Integration of active and passive polymer optics

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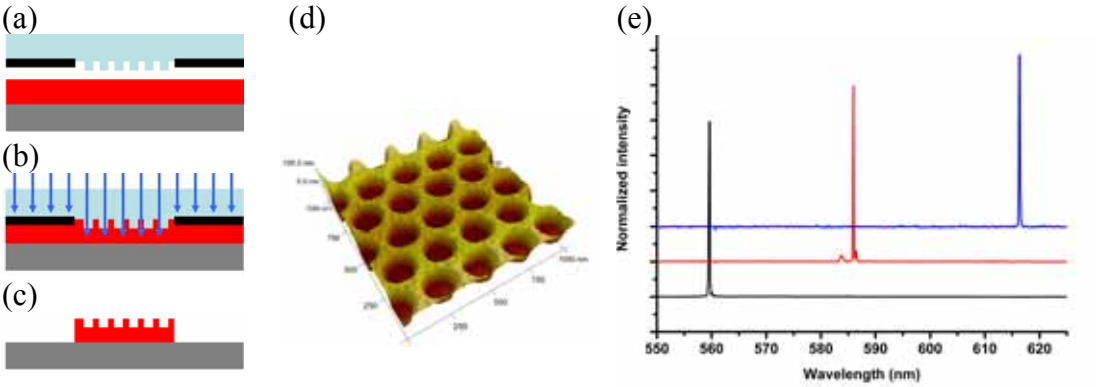
We present Combined Nanoimprint and Photolithography (CNP) [1], as a fast, flexible, and reliable method for parallel definition and integration of both active and passive polymer optics with nm to mm sized features [2]. We have fabricated lasers with a large tuning range within the visible spectrum, and have demonstrated their use as optofluidic sensors.

CNP relies on an UV transparent nanoimprint stamp with an integrated Cr shadow mask. The structures are made of UV curable polymer (SU-8), doped with organic dyes (Rhodamine 6G or Pyrromethene 597), if optical gain is required. First the stamp is pressed into the polymer film at elevated temperatures to define the subwavelength features, and the film is subsequently cross linked selectively at a larger scale by UV exposing through the hybrid stamp/mask.

We have fabricated both DFB lasers and photonic crystal band edge lasers, with reproducible results across 10 cm diameter wafers. When pumped from above with 5 ns pulses from a 532 nm laser, the lasers exhibit narrow emission lines, with a typical threshold of a few μJ/mm^2. The emission wavelengths depend on lattice constants of the 1D or 2D gratings, enabling tuning from approximately 560 nm to 650 nm. Also, the emission wavelength can be tuned by cladding the lasers with fluids of different refractive indices. This suggests the use of the lasers as optofluidic bio-sensors, which are potentially very sensitive, if analytes are immobilized on the device surface, within the evanescent optical field. Lasers have also been integrated with undoped polymer waveguides, and good control of the laser light on the chips has been demonstrated.



(a-c) Combined nanoimprint and photolithography (CNP). A hybrid nanoimprint stamp/UV mask is pressed into a polymer film to define the nm features. The film is subsequently hardened selectively by UV exposure through the stamp/mask. Finally, the reusable stamp is removed and unexposed polymer is dissolved. **(d)** AFM scan of a section of a fabricated photonic crystal band edge laser (PhCBEL) with a lattice constant (*a*) of 225 nm. **(e)** Laser spectra from PhCBELs with different lattice constants (364 nm, 384 nm, and 404 nm).

[1] X. Chen and L. Jay Guo, *Microelectron. Eng.* **71**, 288 (2004)
[2] M. B. Christiansen, M. Schøler, and A. Kristensen, *Optics Express* **15**(7), p 3931 (2007)