer. We have developed a novel graphene-polymer heterostructure membrane (GPHM) which retains much of the advantages of graphene in NEMS, while providing 100% yield during fabrication processes, resulting in high performance and reliable devices. I will demonstrate pressure and touch sensors based on this GPHM technology which outperforms the current state of the art. We have recently demonstrated a route to integrating the GPMH with industry-standard process MEMS fabrication. I will also discuss a new finite element modelling package we have developed for the GPMH MEMS devices.
Biosensor: We have developed a graphene-enhanced quartz-crystal microbalance (G-QCM) chip for biosensor applications. This G-QCM chip is coupled with an in-house open source QCM platform, resulting in a low-cost, easy to use, high performance point of care diagnostic platform. We have demonstrated various immunoassay applications for this platform. In one approach, we immobilise antigens on the graphene surface to detect antibodies, in particular for membranous nephropathy, a kidney disease. In another approach, we have immobilised nanobodies on the graphene surface to detect proteins such as lysozyme. In both applications, the G-QCM sensor shows excellent sensitivity and selectivity compared to industry standard techniques.

References

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[2] C. Burger, et al. Nanoscale, 8 (2016) 17928.
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Figures

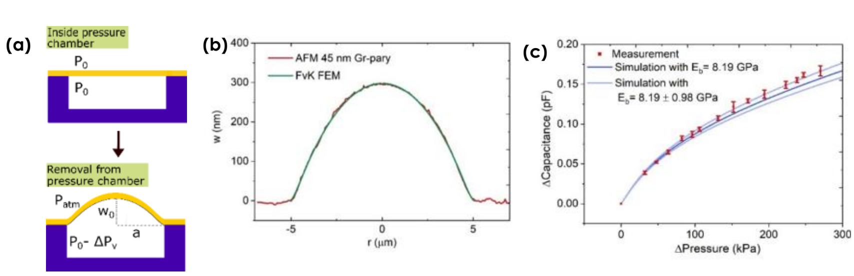

Figure 1: (a) 2-d schematic cross-section depicting the micro-blister inflation testing procedure with a single cavity and actuating membrane with significant parameters labelled. **(b)** 2-d topographical line profile of inflated 45 nm thick GPH micro-blister pressurized to ΔP= 116 kPa, compared to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

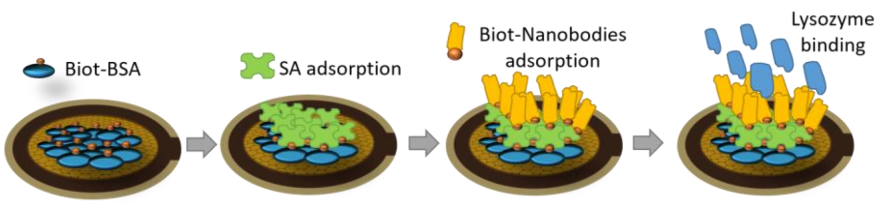

Figure 2: Sensing surface preparation for quantifying lysozyme in cow serum. The gold electrode from a QCM crystal is coated with a thin layer of GO then thermally reduced. Injection sequences are shown.