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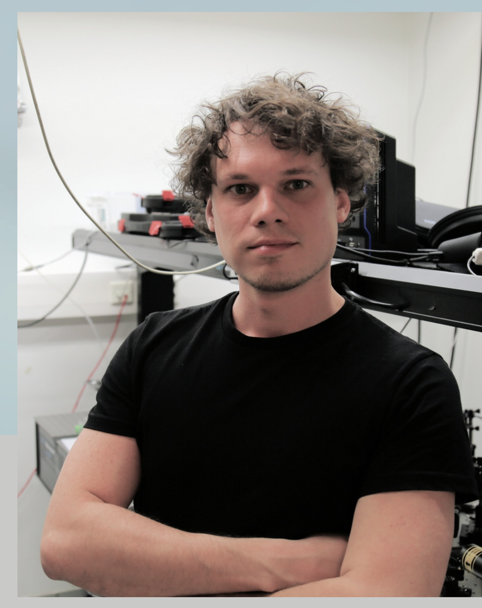
Photoactive liquid crystal elastomers for continuously tunable distributed feedback dye lasers

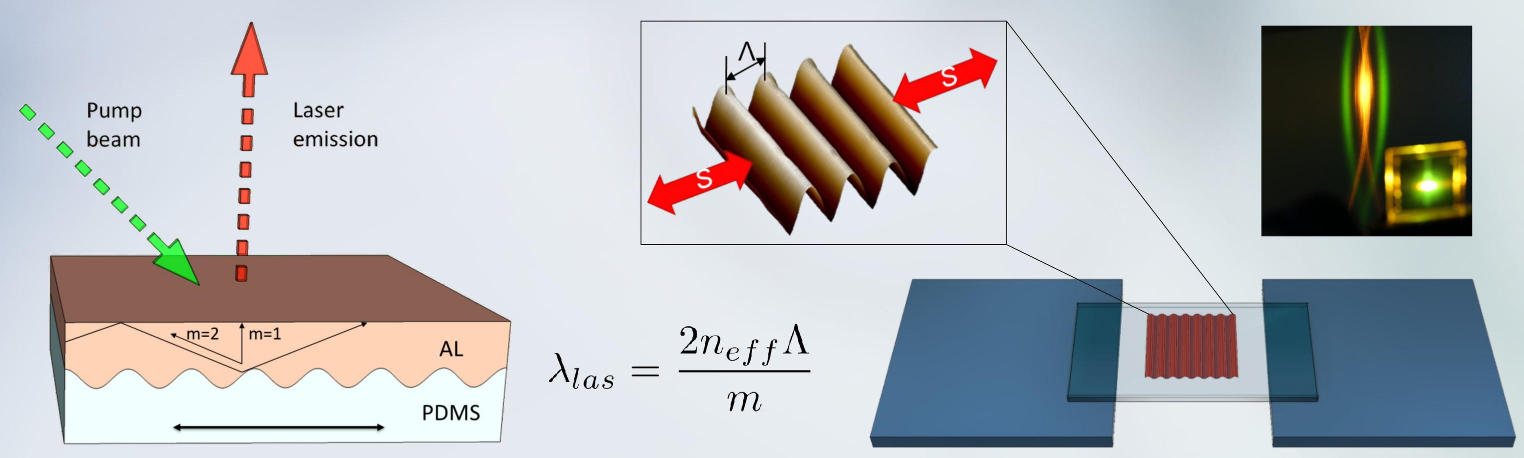


Alex Berdin[1]*, Heikki T. Rekola[1], Arri Priimägi[1]

