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Carbon Hard Mask for Line Width Trimming

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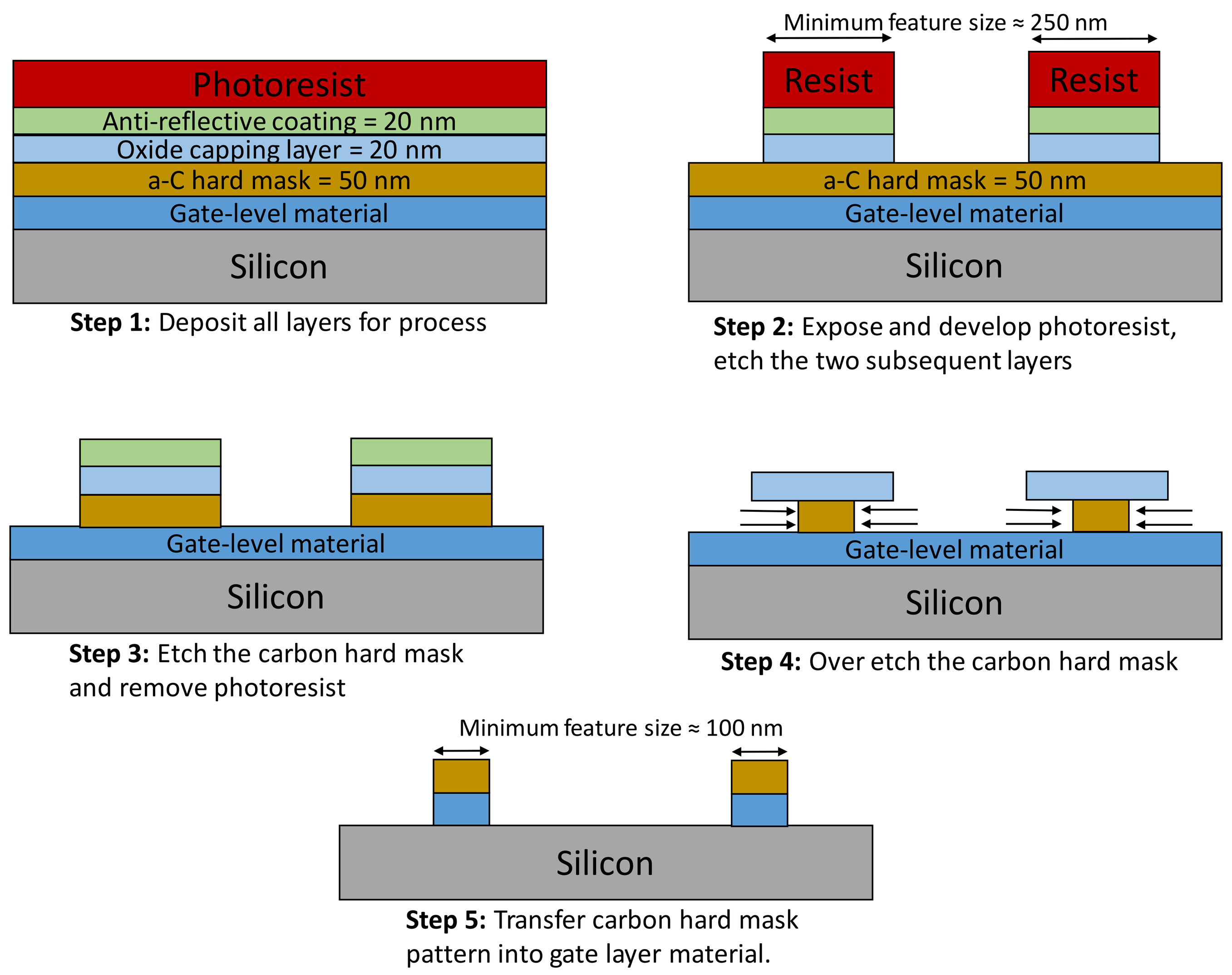
Project Objectives

Goal: Modify carbon hard mask to minimize reflectivity and enable line-width trimming.

- Work in conjunction with Master's thesis work to create an ideal carbon hard mask layer.
- Determine necessary PECVD parameters for processing.

