Monitoring deflection, strain and doping in suspended graphene using Raman spectroscopy

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Suspended graphene is a model atomically-thin nanomechanical system. In particular its low-mass, high Young's modulus, negligible bending rigidity combined with ultrastrong adhesion and impermeability position graphene as a choice material for fundamental opto-electro-mechanical studies and sensing applications [1]. Now, an interesting challenge consists in probing and exploiting the intrinsic electronic, vibrational and optical properties of graphene within nanomechanical devices.

Here, we make use of micro-Raman spectroscopy to perform comprehensive studies of graphene membranes suspended over a Si/SiO_2 substrate and subjected to a pressure load. In such microcavities, the intensity of the Raman modes depends very sensitively on the distance between the graphene membrane and the Si substrate, which acts as the bottom mirror of the cavity. Thus, a spatially resolved analysis of the intensity of the Raman G and 2D modes as a function of the pressure load permits an interferometric readout of the pressure-induced deflection. In addition, the frequency of the Raman modes provide quantitative information about local strain and (if applicable) doping.

We will first present an all-optical blister test performed on a pressurized graphene balloon [2]. Second we will address the case of suspended graphene subjected to an electrostatic pressure [3]. Finally, having explored the mechanical and vibrational properties of suspended graphene in the static regime, we will present our first experimental results towards addressing the relationship the interplay between the macroscopic vibrational modes and the optical phonons in suspended graphene resonators.

References

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[2] D. Metten *et al.*, Phys. Rev. Applied **2** (2014) 054008
[3] D. Metten *et al.*, 2D Materials **4** (2017) 014004

Figure

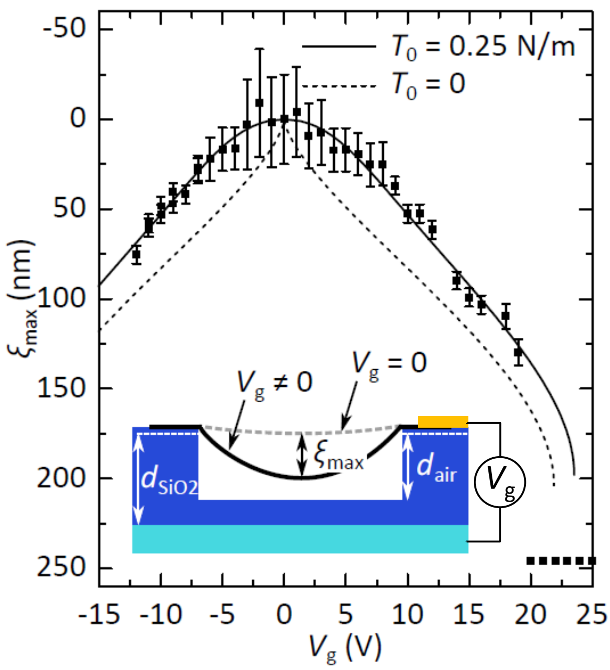

Figure 1: Electrostatically-induced deflection of a suspended graphene monolayer. The deflection ξ_{max} is deduced from the changes in the intensity of the Raman modes induced by the applied gate bias. Our measurements are in good agreement with an electromechanical model that takes into account the built-in tension T_0 of the graphene membrane (solid line). Adapted from ref. [3].