CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

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Project Number

S1826

Project Title

Dependence of Silica Sol-Gel Thin Film Material Properties on Fabrication Methods

Abstract

Objectives/Goals

To experimentally determine the dependence of refractive index (n) and thickness on easily varied synthesis parameters both in isolation and interaction with each other.

Methods/Materials

In this work, 175 thin films were synthesized varying the amount of water, aging time, spin speeds, temperature, and annealing times. The study was carried out in two phases, an axis terms phase, varying one parameter at a time, and interaction terms phase, using a full factorial (25) design of experiments. The thin films were characterized for thickness and n at three wavelengths of light using ellipsometry.

Results

Three models were developed for some of the parameters varied. For others, however, the relationships were too complicated to model accurately without more data, and some of the parameter values chosen were too extreme to offer meaningful results.

Samples that were spun-coat at temperatures cooler than room temperature, excluded from the models, were observed to have fairly consistent pores.

Conclusions/Discussion

High n thin film coatings such as those synthesized in this study are widely used in the field of optics, which touches many aspects of our lives. One application of thin film coatings is in optical biosensors, where increasing n and decreasing film thickness can increase the sensitivity of the biosensors, thus allowing detection of diseases in their early stages. Currently, researchers often settle for doping their films to modify the refractive index. This is not always optimal, as it could degrade other properties, such as increasing the absorption of the film. Before this project, there were no quantitative models researchers could follow to manipulate the parameters of the synthesis process without adding dopants to get the best film for their purposes. In addition to filling this need, the method this study discovered to synthesize porous sol-gels, spin-coating cold, is potentially a very simple and inexpensive route. Porous sol-gels are exciting in their own right for their applications in increasing the sensitivity of biosensors.

Summary Statement

Silica sol-gel thin films were synthesized with various recipes and characterized in order to develop a quantitative model that researchers can use to control the optical properties of the films when using them on their optical devices.

Help Received

Used lab equipment at University of Southern California under the supervision of Dr. Andrea Armani and Mr. Mark Harrison; father taught me MATLAB to help with analysis