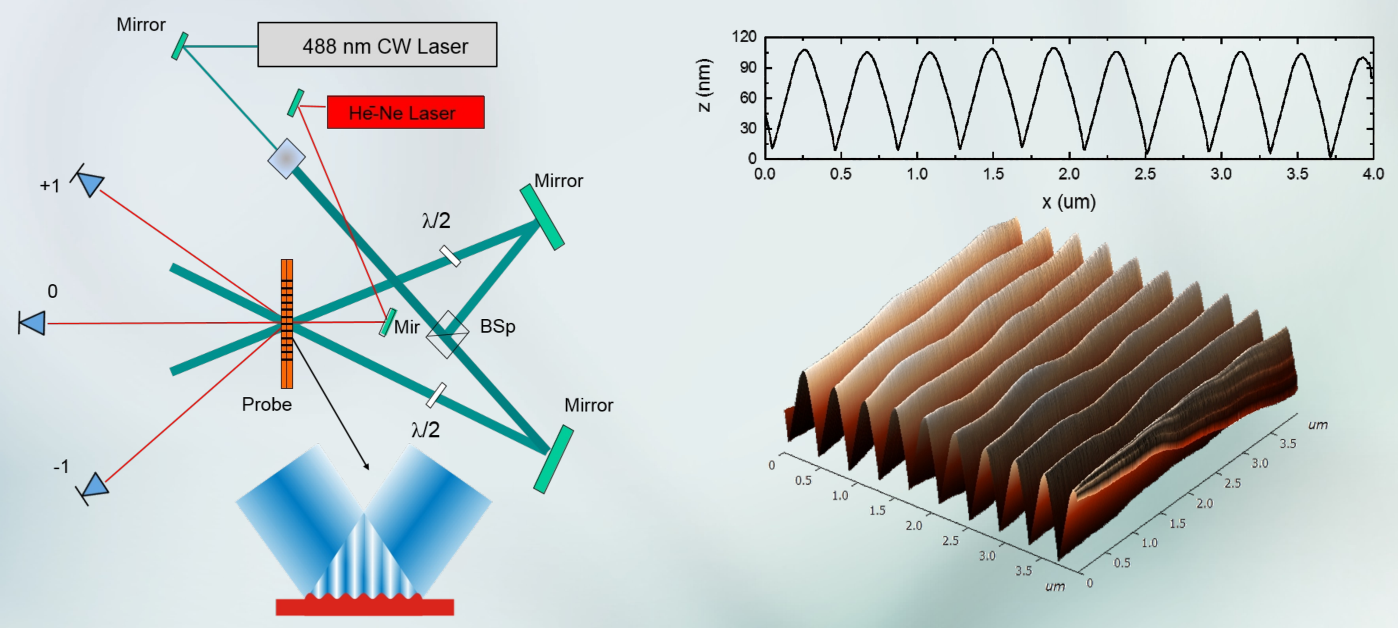
[1] Smart Photonic Materials, Faculty of Engineering and Natural Sciences, Tampere University, Finland

* Email: alex.berdin@tuni.fi

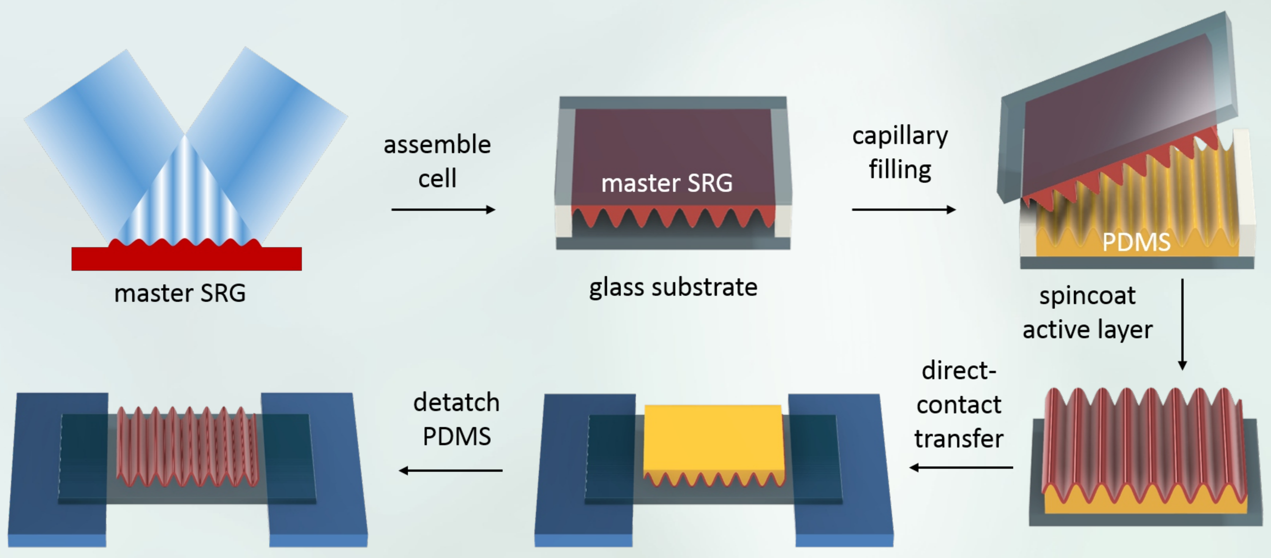
Organic solid-state lasers are a type of flexible coherent light sources.[1] Available gain materials allow emission in all wavelengths from UV to IR. The following work describes lasers using the distributed feedback (DFB) geometry integrated with liquid crystal elastomers (LCE). Using photoresponsive LCE allows changing the corrugation period of the laser cavity with light, which in turn affects the emitted wavelength. Switching wavelength and switching dynamics can be designed by modifying the chemical composition. Current research is focussed on utilizing the emitted light then again as a trigger for photoactuation, creating complex behavior such as oscillation or self-stabilization.



