

Anti-Reflection Coatings

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CHE 384T Lithography
10/26/2017

The University of Texas-Austin

Chemical Engineering

Outline

- Motivation
- Physics
- Modern Approaches



Prize for the Ugliest SEM goes to:

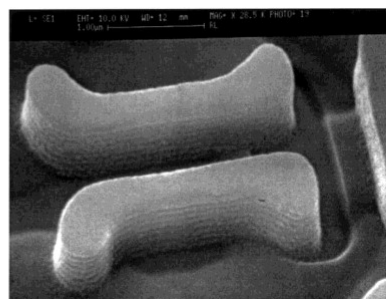
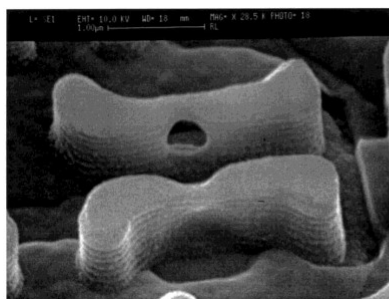


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Runner up?

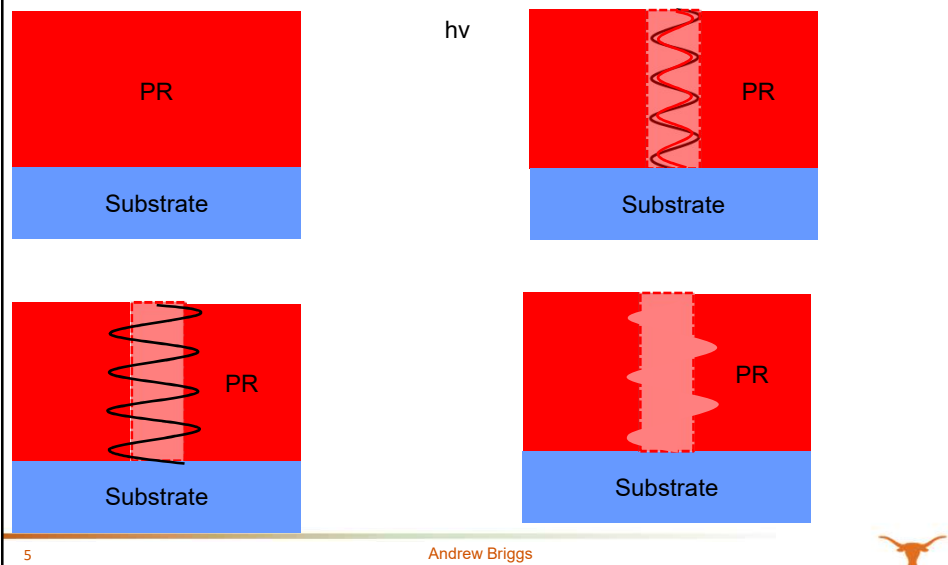


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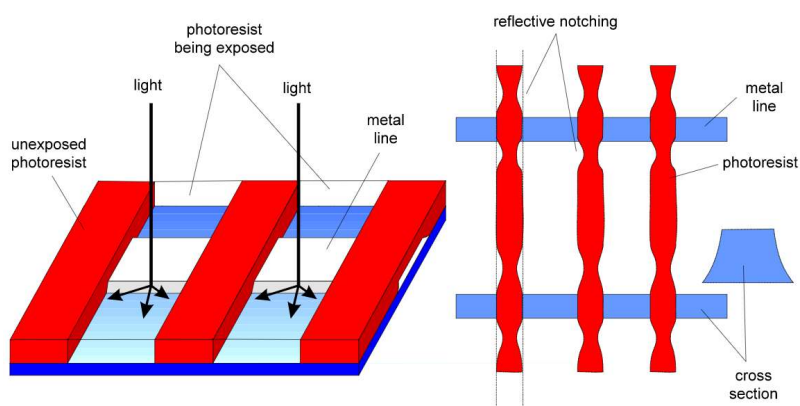
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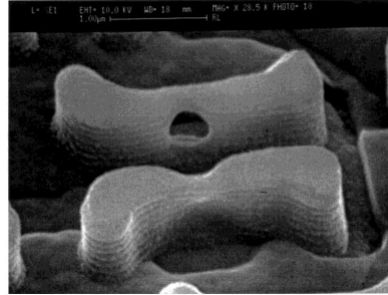
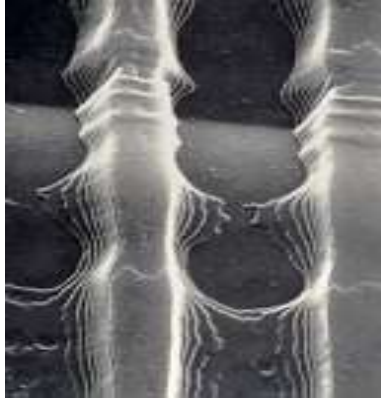
Standing waves and reflective notches are being generated from surface reflections



