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Deterministic wafer-scale growth and transfer of single-domain 2D materials

2D material-based devices have received great deal of attention as they can be easily stacked to obtain multifunctionality. With their ultrathin thicknesses, such multifunctioning devices become so flexible and conformal that they can be placed onto any 3D featured surfaces. However, 2D heterostructures are typically demonstrated as stacked flakes where single or few devices can be fabricated due to lack of strategies for layer-by-layer stacking of 2D materials at the wafer scale. While the growth technique could form wafer-scale 2D materials, it has been difficult to control monolayer-by-monolayer growths. In this talk, I will discuss about our unique strategy to isolate wafer-scale 2D materials into monolayers and stack them into a heterostructures by using a layer-resolved splitting (LRS) technique [1-2]. In addition, I will introduce our new technique to directly grow monolayer single-domain 2D materials at the wafer-scale and monolayer-by-monolayer growth of 2D heterostructures [3].
While 2D heterostructures promise interesting futuristic devices, the performance of 2D material-based devices is substantially inferior to that of conventional 3D semiconductor materials. However, 3D materials exist as their bulk form, thus it is challenging to stack them together for heterostructures. My group at MIT has recently invented a 2D materials-based layer transfer (2DLT) technique that can produce single-crystalline freestanding membranes from any compound materials with their excellent semiconducting performance [4-5]. I will also introduce my group’s 3D heterostructures by stacking various freestanding single-crystalline membranes to obtain new functionality [6]..

References

[1] Science, 342, 833 (2013),
[2] Science 362, 665 (2018),
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[4] Nature 544, 340 (2017),
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[6] Nature, 578, 75 (2020)