Research Report Fall 2019

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Electrical Engineering

Dr. Korampally

Acknowledgements

Without the support of my family, Dr. Korampally, my research team, or the support of my loving girlfriend I would have never been able to come to NIU and work with such a prestigious team and receive this experience.

Introduction

In the last few months I have learned much about the applicable use of optics, quantum mechanics, as well as many useful methods for Nano-electronics. I have learned safety procedures for the Microelectronics Research and Development Lab. I also learned how to use multiple of the devices in the lab, as well as learned applicable uses for gradient vectors, how to implement them as optics, as well as how to operate in a research assistant position.

Background

Dr. Korampally has been working with students throughout his career here at NIU and has been having them aid and further his research currently into optics, photolithography, nanofabrication and applicable uses for engineering and scientific fields. While he has previously worked on creating these optics to be used for application in the medical field, it is now his goal to research a cost efficient and more highly sensitive optic. This optic should have a broad refractive index that could be used for point of care use in less fortunate/developing areas of the world.

Objective

When starting in this project our goal for this semester was to get me trained, get experience with assisting in research, repairing devices, as well as performing minor experiments and interpret results. The main objective at the end of this period is to create a thin film with a specific optical constant. We can print thin films with a high refractive index or a low refractive index however, to get a refractive index between these two set points we need to find a different method. We will be fabricating microsphere assemblies of different sizes and shrinking them to create gradient thin films that will provide optics with specific optical constants.

Methodology

During this research period I was instructed mostly by Dr. Korampally as well as Stephen Binderup in how to prepare myself to be able to make contributions to Dr. Korampally's research group. I was asked to go through an introductory lab safety demonstration with Mr. Binderup and was afterwards given a written test. I have also been receiving lab procedures, reading materials, and have been given instructional videos to help me with my comprehension of our goals and methodologies in our project. I was given two assignments over the semester, the first being to use PDMS stamps to stamp PMSSQ on Silicon with different stamp washing methods to find a reasonable way to wash the stamps. In late November I've begun working on using the Reactive Ion Etcher in the lab to use plasma to shrink microsphere assemblies in the hopes of creating a desirable etching pattern. While I have analyzed data from the results, I plan to continue more extensive testing with the RIE to see how far I can shrink these assemblies and what the shrink rate will be at different forward powers in the RIE.

Instruments

During this process I primarily used the RIE for my experiments. We are currently using a micro RIE, we have CCl_4, SF_6, and O_2 gas at our disposal. I'm currently using O_2 gas as it does not target the Silicon in our etching, it will instead primarily target our Silica microspheres. I'm currently working towards finding an etch pattern for 1 Micrometer microsphere assemblies using 30 SCCM O_2, 80W forward power, and 470 mTorr of chamber pressure. Before this operation I am trying to match the chamber before initial test. When matching the chamber, the goals are to set the devices reflective power to zero, as well as to clear out any nitrogen that might be lingering in the O_2 line. In previous experiments when using primarily O_2 gas we have seen our plasma as a magenta color. This is indicative of Nitrogen gas,

and is not what we want in our test chamber. After matching our plasma should be a white-blue color and is a good sign that we have oxygen plasma etching our substrate.

Data Collection

Data for the microsphere assemblies was acquired using the Scanning Electron Microscope in the lab. During this academic semester I had been given multiple demonstrations on how to properly operate the Scanning Electron Microscope's complex vacuum system, and how to retrieve high resolution images. During this period, I was also given the responsibility of researching and giving an informational demonstration, on what is an SEM, and how to operate it.

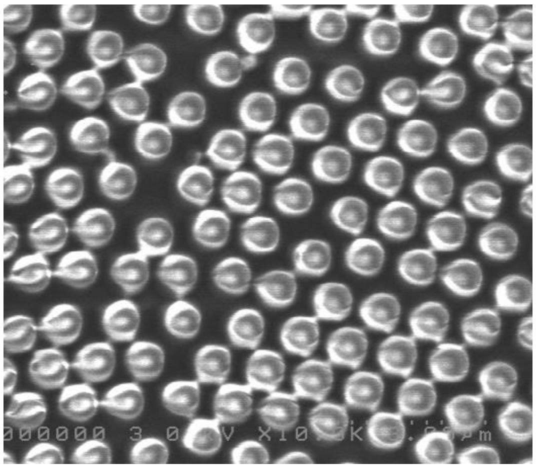
Limitations

Problems in my research has mostly been due to lack of information as I am a beginner researcher and hands on experiments in nanofabrication is quite new to me. Other issues include what I believe to be uneven microsphere assemblies which can cause uneven shrinking. I am also limited in that our RIE is partially damaged, we have a temporary fix, but it appears that our gas line and coolant line our arranged very closely together when entering the test chamber and with oxygen gas, if we are to use higher than 100 W of power in our plasma we heat the chamber to the point that we melt a gasket in our coolant line. I am not sure if there are other methods to raise our power when using oxygen plasma but at the moment, I am limited to the powers of 0W-100W.