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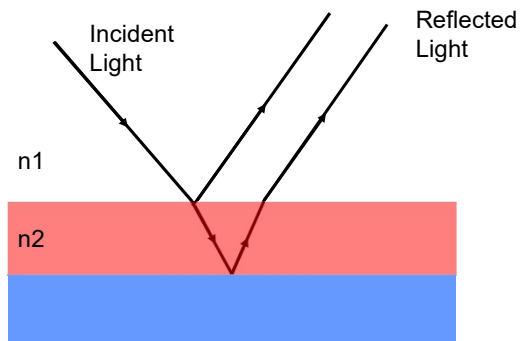


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Its easiest to approach AR coating by explaining thin film interference

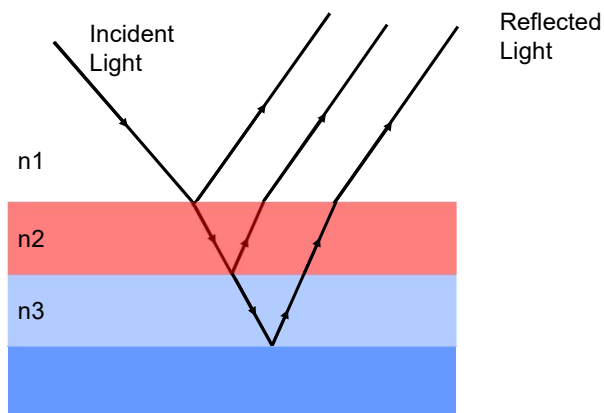


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Adding an extra dielectric layer allows us to control the formation of the standing wave



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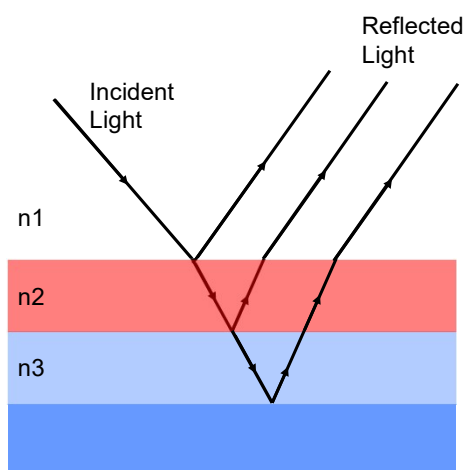
Phase is the most important aspect of a wave for AR

Simple explanation:
 $n \sim 1/v$

Further explanation:

$$E(r, t) = E_0 e^{i(k \cdot r - \omega t)}$$

Where: $k = \frac{2\pi n}{\lambda_0}$

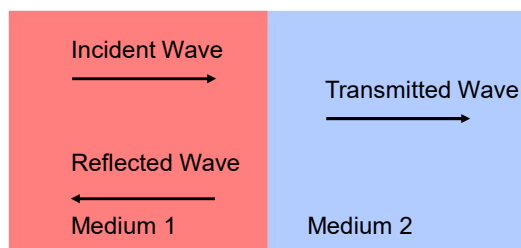


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Reflection at a dielectric boundary: Fresnel's Equations



