CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)

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Project Number

31394

Project Title

World of [Structural] Color: Novel Photonic Polystyrene Nanostructures for Chemical Sensing

Abstract

Objectives/Goals

Chemical nanosensors are becoming increasingly important in the nanotech field due to the reduction of cost and potential of real-time monitoring offered by portable devices. Polymer-based photonic materials possess immense potential in as stable and hydrophobic optical sensing agents, but a method for constructing a truly photonic polymer has not yet been successfully developed. The objectives of this research were to synthesis nanostructured polymers and investigate their potential as chemical or biosensors.

Methods/Materials

Porous Si nanostructured films were prepared using anodic electrochemical etch from silicon wafers in a solution of 48% hydrofluoric acid and ethanol in a 3:1 ratio. The reaction was driven by a sinusoidal electric current. After this initial etch, an electropolishing current was applied to produce freestanding lift-offs, then thermally oxidized to porous SiO_2. Polystyrene of various molecular weights were prepared in toluene and solution-cast into the films. After curing, the templates were removed by HF dissolution. Spectroscopic (visible and infrared) monitoring was utilized to characterize the process.

Results

An optimum molecular weight of around 45,000 g/mol was optimized through numerous trials. Lower molecular weights infiltrated the pores completely but lacked structural stability to maintain the sinusoidal porous shape, while higher molecular weights were unable to diffuse into the pores. Successful polystyrene replicas displayed vivid structural color, and the optical signal changed drastically in response to various solvents while maintaining polymeric properties such as hydrophobicity and mechanical stability.

Conclusions/Discussion

In this research, a complete replication of a porous Si oxide nanostructure was achieved using polystyrene; it was also demonstrated that optical properties were retained in the polymer, and that the novel nanostructured polystyrene responded vividly to various analytes. Complete rejection of water (humidity) was also achieved using this material. This is also the first study that has been done to characterize the templating process and, in doing so, to develop and optimize a novel, reliable methodology of template-based synthesis.

Summary Statement

A novel nanostructured polymer was synthesized using a porous template for chemical and biological sensing applications.

Help Received

Used lab equipment at the University of California, San Diego under the supervision of Professor Michael Sailor.

Preliminary