Wrinkle-Based Strain Engineering of 2D Materials

Sezer Seçkin
André Knapp, Andreas Fery
Leibniz-Institut für Polymerforschung e.V., Hohe Straße 6, 01069 Dresden, Germany
seckin@ipfdd.de

Mechanical properties of 2DMs are of fundamental interest and crucial for potential applications. The determination of the mechanical properties, however, is challenging due to their molecular thickness. The most used methods are nano-indentation of free-standing samples. The investigation of mechanical instabilities such as wrinkling, or crumpling has been identified as alternative approaches. In this study, we focused on the use of controlled wrinkling to derive the mechanical properties of synthetic 2DMs and their vdW heterostacks. The deformation/wrinkling behavior is a complex interplay of single-layer mechanical properties and interlayer adhesion [1], which has yet to be understood and is expected to be crucial for mechanical stability. Beyond mechanical characterization, controlled wrinkling can be used to engineer the electronic properties of 2DMs. In general. local strain has been shown to have a pronounced impact on the electronic band structure of 2DMs and thus on their (opto)electronic properties. We have shown a proof of concept for wrinkling-based strain engineering of electronic/optical properties. Building upon the findings, we will increase complexity using hierarchical wrinkling patterns, that feature wrinkle line defects that could provide an approach for strain engineering in points (0D strain engineering). [2]

References

[1] Yang, Ye, et al., arXiv preprint arXiv:2401.09099, (2024).
[2] Knapp, André, et al., Soft Matter 17.21 (2021), 5384-5392.

Figures

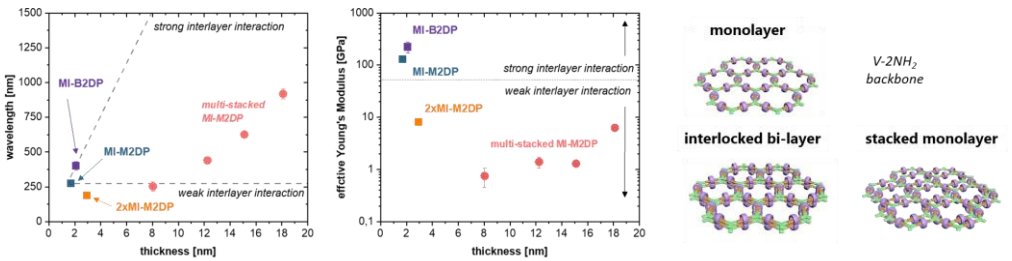

Figure 1: Interlocked 2DMs open a new path to create multi-layered material systems with transferred unique 2DM mechanical properties into a multilayer material behavior

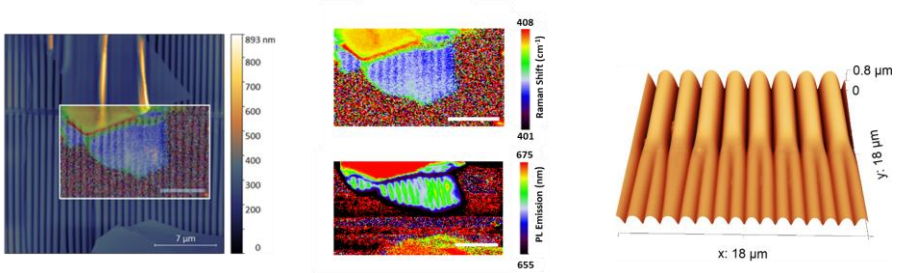

Figure 2: Wrinkling-based bent MoS_2 monolayer with line-like Raman shift for the $A1_g$ mode and photoluminescent emission map, as well as a hierarchical wrinkling pattern