$$E_r = \left(\frac{n_1 - n_2}{n_1 + n_2} \right) E_i$$

$$E_t = \left(\frac{2n_1}{n_1 + n_2} \right) E_i$$

$$R = \left(\frac{n_1 - n_2}{n_1 + n_2} \right)^2$$

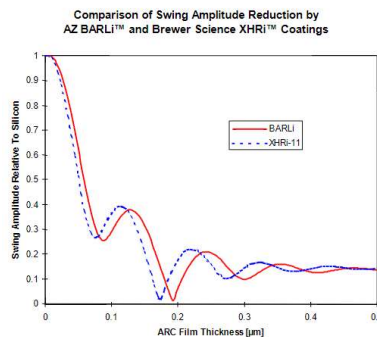
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Swing curves are a fast way to compare AR coatings

$$S = 4\sqrt{R_t R_b} e^{-\alpha_r d}$$

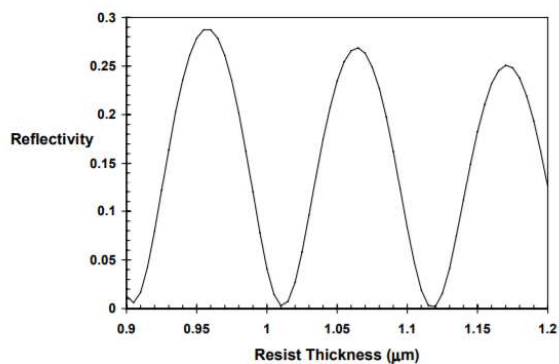


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Helpful example of swing curve



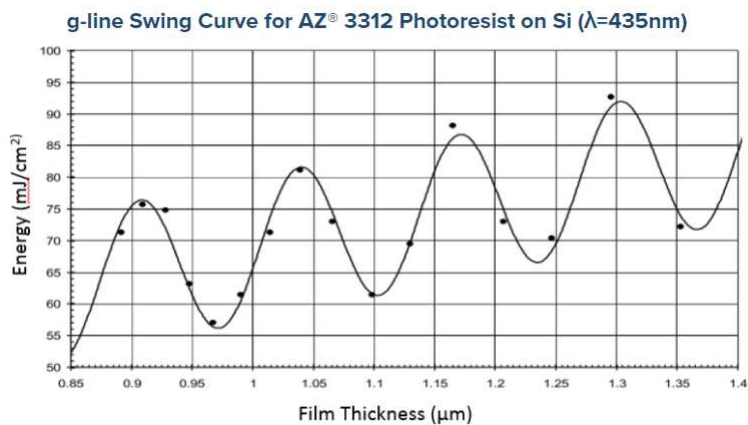
Reflectivity swing curve showing a sinusoidal variation with resist thickness

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The required dose to expose photoresist does not go linearly with film thickness!



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Top and bottom anti reflection coatings can be designed in the same way:

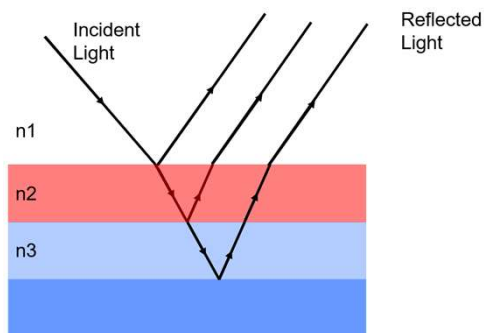
Light reflected off of material 3 must be **equal in intensity** but **opposite in phase** with the light from material 2

Requires index:

$$n_{topcoat} = (n_{bottomcoat})^{1/2}$$

Required thickness:

$$t = \lambda/4n_{ARcoat}$$



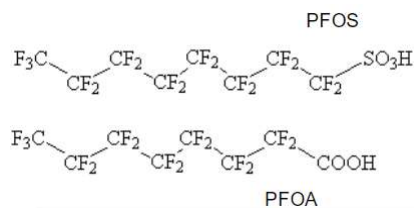
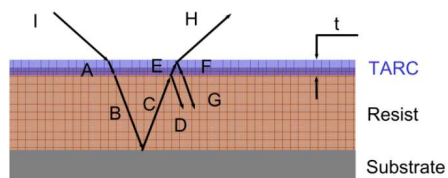
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Top AR Coating

