Photonic Metamaterials Mechanically Re-configurable at Nanoscale via Liquid Crystals

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Metamaterials (MMs) in optics represent a large class of nano-structured artificial media with optical characteristics not found, or superior, to those exhibited by natural materials. They have rapidly advanced over the past decade and are now expected to have major impact across the entire range of photonic technologies. The current effort in the field is focused on implementing the idea of active and tunable MMs, a generation of artificial photonic media with dynamically controlled optical properties [1].

One of the common methods of achieving tunability of MMs is to functionalise their fabric with liquid crystals (LCs), where the MM properties are controlled by changing the LC optical anisotropy with externally applied electric field or light/temperature [2, 3]. Recently, we were able to demonstrate spectral tuning in such hybrid LC-MM systems of nearly 10%, thus approaching the theoretical limit for their tunability [4].

To further improve the tunability of LC-MM systems, the framework of MMs was made mechanically re-configurable. For the first time, elastic properties of LCs were exploited for controlling MM movements at the nanoscale. The resulting novel hybrid systems were free from stiction, while robust control of nano-scopic actuations in such systems was achieved for the entire range of structurally allowed displacements. The new approach also enabled on-demand, fully reversible transition between stiction-free and stiction-dominated regimes of MMs mechanical switching upon changing the phase of LC.

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