Fabrication and Strain Engineering of Transition Metal Dichalcogenides Monolayers on GaAs Nanomembranes

E. Cybula [1], J. Jasiński [1,2], S. Palai [2], M. Śmiertka [1], A. Balgarkashi [3], V. Piazza [3], A. Fontcuberta i Morral [3], A. Surrente [1], M. Baranowski [1], A. Castellanos-Gomez [4], and P. Płochocka [1,2]

[1] *Wroclaw University of Science and Technology, Wroclaw, Poland*
[2] *Laboratoire National des Champs Magnétiques Intenses, Toulouse, France*
[3] *École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland*
[4] *Instituto de Ciencia de Materiales de Madrid, Campus de Cantoblanco, Madrid, Spain*

Transition metal dichalcogenides (TMDs) possess an excellent mechanical robustness and flexibility withstanding strains as high as 10% before breaking. Therefore, strain engineering has become a particularly attractive tool to tailor their electronic and vibrational properties or to preferentially funnel photoexcited carriers towards defects, which act as single photon emitters [1]. One of the approaches to site-control these quantum light emitters is the deposition of TMD monolayers on patterned substrates [1], thereby imposing strain on the two-dimensional layers.

So far, patterned substrates consist mainly of SiO_2 nanostructures, which, however, suffer from surface charge instability. This provokes spectral wandering and blinking of single photon emitters. Here, we explore an alternative approach to deterministically imposing strain on TMD layers by making use of high-quality, epitaxially grown III-V semiconductor nanostructures.

We show a successful deposition of WSe_2 monolayers on 100 nm wide GaAs nanomembranes with 10 μm pitch in Fig. 1a. By performing photoluminescence spectroscopy, we show that the TMD monolayers deposited on GaAs nanomembranes effectively funnel carriers to the potential minima corresponding to strain, which is demonstrated by photoluminescence and Raman spectroscopy. At low temperature, we observe a blue shift of the A exciton of WSe_2 monolayer measured on a nanomembrane, as compared to the same resonance measured on the flat part. (See Fig. 1b) Intensity on the nanomembrane is lower than on the flat part and some resonances are polarization dependent. In addition, we found that the most intense Raman mode splits and shifts to the higher frequency on the nanomembrane, compared to the flat part. (See Fig. 1c) This observation suggests the presence of compressive strain, differently than expected.

This confirms that the applied stress allows to efficiently funnel photocreated carriers to the potential minima. In perspective, we will investigated the single photon emission properties of localized states by photon correlation spectroscopy.

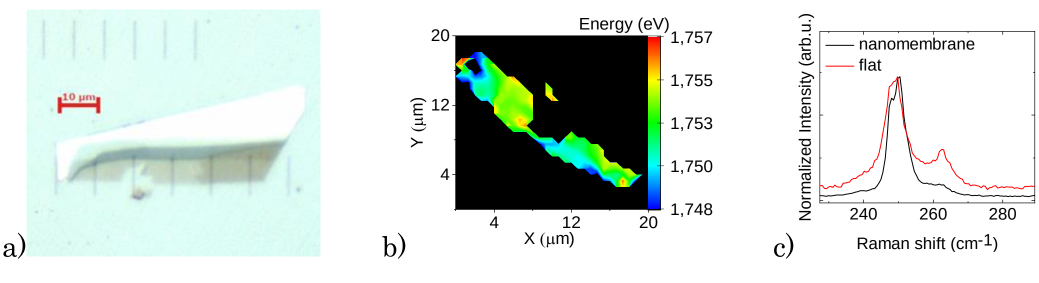

Figure 1. (a) Micrograph of the WSe_2 flake deposited on GaAs nanomembranes. (b) PL map energy of the A exciton. (c) Raman measurements on the nanomembrane (red) and on the flat part (black).

[1] Branny, A., Kumar, S., Proux, R. et al., *Nat Commun* **8**, 15053 (2017).