- I = incident exposure energy
- C = primary reflection from substrate
- D = back reflection from resist/TARC interface
- G = back reflection from TARC/air interface
- t = TARC thickness

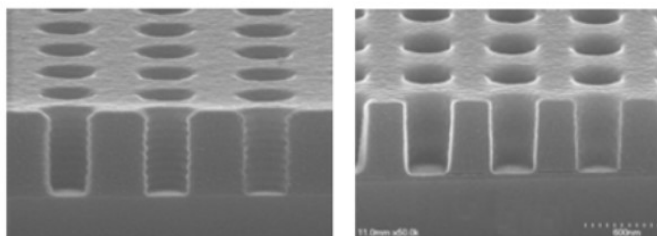


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Top AR coating SEM example



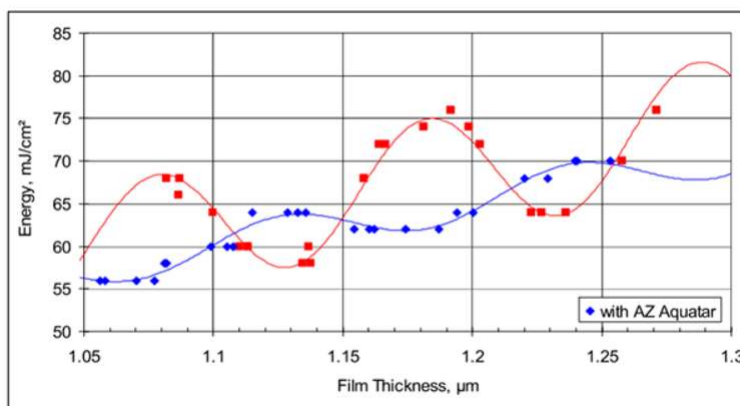
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The top AR coating swing curve is suppressed

Swing Ratio Suppression by AZ Aquatar Coating in AZ 3312 Photoresist

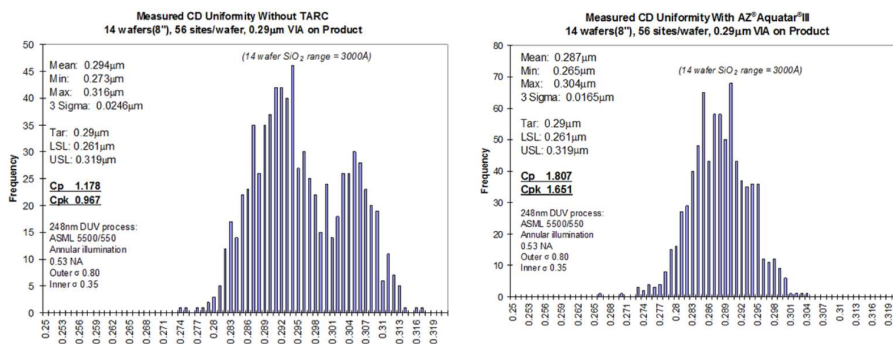


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Uniformity confirms what we found from the swing curve

