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Editorial

Photonic Crystals

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The past and present goal of photonic technology stems in the fine and arbitrary control of light propagation within miniaturized devices that can possibly integrate different functionalities.

Among photonic materials, photonic crystals (PCs) represent a versatile platform, wherein the permittivity modulation at a length scale comparable with the working wavelength prevents light propagation in a frequency range. Exploiting such peculiar PC properties, high efficiency reflectors, filters, integrated 3D circuits, sensors and emission control of selected emitters have been demonstrated. Despite the well-established nature of PCs, the current research is continuously evolving pointing out new materials and geometries together with new fundamental operating principles. Within this scenario, this special issue collects experimental and numerical studies that enrich the world of photonic crystals thanks to new materials and advances in new lithographic techniques, for novel devices in different frequency ranges.

Starting from a 1D photonic crystal prepared by consecutive spin-coated layers of two polymeric materials, Lova et al. reported the fluorescence control of an emissive layer, containing a fluorescent europium complex, into an all-polymeric planar microcavities. By placing the europium complex in the defect layer of the PC, a spectral and directional redistribution of emission was obtained due to modified photonic states of the cavity [1].

Engineering the desired optical properties by playing on the periodic/aperiodic arrangement and constituent materials of the PC unit cells has been pursued using different methods.

An example of design optimization for a 2D photonic crystal with a triangular lattice Al_2O_3 dielectric posts operating for the 5G bandwidth is reported in the special Issue by Y. Wang et al. Numerical calculations based on finite element method were demonstrated crucial to optimize the performance of the magneto-optical isolator made by PC waveguides combined with two rectangular gyromagnetic ferrites. They demonstrated a broadband and high isolation operating in the 24.85–27.15 GHz frequency for the 5G communication system [2].

Another fundamental challenge for the PC application is the scalability and reproducibility of their fabrication. In this issue, M. Domonkos reported how nanosphere lithography, where self-assembled monolayer of polystyrene spheres can be used as a lithographic mask, enabled the fabrication of nanostructured polycrystalline diamond thin film. By playing on the monolayer assembly of polystyrene nanospheres and their dimension, different 2D periodic geometries were demonstrated for large area 2D PCs (up to several cm^2) [3].

A large scale production of materials with well-defined optical properties would also benefit from molecular self-assembly. This has been demonstrated by using block copolymers for periodic arrangement at the nanoscale [4] while nanoporous 3D materials patterned by direct laser writing were recently fabricated in a novel photopolymerizable resin [5]. On the other hand, exploiting the spontaneous molecular alignment of liquid crystal materials and their stimulus responsive behavior, 3D photonic structures have been reported [6]. By modulating their molecular arrangement, the optical properties were controlled by external stimuli [7] thus opening to the fabrication of different tunable photonic platforms [8].

The last topic covered by the issue is related to the low refractive index of polymeric materials with respect to inorganic ones, which can limit their application for PC fabrication. C. Tavella et al. present the synthesis and characterization of a high-refractive index polymer (n = 1.83 at 600 nm) due to the inverse vulcanization by copolymerization of elemental sulfur with an organic tiofene based comonomer. Blending this polymer with polyvinylcarbazole enhances its processability towards high optical quality all-polymer planar photonic crystals [9].

In summary, the works collected in this Special Issue give an insight on the different research tendencies in the PC field that are focused on new materials, designs and lithographic protocols to improve the PC performances and extend their potential. As guest editors, we hope that such contributions will pave the way for the integration of PCs in more complex and smart devices and the introduction of new optical functionalities.

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