Highly Efficient Interlayer Exciton Microcavity Laser in Free-standing 2D Heterostructures

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Monolayer transition metal dichalcogenides (TMDs) and their heterostructures offer a versatile platform for photonics owing to their atomic thickness and strong excitonic interactions. Interlayer excitons (IXs) in heterobilayers possess long lifetimes and tunable emission energies leading to various interesting phenomena, yet their weak oscillator strength limits emission intensities and lasing behaviors. In this work, we report efficient IX lasing from a $MoSe_2/WSe_2$ heterobilayer through integration with a free-standing silica microsphere cavity. The suspended geometry enhances IX emission by more than an order of magnitude relative to supported regions and enables efficient coupling to high-Q cavity (Q ~ 2600). A lasing threshold as low as 75 nW is observed, as confirmed by the superlinear emission kink and linewidth narrowing in the power dependence measurements. The lasing threshold of the suspended sample is reduced by more than ten times compared to the supported samples, consistent with the measured IX lifetimes. These findings establish free-standing van der Waals heterostructures integrated with microcavities as compact and low-power consumption coherent light sources for quantum photonics applications.

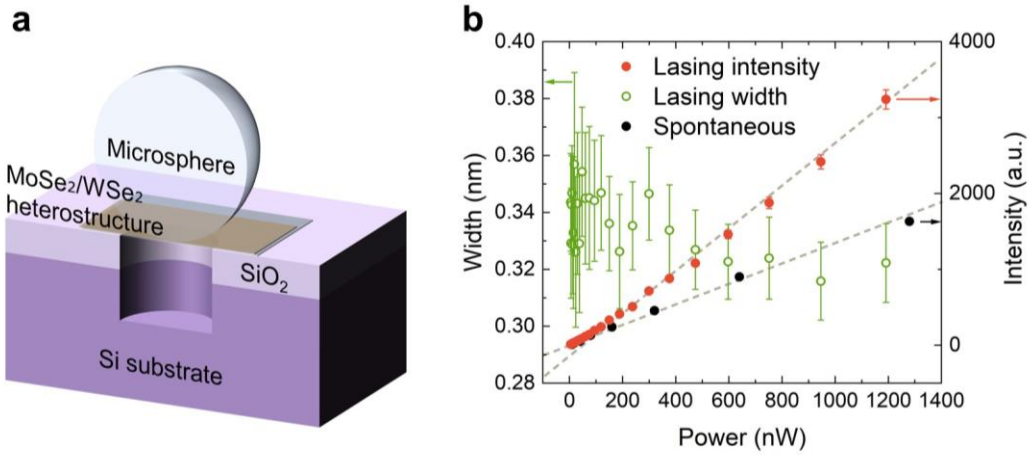

Figure 1. (a) 3D schematic of the interlayer exciton microcavity laser with free-standing geometry. (b) Intensity and linewidth as a function of the excitation power for the lasing mode.

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