Self-Collimation in Quasi Zero-Average-Refractive-Index Photonic Crystal Metamaterial

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Presentation

Abstract: The Molecular Foundry is one of the five DOE Nanoscale Science Research Centers (NSRCs), premier national user facilities for interdisciplinary research at the nanoscale. Together the NSRCs comprise a suite of complementary facilities that provide researchers with state-of-the-art capabilities to fabricate, process, characterize and model nanoscale materials, and constitute the largest infrastructure investment of the National Nanotechnology Initiative. In this framework we will present a user project that will show the potentiality of this DOE initative. The control of light-matter interactions in complex dielectrics offers the ultimate potential for the creation and manipulation of light states. Unlike periodically arranged dielectrics (photonic crystals), periodic and aperiodic dielectric arrays with zero average refractive index (ZARI) show unique light localization and transport properties, which are intrinsically robust to fabrication imperfections, which arise from unavoidable imperfections at small (nanometer) scale, providing a global large scale high-quality of the manufactured devices. This represents an essentially great advantage respect to photonic structure based on the management of defect states inside a bandgap that are intrinsically sensitive to small-scale defects. Negative refracting dielectric photonic crystals (PhCs) represents a viable way to realize Negative Index Materials (NIMs), and are ideal components for ZARI structures for controlling long-range light propagation due to their low absorption loss. We give the first demonstration of a carefully designed and fabricated large-area metamaterials incorporating both negative and positive index media in a synergistic fashion, proving that can be extremely useful for the control of light propagation and light emission. In particular we show that a quasi-zero-average-index metamaterial, leads to strong supercollimation of an near-infrared beam over a large distance of 4 mm. This distance represents more than two thousand times the input wavelength $\lambda=1.55\ \mu m$ while the beam spot size is fully preserved throughout the entire sample. The negatively refracting PhC layer and the air layer in each pair can be conceptually regarded as each other's complementary media, which are spatial regions that optically cancel out each other completely so that to the incident light it is as if they are removed in space.

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