High-β Lasing in Self-Assembled Photonic-Defect Microcavities1 with a TMDC Monolayer as Active Material

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The investigation and development of innovative micro- and nanolasers using transition metal dichalcogenide (TMDC) monolayers[1,2,3] as active materials is attracting considerable attention due to their unique electrical, mechanical, and optical properties. In this report, we detail the fabrication of photonic defect microcavities that are self-assembled and integrated into a dielectric distributed Bragg reflector structure that fully encapsulates a monolayer of tungsten diselenide (WSe_2). The encapsulation process of the WSe_2 monolayer with hexagonal boron nitride (hBN) generates air bubbles that induce parabolic photonic defects in the microcavity. These defects lead to a tight diameter-dependent three-dimensional optical confinement, which we confirm by experimental studies and numerical cavity simulations. In addition, we observe a significant nonlinearity in the input-output characteristics and excitation-power-dependent linewidth narrowing in our resonators, indicating laser operation, which is verified by photon autocorrelation measurements conducted on the smallest structure. The photonic defect cavities are all formed on a single monolayer sample, suggesting potential advantages for multi-wavelength emission photonic applications and facilitating TMDC-based prestructured photonic defect microlasers for large-scale fabrication.

References

[1] Y Ye, Z J Wong, X Lu, X Ni, H Zhu, X Chen, Y Wang and X Zhang, Nat. Photonics **9**, 733 (2015)

[2] C Anton-Solanas, M Waldherr, M Klaas *et al.*, Nat. Mater. **20**, 1233 (2021)

[3] H Shan, J-C Drawer, M Sun *et al.*, Phys. Rev. Lett. **131**, 206901 (2023)