Andres Castellanos-Gomez
Patricia Gant[1], Peng Huang[1,2], David Pérez de Lara[3], Dan Guo[2], Riccardo Frisenda[1]
[1]Materials Science Factory, Instituto de Ciencia de Materiales de Madrid (ICMM-CSIC), Madrid E-28049, Spain.
[2]State Key Laboratory of Tribology, Tsinghua University, Beijing 100084, China.
[3]Instituto Madrileño de Estudios Avanzados en Nanociencia (IMDEA-nanociencia), Campus de Cantoblanco, Madrid, Spain.
Andres.castellanos@csic.es

Strain engineering in 2D materials: towards strain tunable optoelectronic devices

Strain engineering is an interesting strategy to tune a material's electronic properties by subjecting its lattice to a mechanical deformation. Conventional straining approaches, used for 3D materials (including epitaxial growth on a substrate with a lattice parameter mis-match, the use of a dielectric capping layer or heavy ions implantation) are typically limited to strains lower than 2% in most cases due to the low maximum strains sustained by brittle bulk semiconducting materials. Bulk silicon, for example, can be strained only up to 1.5% before breaking. Moreover, these straining approaches induce static deformations of the semiconductor materials and therefore they are not suitable for tunable functional devices.

2D materials can be literally stretched, folded, bent or even pierced.[1] This outstanding stretchability (and the possibility of using dynamically varying strain) of 2D materials promises to revolutionize the field of strain engineering and could lead to "straintronic" devices – devices with electronic and optical properties that are engineered through the introduction of mechanical deformations.

In this talk I will discuss our recent efforts to study strain engineering in 2D materials and to exploit it to fabricate strain tunable functional optoelectronic devices.[2-6]

References

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[3] J Quereda, et al. Nano letters (2016) 16 (5), 2931-2937
[4] JO Island, et al. Nanoscale (2016) 8 (5), 2589-2593
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Figures

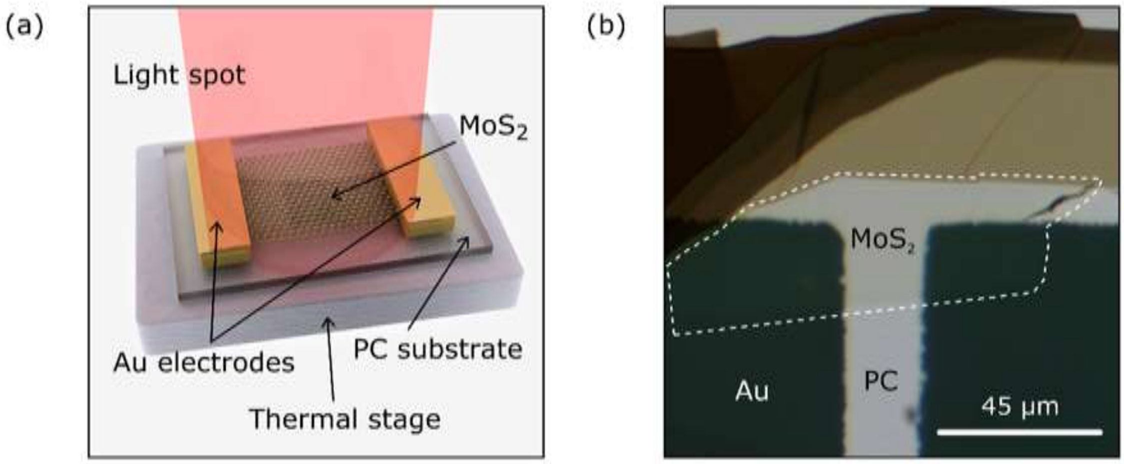

Figure 1: (a) Schematic picture of the setup used to perform all the measurements. The MoS2 photodetectors are placed on a thermal stage and illuminated from the top. (b) Optical transmission photograph of a single-layer MoS2 photodetectors fabricated on polycarbonate.

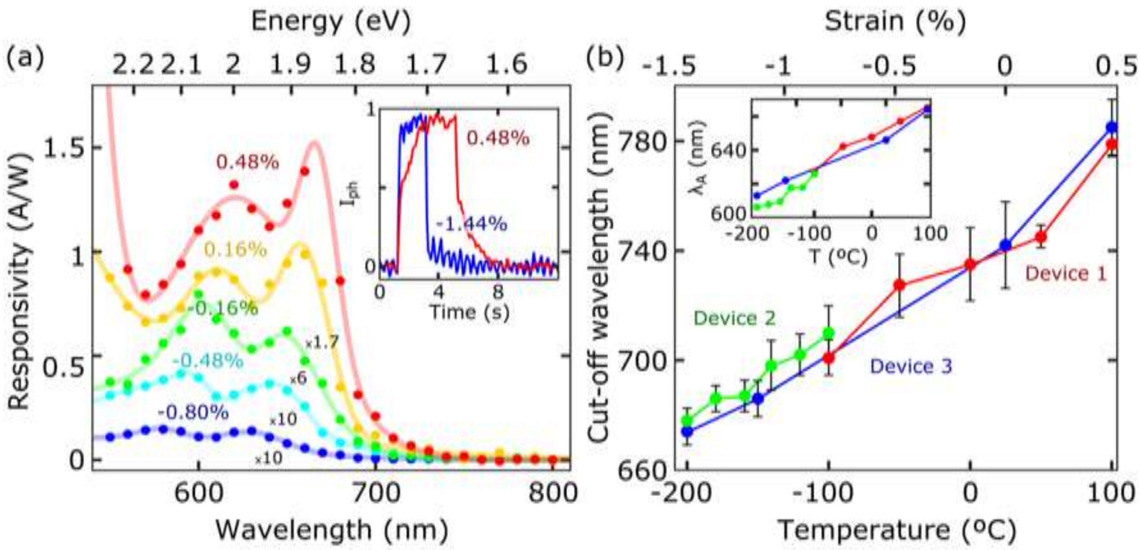

Figure 2: (a) Responsivity spectra of the single-layer MoS2 photodetector #1 obtained by measuring under 5 different strains applied (from -0.80% to 0.48%). Each dot corresponds to the value measured under light power of 8 mW/cm2 and applying a bias voltage of 10 V. Note that the responsivity values for +0.16%, -0.16%, -0.48% and -0.80% have been multiplied by 1.7, 6, 10 and 10 respectively to facilitate the comparison between the spectra. Inset: Response time for different strains applied. (b) Cut-off wavelengths extracted from the responsivity spectra of three single-layer MoS2 photodetectors (#1, #2 and #3) at different strain ranges. Inset: Exciton A wavelengths extracted from the same spectra.