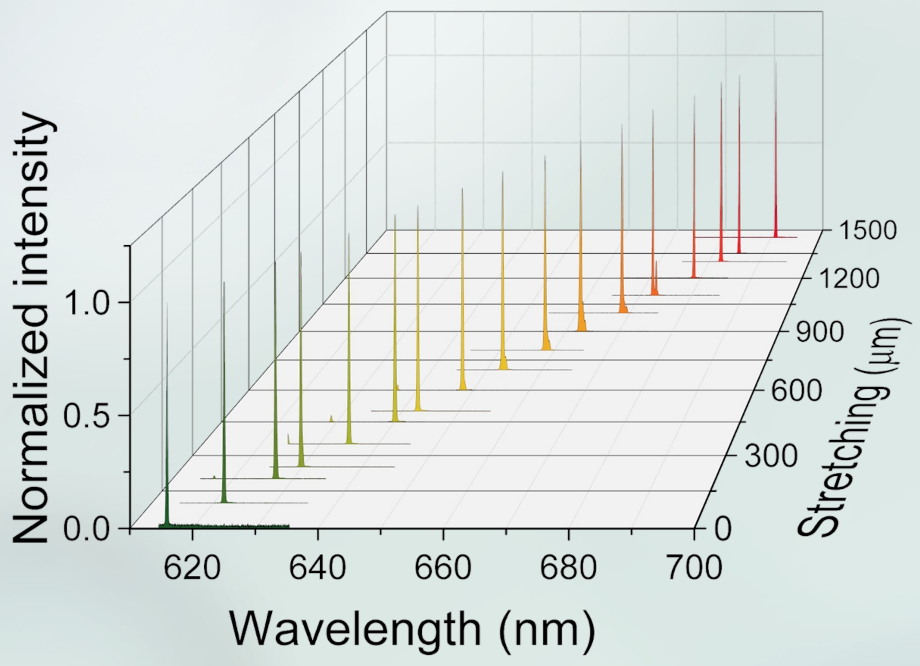
Operating principle. DFB laser have a periodically structured active layer. The emission wavelength is directly proportional to the corrugation period and can be selected by satisfying the Bragg condition. Actuation of LCE is used to tune the wavelength continuously.

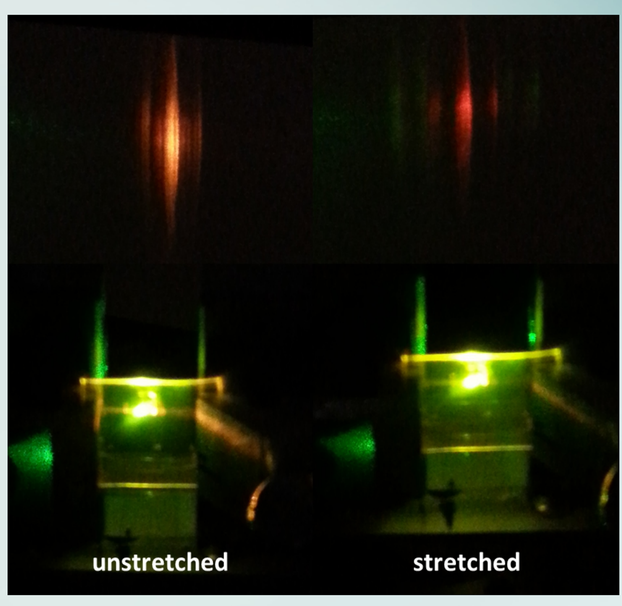


Holographic SRG writing. Surface relief gratings (SRG) are written by exposing an azobenzene-containing film with an interference pattern. Photoisomerization of the azobenzene units induce a mass transport that leads to the surface structuring. The grating period is controlled through the angle of interfering beams.

