Tunable Liquid Crystal Lasers Based on Nanoimprinted Transparent Electrodes

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Transparent conducting films have been developed for transparent electrodes in various photonic applications such as flat-panel displays, touch screens, and solar cells. Particularly, indium tin oxide (ITO) film is one of the widely used transparent electrodes due to its high optical transmission and good electrical conductivity. Recently, we fabricated ITO films with one-dimensional periodic nanostructures by all-solution processing of ITO nanoparticles and a nanoimprint lithography method. The nanoimprint lithography used in this study is a promising technique for quick, simple, and low-cost surface patterning with submicron resolution [2]. The nanoimprinted ITO films on glass substrate showed low sheet resistance of ~200 Ω/sq at high optical transparency ~80% [1]. This sheet resistance at same transmittance is suitable for liquid crystal devices and polymer light emitting diodes although it is higher than that of the conventional ITO electrode. Also, the experimental transmission spectra from the nanoimprinted ITO films with various periodicities showed specific transmission dips due to light diffractions.

Here, we used this nanoimprinted ITO film as a distributed feedback (DFB) resonator, transparent electrode, and alignment layer of nematic liquid crystals. Dye-doped nematic liquid crystals were introduced into the DFB resonator. The DFB structure is one of the preferred resonators to achieve organic lasers with a broad and continuously tunability in the visible region, an intrinsic low threshold, and an easy processing. For a given period of the DFB grating, the second-order diffracted light makes a counter-propagating mode, resulting in optical feedback for lasing action. Lasing can be out-coupled to the surface normal direction by first-order Bragg diffraction.

In addition, the electro-optic performance of the lasing device based on nanoimprinted ITO electrodes is demonstrated successfully. From the field-induced reorientation of nematic LCs and hence changes in the refractive indices of the guided laser mode, laser emission shifts at low applied voltages, below 10 V. The present lasing device provides various opportunities in photonic device application and its simple fabrication process can be readily used for large area geometries from the viewpoint of practical application.

References

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