CALIFORNIA STATE SCIENCE FAIR
2012 PROJECT SUMMARY

Name(s)
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Project Number
S0620

Project Title
Fabrication and Manipulation of One-Dimensional Photonic Crystals

Abstract

Objectives/Goals
Photonic crystals have been the subject of intensive research during the last two and a half decades due to their usefulness in controlling the flow of light. More recently, there has been interest in creating photonic structures that can be controlled with external stimuli. The objective of this experiment is to fabricate iron oxide nanocrystals and use them as building blocks for magnetically responsive photonic structures.

Methods/Materials
Iron oxide nanocrystal clusters were fabricated through the hydrolysis of iron chloride and coated with a layer of silica through a modified Stöber method. This silica layer was then made porous through etching by water. As the nanocrystal clusters exhibited superparamagnetism at room temperature, magnetic fields were used to assemble them into photonic structures. These photonic structures were retained through further silica coating.

Results
Upon application of an external magnetic field, the nanocrystal clusters aligned into dynamic chain-like structures with regular interparticle spacings, causing them to diffract light. The diffraction wavelength of the photonic chains could be tuned across the visible spectrum by varying the magnetic field strength. The porous silica layer significantly improved both the stability and the order of the photonic crystals, increasing the diffraction intensity to nearly 70%. At increased concentrations, the chains assembled into photonic labyrinthine structures with lengths of up to 3-4 mm.

Conclusions/Discussion
The nanocrystal clusters can easily be assembled into photonic crystals with a fast and fully reversible magnetic response, making them ideal for applications such as color displays, antifraud devices, and military camouflage. The transition from photonic chains to photonic labyrinths has also been demonstrated in this study. These photonic labyrinths are very promising, as their assembly can be manipulated in order to create labyrinths with a wide range of morphologies which can be retained for further use by a secondary silica coating.

Summary Statement
Iron oxide nanocrystal clusters were fabricated and assembled into chains and labyrinths which change color in response to external magnetic fields.

Help Received
Used lab equipment at the University of California at Riverside under the supervision of Dr. Yadong Yin and Qiao Zhang.