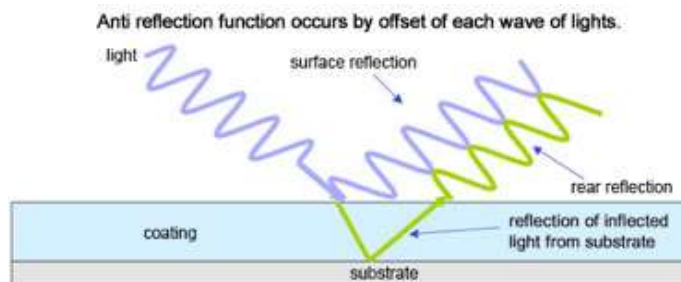


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Bottom AR Coating

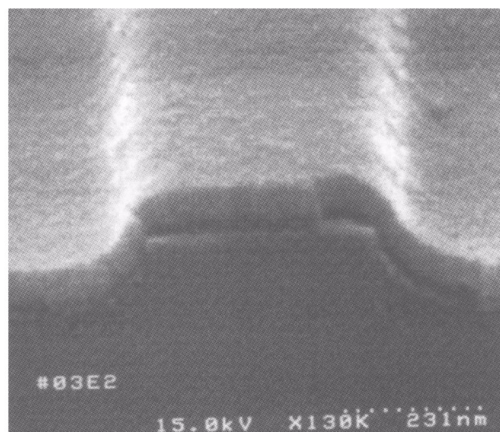


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Photoresists that are conformal lead to differing doses and reflections in each layer

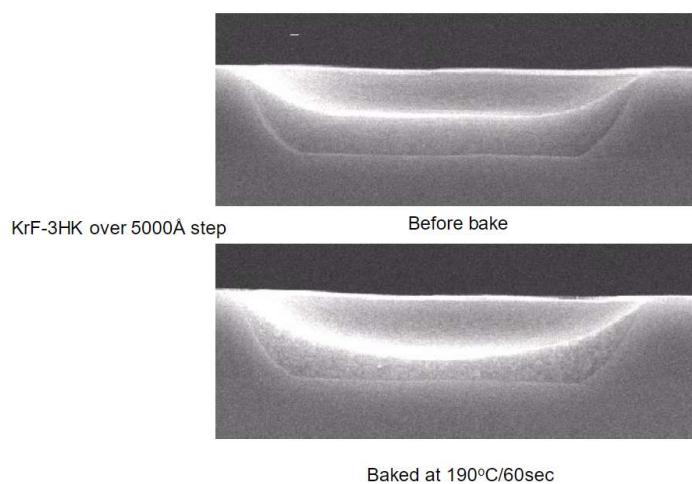


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Bottom anti-reflection coatings can be used to planarize a wafer

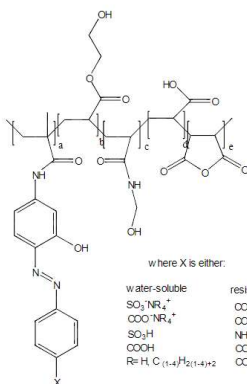
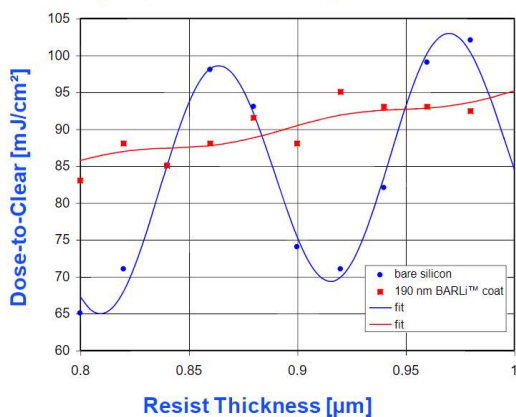


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The bottom AR coating significantly suppressed the swing curve



AZ® 7908 on
AZ® BARLi®

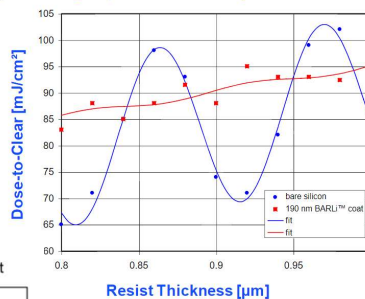
AZ® 7908 on
Aquabar™

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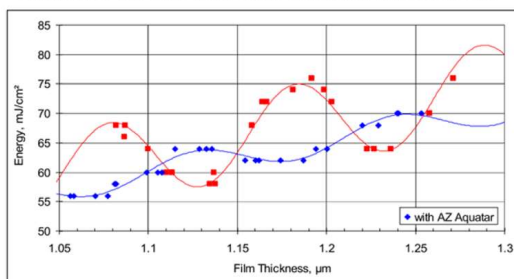
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From the swing curves you can see bottom AR coatings are superior



Swing Ratio Suppression by AZ Aquatar Coating in AZ 3312 Photoresist



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