Wafer-scale transfer-free multi-layer graphene for MEMS sensors

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Graphene has unique properties that make it an attractive material for sensors or nano/micro-electro-mechanical systems (NEMS/MEMS). For sensors, especially those based on mechanical structures, graphene does not necessarily have to be single-layer to achieve good performance. Moreover, few or multi-layered graphene can enhance mechanical stability or processability, especially for large, suspended devices [1].

Chemical vapour deposition (CVD) on a metal catalyst is widely regarded as the most promising method for integrating graphene into semiconductor technology. A downside of CVD graphene is that it requires the transfer of the graphene from the catalyst. This step can introduce polymer contamination, cracks, and wrinkles. Another challenge is adhesion issues with the target substrate, mainly for non-flat substrates [2]. While significant progress has been made in CVD graphene and transfer [3,4], challenges remain, especially when creating suspended graphene devices.

As an alternative to transfer, we have developed a transfer-free method based on Mo as a catalyst [5]. By pre-patterning the catalyst, the graphene anchors to the substrate on the edges of the pattern, enabling lithographic control over the size and location. Furthermore, adhesion issues are circumvented by keeping the catalyst until the end of the fabrication. The limitation of the technology is that the growth is coupled to the target substrate. However, this is not an issue for MEMS devices, as it is customary in the industry to have a separate MEMS chip to form a system-in-package (SiP).

Here, we will show the latest advances in this platform's technology. These include wafer-scale graphene gas sensors on suspended micro-hotplates [6]. By using the transfer-free process, variation of the devices was minimized while the heater enabled fast recovery. We also have demonstrated the first wafer-scale graphene condenser microphones with high mechanical compliance, 10-100x higher than Si MEMS, while being ~9x smaller [7].

References

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Figures

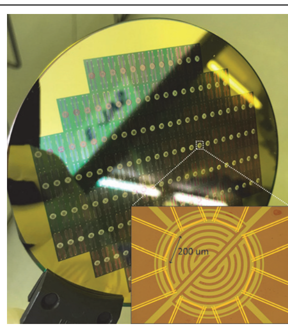

Figure 1: A 100 mm wafer with 156 suspended micro-hotplates. On each hotplate, up to 8 graphene strips are placed (inset).

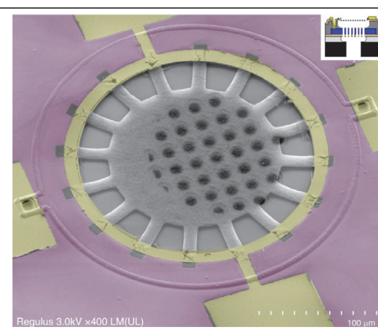

Figure 2: False colour SEM image of a 220 µm diameter, 7 nm thick, suspended graphene condenser microphone with poly-Si backplate.