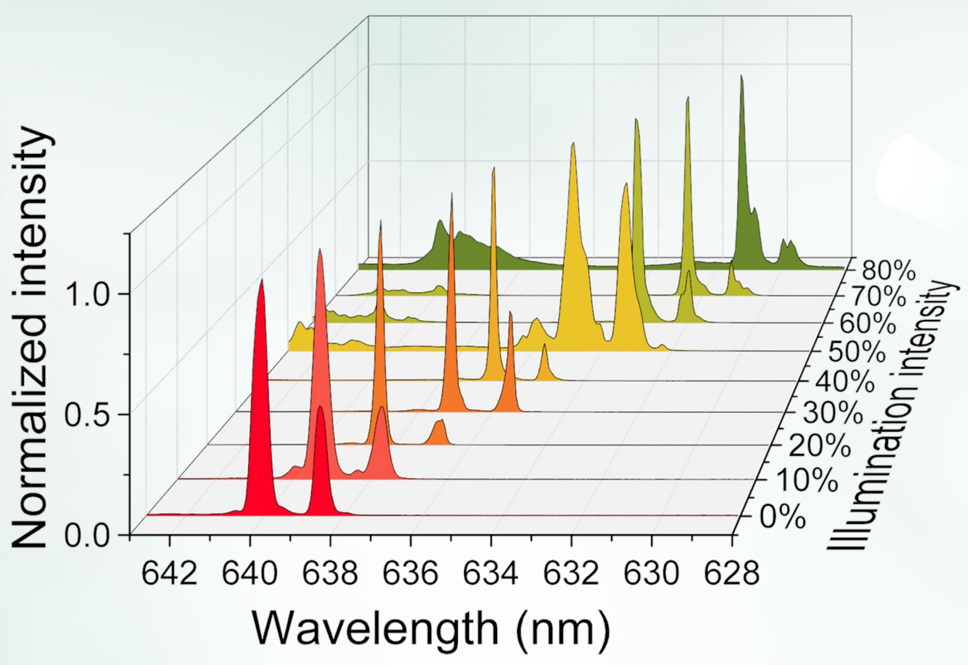


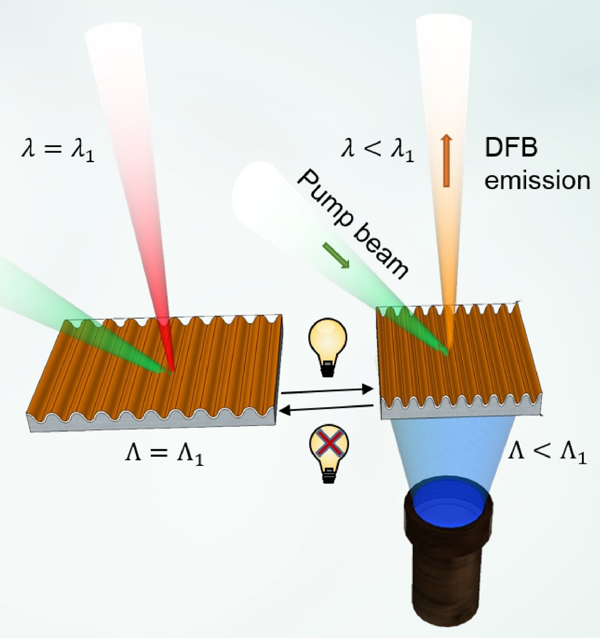
Assembling. The SRG is replicated into a thin layer of silicone. A solution containing a laser dye and a polymer is spincoated on the replica to create the laser membrane. A contact transfer method is used to translate the membrane from the silicone substrate onto the LCE actuator or any other support.





Mechanical tuning. The limits of tunability are explored by stretching a laser membrane mechanically. Stretching the membrane proved the spectral emission tuning over the whole gain region of the used laser dyes. A maximal tuning range of 77 nm was achieved using DCM2 laser dye in a Poly(vinyl acetate) matrix.[2]





Phototuning. Photoactuation of LCEs is based on the orientation control of liquid crystalline molecules inside an elastomeric polymer matrix by using light. On a macroscopic level this leads to a dimension change, for instance to a contraction perpendicular to the the grating direction. This enables controlling the the grating period, thus the emission wavelength of the laser. By incorporating azobenzenes into the LCEs, both switching wavelength and switching dynamics can be designed by tuning the chemical composition of the azobenzenes. Using a LED at 405 nm we demonstrate a wavelength tuning of 10 nm due to photoinduced LCE contraction.

References

[1] I.D.W. Samuel and G.A. Turnbull, Chem. Rev. 107, 1272 (2007).

[2] A. Berdin, H. Rekola, O. Sakhno, M. Wegener, and A. Priimagi, Opt. Express 27, 25634 (2019).

Acknowledgmenets

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