Full-2D simulation of in-plane liquid crystal lasers

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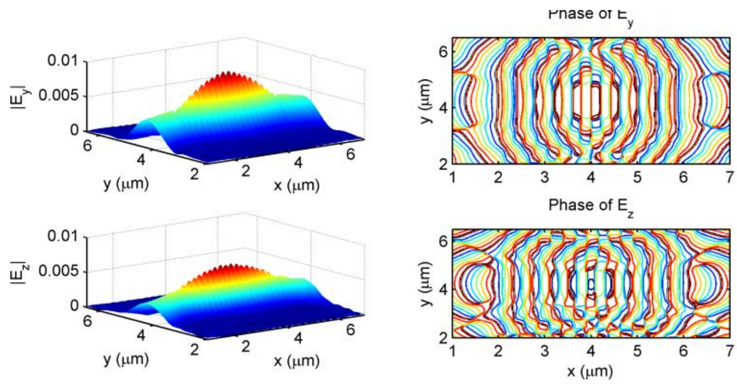
Lasing in liquid crystals has been demonstrated in numerous configurations and material systems. In most systems the laser light is emitted perpendicularly to the liquid crystal layer, but in the last few years also in-plane lasers have been demonstrated [1]. Such cheap in-plane tunable lasers could be combined in an opto-fluidic device, allowing to build fully integrated platforms for biological sensing applications.

The accurate modelling of light generation in in-plane liquid crystal laser is difficult because the structure is two-dimensional and the optical properties are anisotropic. Moreover, 2D simulations of the liquid crystal orientation in such layers is necessary because the lying helix structure, which is often used for such lasers, exhibits defects. These defects appear because typical planar or homeotropic alignment is not compatible with the lying helix structure. Quite a lot of theoretical and numerical work has been carried out for perpendicularly emitting LC lasers. A one-dimensional plane wave expansion method was previously applied for the analysis of light emission from OLEDs. The extension to anisotropic materials and to simulation of lasing threshold makes it suitable for the simulation of LC lasing characteristics. Good agreement between simulations and experiments was found [2].

For the simulation of in-plane lasers we rely on finite-element calculations of the optical modes in periodic two-dimensional structures [3]. The optical modes in a lying-helix configuration are calculated including the band diagram. The band diagram reveals at which wavelength lasing can occur while the optical mode profile gives information about the electric field profile and the polarization state. Additionally the laser mode of the complete structure can also be calculated. The figure below gives an example of the field profile of the laser mode in a lying helix liquid crystal. The structure consists of a number of periods, terminated by an air layer at both sides.



Field profile of a lying helix laser mode (left: absolute value, right: phase). The liquid crystal layer thickness is 1 μm, the period 0.4 μm, with a total lateral dimension of 4 μm.

References:
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