Towards crystalline topological lasers based on organic emitter system Alq3:DCM

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Topological photonics has emerged as a powerful concept for exploring robust light-matter interactions and enabling novel optical functionalities that are immune to disorder and imperfections [1]. Inspired by analogies with electronic topological insulators, this field has grown rapidly, introducing photonic structures that support edge states protected by symmetry or topology. Among its most promising applications are topological lasers, which benefit from enhanced coherence, robustness against fabrication defects and notably higher slope efficiencies, as demonstrated in pioneering work by Bandres *et al.* [2]. Another intriguing model describes a two-dimensional photonic crystal that exhibits symmetry-protected topological phases with helical edge states through the controlled deformation of a hexagonal lattice [3]. This model was experimentally realized by Dikopoltsev *et al.* [4] using a semiconductor vertical-cavity surface-emitting laser (VCSEL) array at cryogenic temperatures.

Here, we propose realizing the crystalline topological insulator model at room temperature using Alq_3:DCM, a widely studied organic light-emitting diode (OLED) material known for its high photoluminescence efficiency and compatibility with dielectric microcavity structures. Recent work has demonstrated photonic confinement [5], optically pumped lasing in a hybrid OLED structures [6] and one-dimensional topological lasers [7] with Alq_3:DCM-based microcavities under ambient conditions. In our case, we implement the photonic topological potential landscape by focused ion beam milling of the glass substrate, before applying the dielectric cavity mirrors via dual ion beam sputtering. This method is well known for emulating any complex lattice potentials for e.g. exciton-polariton lattices at room temperature [8, 9]. To achieve electrical driving in the future, monolithic microcavity structures and therefore strain compensation via buffer layers are necessary. We will discuss different fabrication methods of our microcavity devices and will present preliminary band structures towards crystalline topological lasers. This would represent a significant step toward practical topological photonic applications and devices operating without cryogenic infrastructure.

References

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