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Title of the Presentation:
Dynamically-enhanced strain in atomically thin resonators

First Name: Xin

Last Name: Zhang

Affiliation: State Key Laboratory of Superlattices and Microstructures, Institute of Semiconductors, Chinese Academy of Sciences, Beijing 100083, China

Email: zhangxin@semi.ac.cn

Short Biography:

Xin Zhang is a professor at the State Key Laboratory of Superlattices and Microstructures at Institute of Semiconductors, Chinese Academy of Sciences. He obtained his BS (2010) and PhD (2015) in Physics from Soochow University and Institute of Semiconductors, Chinese Academy of Sciences, respectively. He successively worked at Institut de Physique et Chimie des Matériaux de Strasbourg (IPCMS), UMR 7504 CNRS – Université de Strasbourg, Nanyang Technological University and Concordia University as a Postdoc research fellow from 2016-2020. He is currently working on the studies of hybrid quantum systems, cavity optomechanics and quantum nanomechanics.

Abstract:

Graphene and related two-dimensional (2D) materials associate remarkable mechanical, electronic, optical and phononic properties.[1] As such, 2D materials are promising for hybrid systems that couple their elementary excitations (excitons, phonons) to their macroscopic mechanical modes. These built-in systems may yield enhanced strain-mediated coupling compared to bulkier architectures, e.g., comprising a single quantum emitter coupled to a nano-mechanical resonator.[2] Here, using micro-Raman spectroscopy on pristine monolayer graphene drums, we demonstrate that the macroscopic flexural vibrations of graphene induce dynamical optical phonon softening.[3] This softening is an unambiguous fingerprint of dynamically-induced tensile strain that reaches values up to $\approx 4 \times 10^{-4}$ under strong nonlinear driving. Such non-linearly enhanced strain exceeds the values predicted for harmonic vibrations with the same root mean square (RMS) amplitude by more than one order of magnitude. Our work holds promise for dynamical strain engineering and dynamical strain-mediated control of light-matter interactions in 2D materials and related heterostructures.

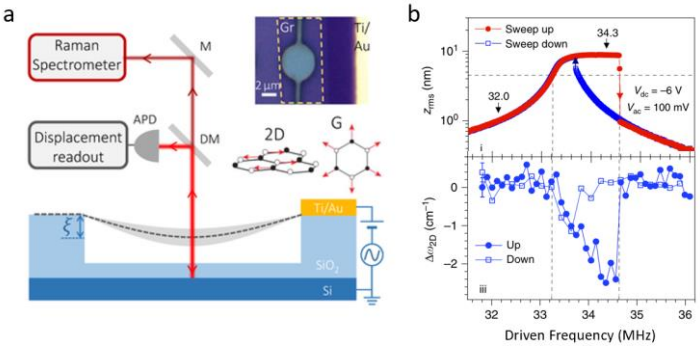

Fig. 1. a. Sketch of our experiment. The graphene layer is represented by the dark grey dashed line; its flexural motion is sketched with the light grey shade. M, DM, APD represent a mirror, a dichroic mirror, an avalanche photodiode, respectively. Upper inset: optical image of a suspended graphene monolayer contacted by a Ti/Au lead (scale bar: 2 μm). b. (up) Mechanical root mean square (RMS) displacement of a non-linearly driven graphene drum showing a hysteretic behavior. (down) The softening of the Raman 2D mode recorded during the mechanical frequency sweep.

[1]Q. Wang et al., Nat. Nano. 7, 699-712 (2012).
[2]I. Yeo et al., Nat. Nano. 9, 106-110 (2014).
[3]X. Zhang et al., Nat. Commun. 11, 5526 (2020).