Liquid Crystal Microlasers

Hideo Takezoe
Department of Organic and Polymeric Materials, Tokyo Institute of Technology
2-12-1-S8-42, O-okayama, Meguro-ku, Tokyo 152-8552, Japan
takezoe.h.aa@m.titech.ac.jp

1. Introduction: Liquid crystals (LCs) and photonic effect
2. Kinds of LC microlasers: DFB lasers, Defect mode lasers, and DBR lasers
3. Tunability of LC microlasers: Wavelength, Polarization, and Direction
4. Toward cw lasing: Lowering threshold (cavity structure, excitation, dye)

In this lecture I introduce liquid crystal (LC) microlasers particularly using cholesteric LCs (CLCs). For the purpose, the first lecture is devoted to the introduction of LCs and photonic effect. In the second lecture, I summarize three kinds of LC microlasers, i.e., distributed feedback (DFB) lasers, defect mode lasers, and distributed Bragg reflector (DBR) lasers. DFB lasers are the simplest lasers using unperturbed CLC helical structures. By introducing defects such as phase jump, another thin isotropic or anisotropic layers, a defect mode emerges and gives low threshold lasing. If one inserts thick defect layers in between DBRs such as CLCs, many Fabry-Perot cavity modes emerge within the photonic band. I will emphasize Fermi golden rule for lasing emission and optical density of state.

One of the most important features in CLC microlasers is tunability. We can tune lasing wavelength, polarization state, and even directions. For wavelength tuning, external stimuli such as temperature, electric field, light irradiation, and mechanical stress can be used. If we introduce spatial variation of the helical pitch, we can achieve position-dependent wavelength tuning over the whole visible wavelength range. Polarization states such as linear and circular polarizations can be controlled by passing through a field-controlled nematic LC layer. Nonreciprocal lasing and omni-directional lasing are also introduced.

Final goal of LC microlasers is continuous wave (cw) lasing. For the purpose, a variety of effort has been made from viewpoints of cavity structures, excitation methods, and development of dyes. I will summarize such effort.