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Lasing Reporting Summary

Nature Research wishes to improve the reproducibility of the work that we publish. This form is intended for publication with all accepted papers reporting claims of lasing and provides structure for consistency and transparency in reporting. Some list items might not apply to an individual manuscript, but all fields must be completed for clarity.

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• Experimental design

Please check: are the following details reported in the manuscript?

1. Threshold

Plots of device output power versus pump power over a wide range of values indicating a clear threshold	☒ Yes ☐ No	This can be found in Figure 2e.

2. Linewidth narrowing

Plots of spectral power density for the emission at pump powers below, around, and above the lasing threshold, indicating a clear linewidth narrowing at threshold	☒ Yes ☐ No	This can be found in Supplementary Fig. S9.
Resolution of the spectrometer used to make spectral measurements	☒ Yes ☐ No	This can be found in Methods.

3. Coherent emission

Measurements of the coherence and/or polarization of the emission	☐ Yes ☒ No	The lasing threshold and linewidth have been characterized. Thus, in our study, there is no necessary for the measurement of coherence or polarization.

4. Beam spatial profile

Image and/or measurement of the spatial shape and profile of the emission, showing a well-defined beam above threshold	☒ Yes ☐ No	This can be found in Figures 2 and 3.

5. Operating conditions

Description of the laser and pumping conditions *Continuous-wave, pulsed, temperature of operation*	☒ Yes ☐ No	This can be found in Methods.
Threshold values provided as density values (e.g. $\mathrm{W\ cm^{-2}}$ or $\mathrm{J\ cm^{-2}}$) taking into account the area of the device	☒ Yes ☐ No	This can be found in Figure 2e and Supplementary Fig. S9.

6. Alternative explanations

Reasoning as to why alternative explanations have been ruled out as responsible for the emission characteristics *e.g. amplified spontaneous, directional scattering; modification of fluorescence spectrum by the cavity*	☐ Yes ☒ No	The lasing behaviors are very obvious.

7. Theoretical analysis

Theoretical analysis that ensures that the experimental values measured are realistic and reasonable *e.g. laser threshold, linewidth, cavity gain-loss, efficiency*	☒ Yes ☐ No	This can be found in the part of 'theoretical analysis and simulation' in manuscript.

8. Statistics

Number of devices fabricated and tested	☒ Yes ☐ No	This can be found in Methods and Figure 2.
Statistical analysis of the device performance and lifetime (time to failure)	☒ Yes ☐ No	This can be found in Supplementary Fig. S11.