Introduction

- Amorphous carbon (a-C)
- Alternative hard mask to nitride
- Provides several benefits, including:
    - Low deposition temperatures (PECVD)
    - Excellent optical properties
    - High mechanical strength
- Useful for line-width trimming in lithography applications



- Useful for eliminating stack reflectivity in conjunction with an anti-reflective film

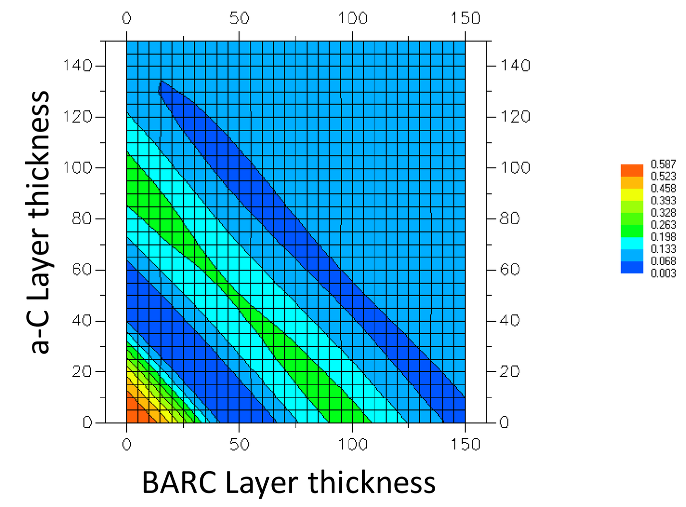
Producing the Film

- Can be created by plasma enhanced chemical vapor deposition (PECVD) using methane.
- Using methane has the benefit of having higher mechanical strength than other potential precursors.
    - Higher hydrogen content
    - Lower deposition rate (more uniformity)

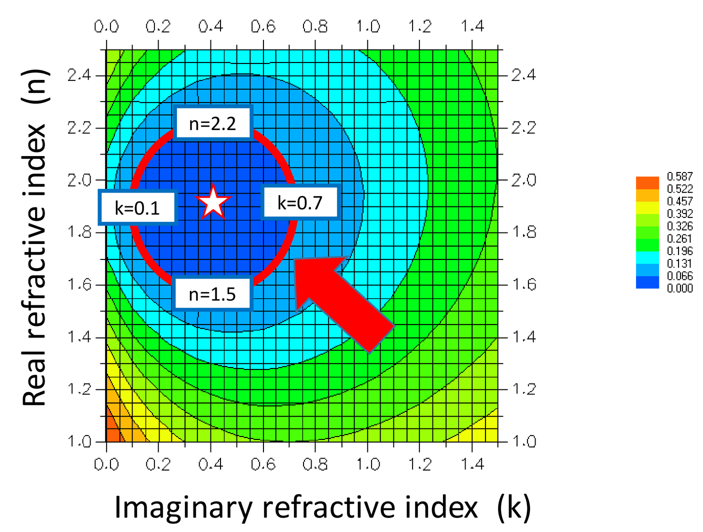
Project Work

Simulations

Simulations were performed in PROLITH to determine stack reflectivity and ideal thicknesses for both films in the film stack.



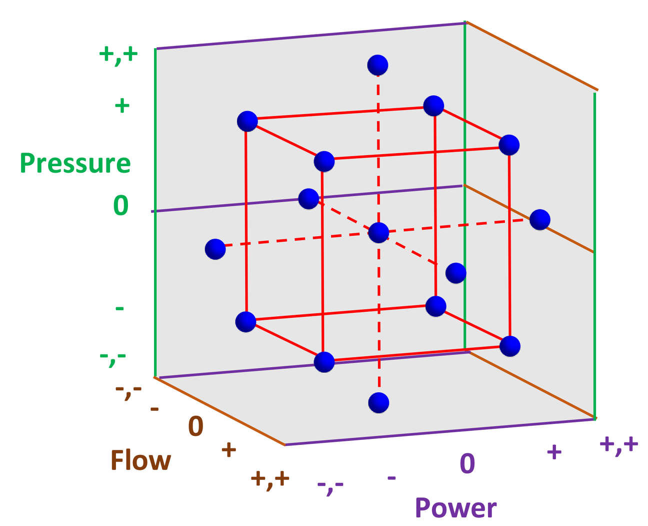
The area of interest is labeled based on the location of the red circle on each plot, where the **dark blue** areas have the **lowest** simulated reflectivity (approximately 0).



