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Designing Manufacturable Photonic and Plasmonic Structures using Topology Optimization

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Since the first application of density based topology optimization to photonic-crystal structure synthesis [1], the field has experienced a tremendous development. During the 2000s the use of topology optimization in photonic design expanded to include photonic-crystal band-gap engineering, design of slow-light wave-guides, photonic filters and modulators as well as plasmonic grating couplers [2]. This was followed in the 2010s by applications to the design of multiplexers and power-splitters, hyperlenses and on-chip Fabry-Pérot resonators [3] to name a few examples. Further developments, refinement and applications to ever more complex design problems are ongoing.

A key reason for the growing interest in topology optimization as a design tool is the ultimate geometric design freedom provided by the method, the only restriction being the resolution of the design field, which in principle can be made arbitrarily fine. This design freedom, however, comes with a crucial pitfall in the form of the lack of any inherent detail- or length-scale control in the design process if no special measures and taken. Lack of a strict feature size control risks rendering the physics modelling inaccurate, makes designs highly sensitive to manufacturing uncertainties and/or hinders accurate fabrication by standard processes.

The talk will provide a review of selected advanced geometric control methods which establish detail- and length-scale control as well as robustness [4] in the topology optimization process, hereby ensuring accurate modelling of the physics, manufacturability and guaranties agreement between numerical predictions and practical measurements.

Finally, some recent applications of density based topology optimization to the design of photonic resonators [5], plasmonic field enhancement devices [6], photonic up-conversion structures [7] and topological insulators, will be presented and discussed.

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