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

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High refractive index (n) thin film coatings 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 biosensors' sensitivity, thus allowing detection of diseases in their early stages. Thin films from synthesized sol-gel silica are one promising avenue of research. Currently, researchers often settle for doping their films to modify the n. This is not always optimal, as it could degrade other properties, such as increasing the absorption of the film. However, there are no continuous quantitative models researchers can follow to manipulate the parameters of the synthesis process without adding dopants. This study seeks to fill that need by testing the dependence of n and thickness on easily varied synthesis parameters. In this work, 175 thin films were synthesized varying the amount of water, aging time, spin speed, temperature, and annealing time, with both axis terms, varying one parameter at a time, and interaction terms, using a full factorial (2^5) design of experiments. These were characterized for thickness and n at three wavelengths of light using ellipsometry. 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. Very simple and inexpensive, this potential route to fabricate porous sol-gel films has exciting applications in increasing the sensitivity of biosensors.

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