Experimental

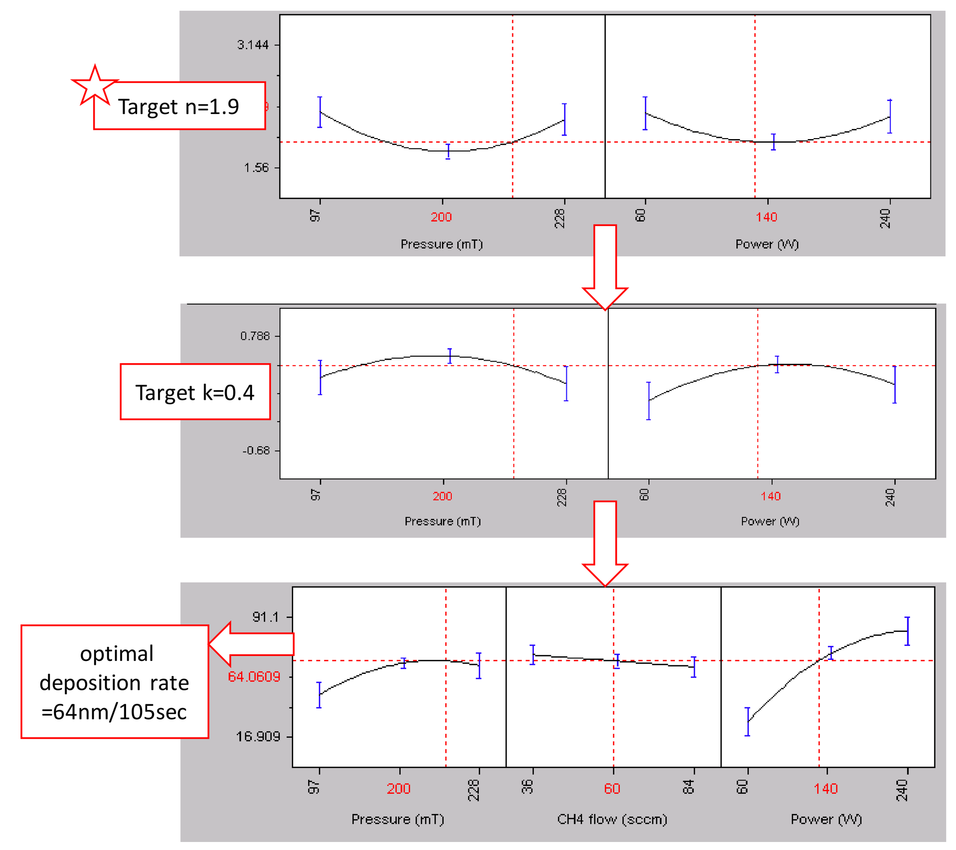
- Central composite design (CCD)
- 3 levels
- 3 measured responses

Run	Block	CH4 flow (sccm)	Pressure (mT)	Power (W)
1	1	45	125	100
2	1	75	200	100
3	1	75	125	200
4	1	45	200	200
5	1	60	162.5	150
6	1	60	162.5	150
7	2	75	125	100
8	2	45	200	100
9	2	45	125	200
10	2	75	200	200
11	2	60	162.5	150
12	2	60	162.5	150
13	3	36	162.5	150
14	3	84	162.5	150
15	3	60	97.3	150
16	3	60	228	150
17	3	60	162.5	60
18	3	60	162.5	240
19	3	60	162.5	150
20	3	60	162.5	150



Results

By modifying chamber pressure, gas flow rates, and power, the refractive index (n, k) for the films can be modified over a large range of values. The 40 nm target thickness can be obtained using the optimized power and pressure in 66 seconds. As seen below, the film has been optimized to target the area of interest determined by the simulations.



For the changing pressure and power, n, k, and thickness are all affected. Based on the constant time used for all the sample runs, thickness is directly related to the deposition rate. By comparing these results to the simulated results, we see that all parameters are in the center of the area of interest, allowing for the most process latitude.

Conclusions

The amorphous carbon film has been optimized to nearly eliminate stack reflectivity in the samples. The results of this work allow for optimization over a large range of desirable refractive index values while still providing information on the deposition rate.

The RIT SMFL is now capable of depositing carbon hard masks which will allow for sub-lithographic patterning techniques like line-width trimming, while enabling reduction in reflectivity and improving existing processes.

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