CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

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Project Number

34656

Project Title

Novel Stable Photonic Crystal Polyester Nanosensor Capable of Quick Visual Detection of Chemicals and Biochemicals

Abstract

Objectives/Goals

The goal of the project was to create a stable, fast reacting nanosensor from low-cost, easily manufactured cross-linked polyester. To do so a method would be developed to make materials other than silicon have a nanostructure unique to porous silicon called a photonic crystal rugate structure that allows quick and easy visual detection of chemicals and biochemicals.

Methods/Materials

First, a rugate structure silicon chip was electrochemically etched with a sinusoidally modulating current density. After a bolt with an aluminum foil along its inner radius was placed on the etched silicon chip, a mixture of polyester resin and methyl ethyl ketone peroxide catalyst was inserted into the aluminum-coated bolt. After infiltration and polymerization, the silicon template was removed to result in the freestanding polyester replica. Various parameters were explored such as the etch conditions, polymerization conditions, methods of silicon template dissolution, and other troubleshooting. After each adjustment the reflection graph of the replica was analyzed using a spectrophotometer to check for successful replication. The samples were further characterized by SEM.

Results

A successful method of replicating the rugate structure was developed. The following is the novelly developed method optimized for polyester: The silicon template is etched with 100-200mA/cm2 current density modulation, 5 second period and 200 repeats. Then the silicon is thermally oxidized for 2 hours at 550°C. The bolt and aluminum are placed on the chip and a mixture of 1 drop catalyst and 1mL polyester resin is put in the inner hole of the bolt. The composite is heated at 80°C for 3 hours and after 3-5 days the template is dissolved using 1M KOH. After dissolution, the sample is immediately dried using vacuum.

Conclusions/Discussion

After many ideas and troubleshooting, the polyester was able to replicate the photonic crystal rugate structure and was stable in air. The resulting replica sensor is much more mechanically and chemically stable than any other containing the rugate structure so far. Furthermore it has practical applications due to its low material cost, quick and simple visual detection of chemicals and biochemicals, portability, ability to control its size and shape, and its possible expansion of the field by making similar sensors with other materials through the developed method.

Summary Statement

A low-cost, easily manufactured, portable chemical sensor with a quick reaction time was developed by imprinting a photonic crystal structure of porous silicon onto cross-linked polyester.

Help Received

Used lab equipment and facilities of the Sailor Lab at University of California, San Diego, under the mentorship of Joanna Wang and overall supervision of Prof. Michael J. Sailor; Participant in the Summer School for Silicon Nanotechnology; Parents helped print and mount the poster;

Preliminary