Integration of 2D materials in suspended MEMS devices

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1. Introduction

Micro-electromechanical system (MEMS) resonators are small suspended structures, typically ranging in size from 10 to 1000 μm, that vibrate at specific resonant frequencies. Their peculiar frequency response has been used as the key mechanism for sensing applications of , among others, temperature [1], position [2] and mass.

The possibility of achieving high measurements sensitivity is mainly due to a large Q factor, that can be tailored employing innovative mechanical solutions such as soft clamping and dissipation diluition.

An interesting route sees the combination of MEMS with weightless and stiff 2D materials (2DM) which can be used to enhance the device functionalities or exploit its existing capabilities to tune and investigate the material itself. Transferring the 2DM after the whole MEMS has been fully fabricated offers a large degree of flexibility and an optimal conservation of the 2DM quality, being essentially unexposed to any wet/dry etching process.

This combined platform offers several interesting advantages; for instance, the tunable thermal conductiviy of MEMS can be exploited to investigate the 2DM properties under local heating. Furthermore, the MEMS mechanical motion can be used to impart a dynamic stress on the material, which would be of interest for photoluminescent transition metal dichalcogenides, such as MoS2 and WS2, where strain-dependent photoluminescent has been demonstrated at room temperature [3]. Finally, the 2DM can be employed as ultra-thin absorbers in broadband thermomechanical microbolometers (TB) [4].

2. 2DM as absorbers in TBs

In our work, we integrated ultra-thin (almost 2D) graphitic materials in silicon nitride (SiN) trampoline TBs in order to boost the overall absorbance, hence the detection responsivity, without impacting on the mechanical quality of the resonator. We chose graphene, specifically multi-layer graphene (MLG) due to its tunable conductivity, which is strongly linked to its absorption spectra.

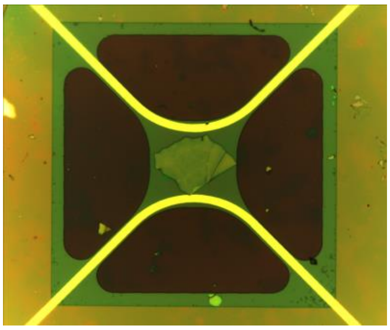

Figure 1: Optical microscope image of a MLG flake deposited at the center of the trampoline membrane.

The transfer technique is based on a multilayer PPMA-PVA vector, which allows us to precisely place the exfoliated MLG on a device region where it is enhnancing its properties without impacting its operation, see Figure 1.

Measuring the absorbance in the mid-IR range we found an average value of 30%, while SiN is basically transparent over a broad spctrum region.

Showing a substancial absorption enhancement over the bare TB trampoline, our approach offers interesting possibilities for material investigation and enhanced devices.

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