Name(s)
Gha Young Lee

Project Number
S0611

Project Title

Novel Self-Reporting Photonic Crystal Nanosensor: Controllable Hydrophobicity, Flexibility, and Chemical Resistance

Abstract

Objectives/Goals

The objective is to develop and optimize a protocol to make instantaneous, self-reporting, color-changing chemical nanosensor that is commercially and practically viable. A method to have a such a sensor that is stable, reproducible, and chemically and mechanically sturdy will have immense commercial potential in medicine, military, laboratories, and households. The project intends to also add aspects that would enhance the end product even more - flexibility (which adds so much more mechanical durability and also adds potential as stable wearable sensors) and enhanced hydrophobicity (to be able to filter out small amounts of chemicals from dilute solutions and to avoid damage by humidity).

Methods/Materials

Porous silicon was electrochemically etched to have nanopores that display Fabry-Perot interference. Fluoropolymer PVDF (poly(vinylidene)-fluoride) was melt-casted into the pores with a 200g weight on, and the composite was then dissolved in dilute KOH to eliminate the template nanoporous silicon. The remaining polymer is characterized via optical spectrophotometry, FTIR, and contact angle measurement.

Results

A successful, novel stable porous silicon-templated nanosensor is developed. The nanosensor demonstrates instantaneous color change in presence of chemicals, is flexible, has an improved near-superhydrophobicity that is found to be controllable, and has unprecedented chemical resistance.

Conclusions/Discussion

The optimal melt-cast setting of the PVDF is 230°C for 2 hours, with 200g weight on top. Molecular weight and thus viscosity of the polymer was one of the biggest factors in determining replication success. The polymer#s natural hydrophobicity drastically increased with the nanostructure to almost superhydrophobic, and the duration the silicon-polymer composite was left in the dilute KOH was able to alter the hydrophobicity of the sample. That, along with the flexibility, holds much promise in manufacturing, future research, and as wearable sensors. This product#s most useful application is as a medical device coating to determine whether devices such as needles or catheters have been sterilized. The PVDF can serve as a precedent for other hydrophobic and chemically resistant polymers, and perhaps PTFE can be used to achieve superhydrophobicity and even more chemical resistance.

Summary Statement

A successful, novel stable nanosensor is developed that can instantaneously change color in presence of chemicals, is flexible, has a controllable near-superhydrophobicity, and has unprecedented chemical resistance.

Help Received

Participant and Project Leader at the UCSD Summer School for Silicon Nanotechnology, and learned useful materials; Used lab equipment and chemicals of UCSD under the supervision of Dr. Michael J. Sailor; Lab's Ph.D student Ms. Joanna Wang helped with etching since I am a minor, and also took SEM