CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

Michael L. Janner

Project Number

S0698

Project Title

Assembly of Magnetic Particles and Magnetic Holes into 1D, 2D, and 3D Photonic Crystals

Abstract

Objectives/Goals

Photonic crystals are structures with a periodic index of refraction that can prevent the propagation of light within a certain range, known as the band gap. This photonic effect occurs only in dimensions with the appropriate periodicity, so it is therefore possible to create photonic structures that act in only specific directions. The objective of this experiment is to fabricate one-, two-, and three-dimensional photonic crystals and to manipulate the assembly of these structures so that their morphology and photonic response may be controlled.

Methods/Materials

Building blocks for the photonic crystals included porous silica-coated iron oxide nanocrystal clusters, which were fabricated through the hydrolysis of iron chloride, and uniform polystyrene beads, which were fabricated through emulsion polymerization. The polystyrene beads were placed in a ferrofluid, also created in a hydrolysis reaction, so that they acted as magnetic holes. Patterned templates were created from polydimethylsiloxane and polyurethane and were used to direct the assembly of the photonic crystals into specific arrangements.

Results

Magnetic fields were used to assemble the nanocrystal clusters into 1D photonic chains, which could be reassembled into 2D photonic labyrinths by increasing concentration and magnetic field strength. The photonic labyrinths could be controlled using patterned templates and glass spheres in order to create photonic crystals with varying structures. Polystyrene beads acting as magnetic holes were assembled into not only 1D chains and 2D labyrinths, but also proved to be uniform enough to create 3D photonic crystals with high interior order and an exterior shape that could be easily manipulated.

Conclusions/Discussion

The ability to fabricate photonic assemblies with precise control over the structure, diffraction wavelength, and directions of diffraction marks a development that will allow photonic crystals to be created for highly specific purposes with narrow constraints for the photonic properties. Such crystals may find use in applications such as flexible computer and television displays, color-changing clothing, and photonics-based computer chips.

Summary Statement

Hydrolysis and emulsion polymerization reactions were used to create building blocks for magnetically responsive photonic crystals with highly tunable structures and photonic properties.

Help Received

Used lab equipment at the University of California at Riverside under the supervision of Dr. Yadong Yin and Le He.