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DESIGN OF FINITE SIZE OPTICAL CAVITIES USING TOPOLOGY OPTIMIZATION

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Abstract: Optical cavities have unique properties by confining light in a wavelength-size volume with very small loss. They exhibit high quality factor (Q) and small mode volume (V). This makes them promising building blocks for future integrated photonic circuits [1]. Previously, several studies were presented to design optical cavities based on photonic crystal platform to increase the Q factor while decreasing the modal volume (V), i.e. to enhance the Purcell factor, which is proportional to Q/V. Most of the studies focused on shape optimization of photonic crystal cavities using geometrical perturbations. The Purcell factor was enhanced by trial-and-error approaches through extensive simulations by changing locations or radii of air holes in photonic crystals [2]. More recently, an optimization formulation was presented to design optical cavities with enhanced Purcell factor using topology optimization. However, the optimized cavities presented in [3] were hardly manufacturable due to lack of length scale. In this study, we employ the optimization formulation presented in Ref [3] to design optical cavities with enhanced Purcell factor. The optimization problem is formulated to maximize a frequency-averaged local density of state (LDOS) [3]. To ensure manufacturability, length-scale and design robustness, the robust formulation presented in [4] is employed by considering different design realizations simulating manufacturing errors. The optimization problem for designing manufacturable optical cavities is recast to maximize the minimum LDOS among the different design realizations considered. Both 2D and 3D slab cavities with different sizes will be systematically designed. Based on the optimized cavities, influence of cavity size on the cavity performance will be further investigated.

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