Light-matter coupling in large-area van der Waals superlattices

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Project Summary: Two-dimensional (2D) crystals have renewed opportunities in design and assembly of artificial lattices without the constraints of epitaxy. However, the lack of thickness control in exfoliated van der Waals layers prevents realization of repeat units with high fidelity. Recent availability of uniform, wafer-scale samples permits engineering of both electronic and optical dispersions in stacks of disparate 2D layers with multiple repeating units. Here we present optical dispersion engineering in a superlattice structure comprising alternating layers of 2D transition metal dichalcogenides (TMDC) and dielectric insulators. By carefully designing the unit cell parameters, we demonstrate greater than 90% narrow band absorption in less than 4 nm of active layer excitonic absorber medium at room temperature, with enhanced photoluminescence. These superlattices show evidence of strong light–matter coupling and exciton–polariton formation with geometry-tuneable coupling constants. Our results demonstrate proof of concept structures with engineered optical properties and pave the way for a broad class of scalable, designer optical metamaterials from atomically thin layers.
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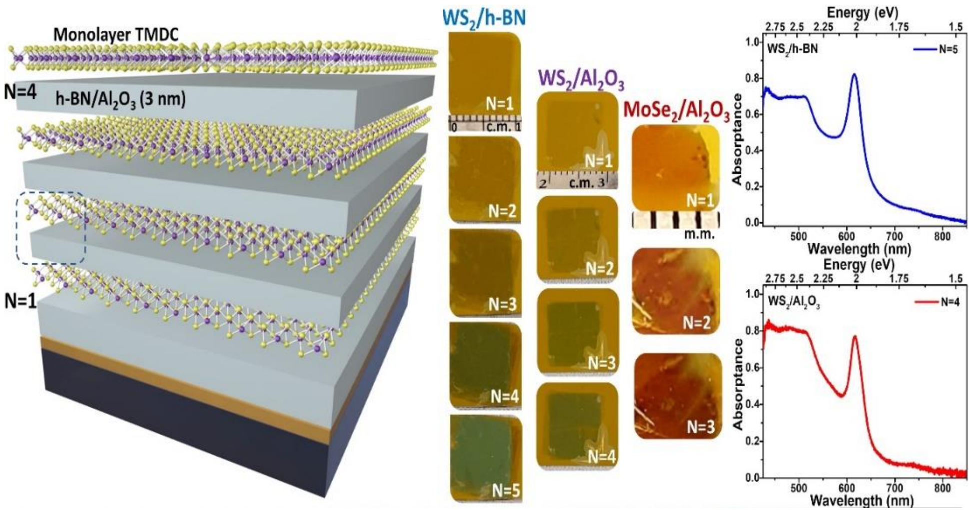
2DCC Role: This paper resulted from a collaboration between three external users (D. Jariwala, O. Whear, A. Davoyan) and used wafer-scale WS_2 monolayers synthesized at the 2DCC facility)



Intense, narrow band absorption demonstrated in optical dispersion engineered TMDC/dielectric superlattices enabled by the availability of wafer-scale 2D monolayers.