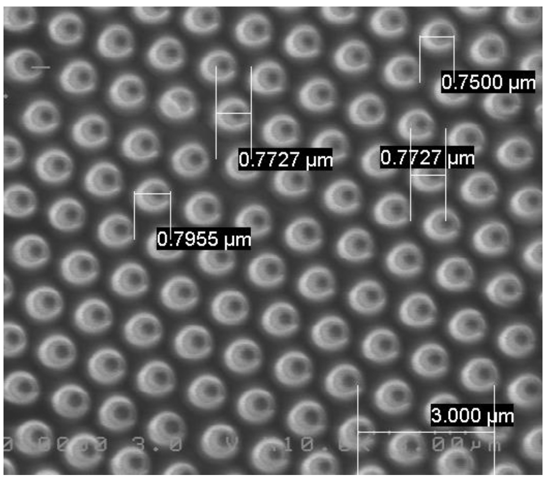
Results

Initially our goal was to find the etch rate for our microsphere assemblies at our test conditions. While I have made progress in the comprehension for the subject matter needed and have made progress on finding the function for shrink rate with respect to exposure time there is still additional testing that must be done before moving forward with fabricating optic lenses. Below you can see the results for current testing and the discussion for moving forward.

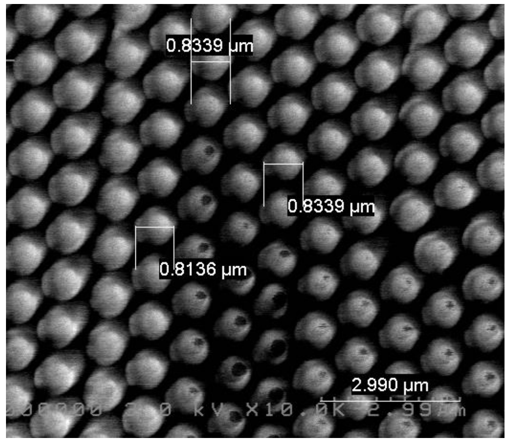
Microsphere shrink rate Oxygen Plasma 30 SCCM, 80 W	Column1
Exposure Time(min)	Size of Microspheres(micrometers)
0	1
3	0.75
6	0.77
12	0.82
15	0.58



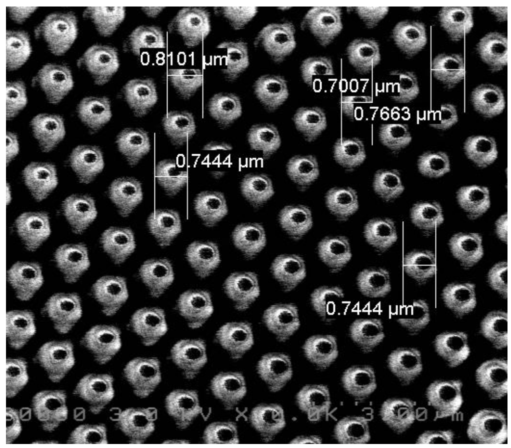
Exposure Time: 3 minutes



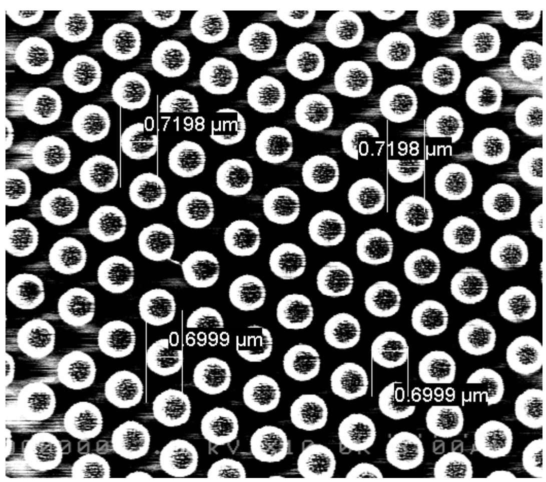
Exposure Time: 6 minutes



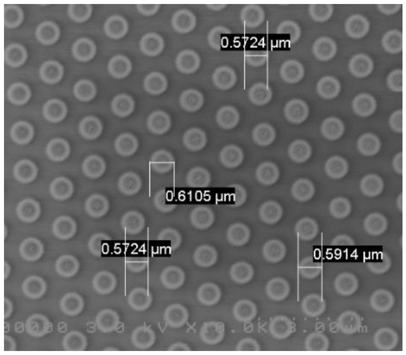
Exposure Time: 9 minutes region 1



Exposure Time: 9 minutes region 2



Exposure Time: 12 minutes

Exposure Time: 15 minutes 

Error in our data is assumed to be due to uneven shrinkage across our sample.

While we have good data to begin plotting a function of microsphere shrinkage to time it can be inferred by the final test sample that these spheres can most likely shrink much further. I am hoping that with a longer exposure time the microsphere's in the assembly will shrink further and continue to have even spacing between the individual spheres.

Discussion

I believe that possible reasons for error in exposure time 9 could be due to an irregularity either in our Silicon Wafer or in the assembly itself. When viewing these spheres, it appears that the spheres have grown since the last sample. While I don't believe this is possible in the test conditions the substrate was under, I do believe it is possible that some regions experienced less shrinkage than others creating an uneven gradient vector. It is currently unclear how much this could potentially affect the refractive index of the potential Lense that could be created from this assembly, but after trying to view more areas in the rest of my test samples it appears that this could have just been an anomaly. I hope to continue my research in the spring, finish a correct function for shrinkage with respect to time and then hopefully make a Lense with a specific refractive index. Regardless of my results I plan to show my methods, and findings at a upcoming to be decided conference relevant to my subject in the spring.