Transfer-free multi-layer graphene: a platform for NEMS/MEMS sensors

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Graphene has several unique properties which make it a very attractive material for sensors, optoelectronics, or as nano/micro-electro-mechanical systems (NEMS/MEMS). To allow integration into semiconductor technology, graphene deposited by chemical vapour deposition (CVD) on a metal catalyst is widely regarded as the most promising method.

A downside of CVD graphene is that it requires transfer of the graphene from the catalyst. This step can introduce polymer contamination, cracks, wrinkles and can result in adhesion issues with the target substrate, especially for non-flat substrates [1]. While significant progress has been made in CVD graphene and transfer [2], there still does not exist an ideal recyclable growth template and a repeatable transfer method.

In this work, we present our wafer-scale transfer-free platform based on Mo as catalyst which can circumvent the above-mentioned issues involved with transfer [3]. The key to this technology is the pre-patterning of the Mo catalyst layer. Upon removal of the catalyst, the few-layer graphene adheres to the substrate at the edges of the pattern. Therefore, lithographic control over the location and size of the graphene is achieved.

Furthermore by keeping the Mo underneath the graphene through post-processing delamination issues can be prevented. This enables surface and bulk micromachining allowing suspended graphene device formation on wafer-scale with high yield, fig. 1, 2 [4, 5]. Limitations of the technology are that the growth is coupled to the target substrate, and that we have only been able to realize few or multi-layered graphene due to reactor limitations.

Using this platform we have fabricated several graphene-based sensors, including gas [3], pressure [4], and recently microphones [5]. Finally, we have demonstrated that the process could be inserted at the end of the front-end of an in-house CMOS process [6]. With this, we present an alternative route for graphene device integration on CMOS which avoids many of the challenges related to transfer and can enable the realization of smart (suspended) graphene-based sensors.

References

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Figures

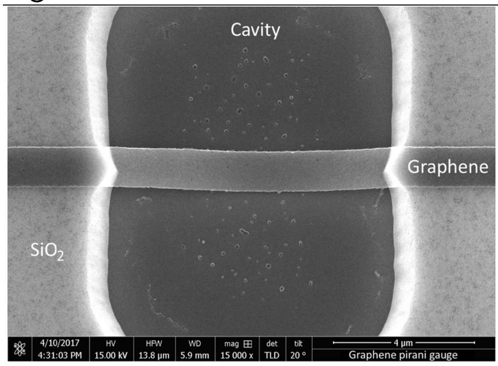

Figure 1: Pirani pressure sensor. The graphene bridge is 1 μm wide, while the SiO2 is 600 nm thick.

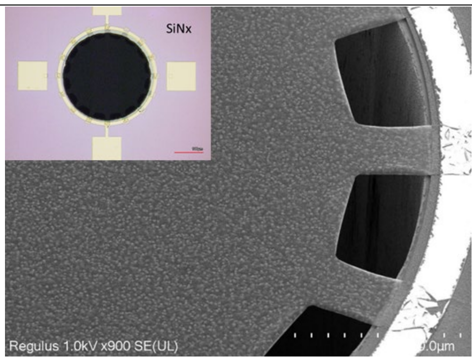

Figure 2: Graphene drum with a 250 μm diameter fabricated using bulk micro-machining