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Printed Soft Matter Micro-Photonics

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Photonic circuits offer a promising route toward faster and more energy-efficient information processing by exploiting light rather than electrons. Here we combine two-photon polymerization for the precise fabrication of three-dimensional polymer microstructures for soft-matter photonics, where cholesteric liquid crystal (CLC) microlasers act as active resonant elements. This integration establishes new platform for printed soft micro-photonics in which optical and photonic components can be directly fabricated and integrated on-chip [1,2]. Nanosecond dynamic control over light emission is achieved through a resonant STED mechanism, whereby an additional optical pulse selectively suppresses population inversion in the CLC microlaser, enabling efficient and reversible modulation of light flow. By embedding liquid-crystal resonators within three-dimensionally printed nanostructures, we realize photonic circuits in which light is simultaneously generated, guided, and dynamically controlled on a nanosecond time scale. Such soft and reconfigurable photonic architectures open a pathway toward compact, biocompatible, and energy-efficient devices for optical logic, signal processing, and sensing technologies.

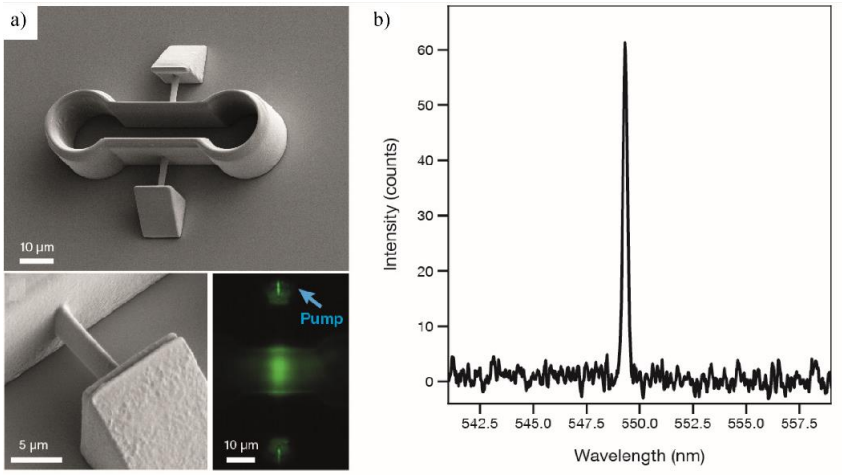

Figure 1. (a) The smallest fabricated CLC microlaser features an 8.2-µm-long cavity filled with a high-birefringence cholesteric liquid crystal and coupled to 1 µm-wide polymer waveguides. Close-up SEM image highlighting the 1 µm waveguide connection between a 10 µm right-angle prism and the laser cavity. Optical micrograph of the microlaser during operation under optical pumping, showing light emission from the cavity. (b) Lasing spectrum of the 1 µm-waveguide-coupled CLC microlaser.

References:

[1] U. Jagodič et al, ACS Photonics 2025, 12, 11, 5970–5977
[2] Vellaichamy, M., Jagodič, U., Pišljar, J. et al. Nat. Photon. 19, 758–766 (2025).

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