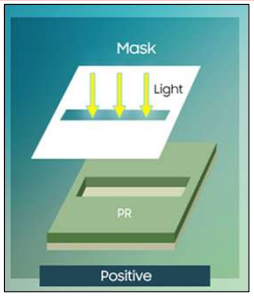
MSE Team 2

Chitosan-Based Photoresist

Huda Kemal, Hannah Kriney, Zachery Meehan, Enoch Oluwaboro, Kim Taylor

Motivation

Photoresists are a key component in processing electronic and optical materials. Typical photoresists utilize toxic chemicals and have a negative impact on the environment, the goal of this project is to characterize a potentially eco-friendly photoresist that does not use toxic chemicals.



Chitosan as a Solution: **Chitosan, a biopolymer from chitin, can serve as a positive photoresist in DUV and electron beam lithography *without requiring harmful chemical modifications.***

What is Chitosan? Chitosan is the second most abundant polymer and primarily sources from seafood waste

Process can *decrease environmental impact and waste, while also lowering disposal costs.*

Design Calculations and Analysis

$$R = R_{max}\frac{(a+1)(1-m)^n}{a+(1-m)^n} + R_{min} \qquad a = \frac{(n+1)}{(n-1)}(1-m_{TH})^n$$

Mack Model

The model determines the change in development rate of the photoresist developer as the maximum development rate available, selectivity of the developer, and threshold PAG concentration fluctuates.

$$h = \left(\frac{3\eta}{\rho\omega^2}\cdot\frac{1}{E}\right)^{\frac{1}{3}}$$

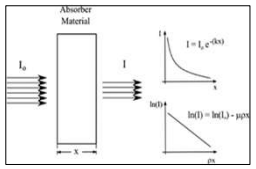
Spin-Coating Thickness Model

The model determines the final film thickness of a photoresist deposited by spin coating.

$$n(\lambda) = A + \frac{B}{\lambda^2} + \frac{C}{\lambda^4} + \cdots$$

Cauchy Model

The model determines the refractive index of transparent materials as a function of wavelength



$$I(x) = I_0 \cdot e^{-\alpha x}$$

Beer-Lambert's Law; Exponential

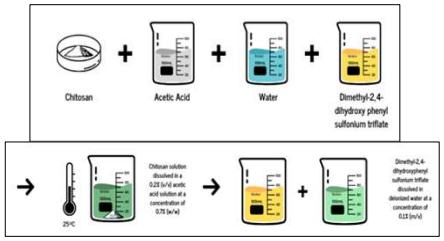
The law determines the transmission of light as a function of photoresist depth.

Methodology and Design

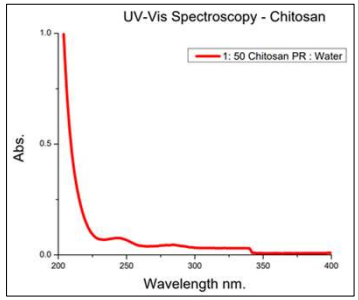
Goal: Characterize an unexplored bio-based Chitosan photoresist through foundational front-end processing experiments, as there is limited literature available on this photoresist:

- Viscosity measurements to model spin-coated film thickness and compare with experimental values
- UV-Vis spectroscopy to identify viable exposure wavelengths
- Model development for Intensity distribution (Intensity vs. Lateral position) and preliminary Mack model fitting

Resist Formulation

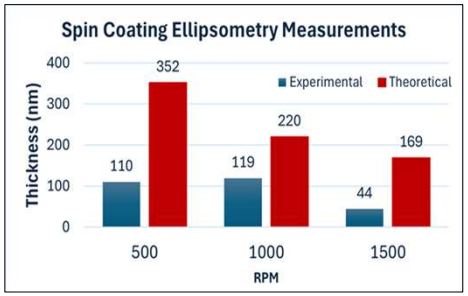


UV-Vis Spectroscopy



	I-line (365)	248nm Resist	200nm Resist
Absorbance	0.007	0.071	1.522

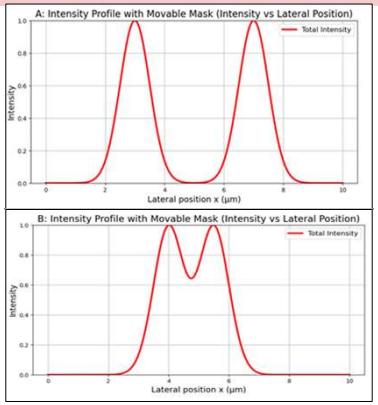
Spin-Coated Samples and Modeled Thicknesses



Conclusions

The absorbance range for this photoresist works best when used in the 200-225 nm range and we do not have access to equipment operating in that range. Our spin-coating model produced thicker results than our measured results, indicating there are other factors that need to be taken into account.

Modeling



The graphs describes the intensity of light through two slits in a photomask as the distance between them shifts laterally.

Future Work

Proposed Experimental Design to Extract Mack Model Parameters

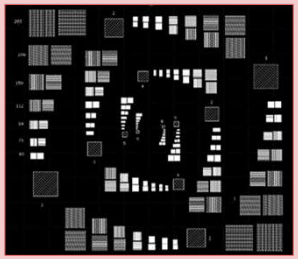
Spin Coat resist on all samples to the same target thickness
Measure all samples using Ellipsometry

→ Expose samples at a range of Exposure Dose Intensities: 1-1000 mJ/cm²

→ Develop samples after exposure
Use 3-5 time intervals (5-15 second increments)
Remove from developer and measure remaining thickness

→ *R = ΔThickness/ΔTime*
Plot R vs. Dose for each Exposure Dose point

→ Use experimental data to estimate two Mack Model values* for predictive dissolution behavior:
*Rmax** = highest measured rate
*mth** = Dose where resist just begins to develop / Rmax
m = within the range 0-1
n = will need to fit



Resolution Test Mask

This resolution test mask features line-space patterns ranging from 6 µm to 265 µm, where line width equals spacing. The layout is arranged radially to test resolution across the wafer.

Possible applications:

- *Minimum feature size determination*
- *Development rate and profile uniformity*
- *Exposure dose calibration*
- *Edge roughness analysis*