Strain Engineering of the Polarization Properties of MoS_2 Monolayers via Integration on GaAs Nanomembranes

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Transition metal dichalcogenides (TMDs) are layered semiconductors that are characterized by fascinating electronic and mechanical properties. These materials can withstand very large strain fields (up to 10%), both uniaxial and biaxial. The strain can therefore be used to engineer their optoelectronic properties to a level unattainable in epitaxial semiconductors.

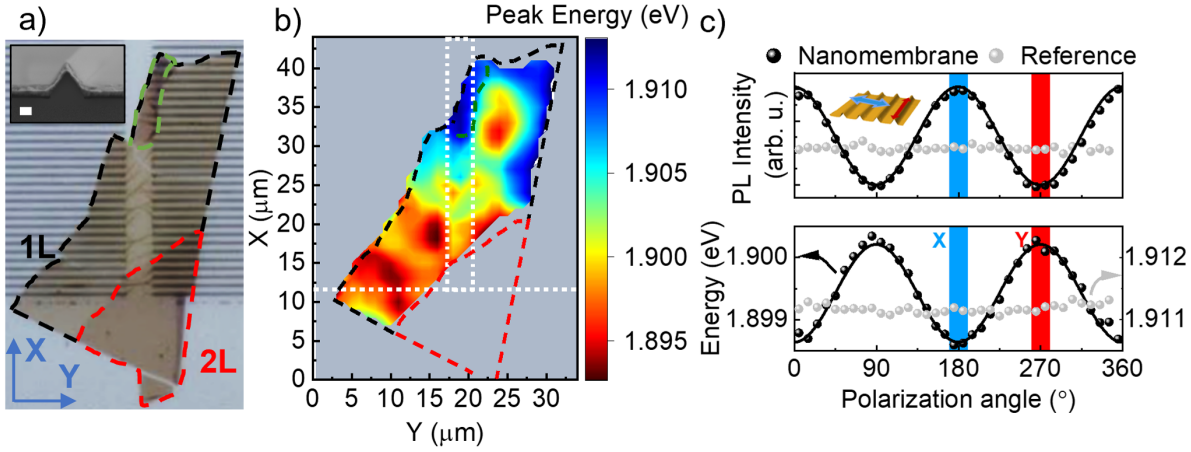

Figure 1: (a) Micrograph of the MoS_2 deposited on GaAs nanomembranes. Inset: SEM crossection of a single nanowire. Scale bar is 100 nm. (b) Position-dependent PL peak energy. (c) Polarization-dependent PL intensity (top panel) and peak energy (bottom panel) from a flat reference MoS_2 and from MoS_2 on nanomembrane.

Usually, localized strain fields are applied by transferring a TMD flake on a stressor of amorphous material [1]. Here we present a novel approach where strain is induced by epitaxial semiconductor nanostructures. We use an array of epitaxially grown, $\sim$ 100nm wide, 1μm pitch GaAs nanomembranes [2] (Fig. 1a) which act as the stressor for a MoS_2 monolayer transferred on them. This platform represents an effective way to control the optical response of the TMD layer.

From position dependent Raman scattering and microphotoluminescence (microPL) mapping (Fig. 1b), combined with AFM studies, we show that the nanomembranes induce a non-uniform tensile strain in the MoS_2 flake.

We show that the imposed strain lifts the degeneracy of the exciton states, which become linearly polarized and energetically split. The principal axis of the PL linear polarization is perpendicular to the nanomembranes. We attribute the observed exciton state splitting to the broken crystal symmetry resulting from the imposed strain.

[1] C. Palacios-Berraquero, *et al.*, Nature Communications **8**, 15093 (2017).
[2] G. Tutuncuoglu, *et al.*, Nanoscale **7**, 19453 (2015).