Towards Strain Engineering of High Quality 2D Perovskite Flakes

K. Zalewska[1], K. Posmyk[1], M. Śmiertka[1], M. Mączka[2], K. Watanabe[3], T. Taniguchi[4], M. Dyksik[1], M. Baranowski[1], P. Płochocka[1,5], A. Surrente[1]

[1] *Wrocław University of Science and Technology, Wrocław, Poland*
[2] *Inst. of Low Temp. and Structure Research, PAN, Wrocław, Poland*
[3] *Research Center for Functional Materials, NIMS, Tsukuba, Japan*
[4] *International Center for Materials Nanoarchitectonics, NIMS, Tsukuba, Japan*
[5] *Laboratoire National des Champs Magnétiques Intenses, CNRS Toulouse, France*

While strain engineering is a well-established tool to tune the optoelectronic properties of graphene and transition metal dichalcogenides [1], this approach is still at its infancy for two-dimensional (2D) metal halide perovskites. Before systematically applying uniaxial or biaxial stresses to 2D perovskites, it is essential to introduce an exfoliation strategy which enables to obtain flakes of optical quality comparable to that of the parent crystal.

Here, starting from $(PEA)_2PbI_4$ 2D perovskite crystals shown in Fig. 1(a), we exfoliate and encapsulate in hBN thin perovskite flakes [see Fig. 1(b)]. The high quality of both crystal and exfoliated flakes is demonstrated by the sharp resonances visible in the reflectance spectra of Fig. 1(c,d), attributed to bright, fine-structure split excitons. To test the response to external mechanical stimuli, we transferred $(PEA)_2PbI_4$ flakes to the non-planar substrates shown in Fig. 1(e) [2], and measured the room temperature PL spectrum as a function of the strain. The variation of the PL energy with increasing strain suggests the presence of an effect of the mechanical deformation on the electronic properties of these flakes.

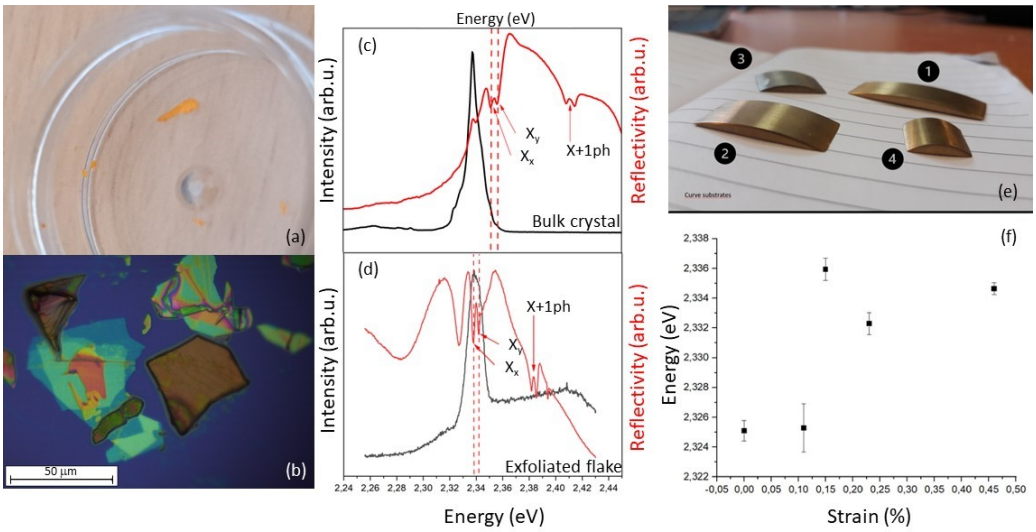

Figure 1: (a) Bulk $(PEA)_2PbI_4$ crystals used for the exfoliation of thin perovskite flakes. (b) hBN-encapsulated $(PEA)_2PbI_4$ flakes. Low temperature PL and reflectance spectrum of (c) the parent bulk $(PEA)_2PbI_4$ crystal and the exfoliated flakes. Relevant excitonic resonances are indicated. (e) Photograph of the curved substrates on which some flakes were transferred. (f) Room temperature PL energy of a flake transferred on substrates of different radii of curvatures.

[1] E. Blundo, *et al.*, Appl. Phys. Rev. **8**, 021318 (2021).
[2] Q. Tu, *et al.*, ACS Energy Lett. **4**, 796 (2019).