CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

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Project Number

34849

Project Title

Magnetic Field Modulation for Assembly and Manipulation of Responsive Nanoscale Optical Systems

Abstract

Objectives/Goals

In recent years, nanoscale materials have proven useful as building blocks for systems which utilize constructive interference in the visible spectrum to create brilliant optical effects. In order for these systems to be implemented in real-world applications, though, there must exist a mechanism by which their structure, and effectively their structural color, can be finely tuned. The objective of this experiment is to investigate magnetic field modulation by polymer templates as a means to assemble arbitrary building blocks into nanoscale systems that exhibit visible structural color and possess unique, highly controllable arrangements.

Methods/Materials

Highly uniform nonmagnetic beads were fabricated through emulsion polymerization and subsequently used as building blocks for photonic crystals by placing them in a ferrofluid, created in a hydrolysis reaction, so that they could be magnetically arranged into periodic structures. Patterned polyurethane templates were fabricated and used as a substrate for the photonic crystal assembly. Subsequently, the ferrofluid was used as a building block for the optical system itself, by allowing sufficient time to pass for the ferrofluid to arrange into thin films on top of the polyurethane.

Results

By surrounding the polymer templates and structural building blocks with ferrofluid, optical nanoscale assemblies were fabricated from a wide variety of materials which would previously not have been suitable for such responsive systems. Additionally, the use of patterned templates allowed for a much higher degree of control over the shape and size of the resultant structures. The photonic crystals exhibited tunability across the visible spectrum, and the thin films displayed visible color dependent on their thickness and the viewing angle.

Conclusions/Discussion

The ability to build responsive optical systems from nearly any uniform nanoscale material, and to assemble them into a variety of structures through the use of polymer templates, marks a development which can be readily generalized to create highly unique optical systems for niche applications. In particular, this method of fabrication allows for increased accessibility to building blocks of various properties, which will play an increasingly important role as these structures begin to find use in applications such as color-based sensors and anti-counterfeiting devices.

Summary Statement

A general self-assembly procedure involving polymer templates and ferrofluids was investigated with the purpose of building responsive optical systems out of a wide variety of starting materials and with a high degree of structural control.

Help Received

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