# EUV RLS Performance Tradeoffs for a Polymer Bound PAG Resist Process

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## Introduction

**Challenge:** No resist process meets resolution, LWR and sensitivity requirements for EUVL

**Goal:** Quantify RLS performance tradeoffs for a polymer bound PAG resist

**Approach:** Create "physical" resist models for a single resist across multiple exposure wavelengths (248 nm, 193 nm, EUV)

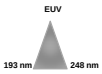
## Background

**Resist models are generated with 248 nm, 193 nm and EUV exposures**
- acid generation
- polymer kinetics
- dissolution contrast
- acid diffusion

**1)Sensitivity:** Is EUV latent acid "blur" generated by secondary electrons captured using traditional resist model methods?

**2)LWR:** Does EUV effect LWR in a unique way?

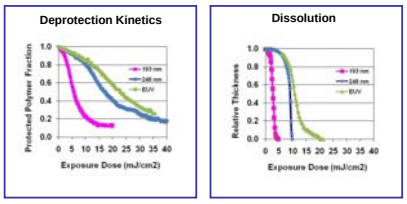
**3)Resolution:** Does exposure wavelength affect acid diffusion?

| Resist Material Challenges | EUV RLS Simulations | LWR Fundamentals |
|---|---|---|
| |  | |
| Polymer Bound PAG Resist | Single Resist Evaluation | EUV Impact |
| Increase Sensitivity<br>Minimize PAG segregation<br>Minimize Acid diffusion | Use resist models to compare material properties at multiple wavelengths | Link to 2D acid concentration<br>Substrate Effects |

**Our goal is to create "physical" resist models that are calibrated to kinetic, dissolution and CD data (Not OPC)**

## Experimental Data

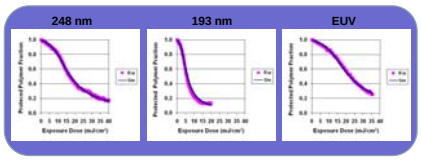
**Resist models are calibrated from experimental kinetic and dissolution contrast data**




**Resist sensitivity is higher for 193 nm and 248 nm exposure wavelengths compared to EUV**

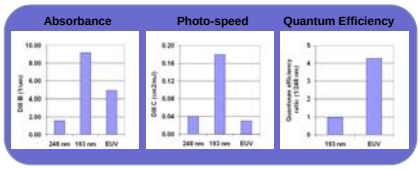
## Resist Model Calibration

### Deprotection Kinetics



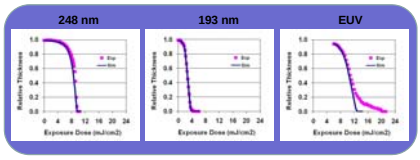

**A single kinetic model is capable of fitting experimental data across each wavelength**
- **Deprotection and quencher reaction rates are equal**
- **Only acid generation rate (Dill C) is different**
- **Multi-wavelength fit validates methodology**

### Sensitivity




**EUV sensitivity is lower, but quantum efficiency is higher than other wavelengths**
- **248 and 193 nm photo-speed correlates to absorbance**
- **EUV photo-speed correlates to quantum efficiency ratio**

### Dissolution Contrast

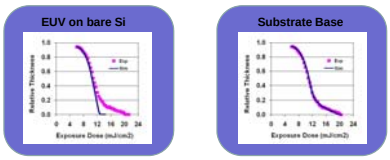



**A single dissolution model fits the 248 nm and 193 nm data, but it only fits the top 75% of the EUV dissolution data**

**Why does the dissolution rate slow down in the bottom 15 nm (25%) of the film at EUV?**

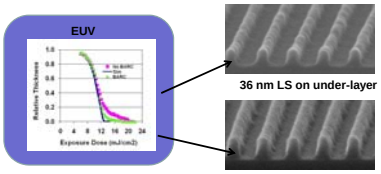
## EUV Substrate Impact

### EUV Dissolution Contrast




**EUV dissolution data was collected on Si (no BARC)**
- **PAG segregates away from interface (polymer bound PAG) X**
- **Secondary electron blur is reduced at Si interface (~5-7 nm) X**
- **Base/ contamination accumulates at substrate interface ?**

### EUV Dissolution Contrast with BARC

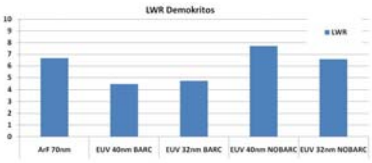



36 nm LS on under-layer

36 nm LS on bare Si

**Hypothesis: A depletion of acid in the bottom 15 nm of the resist (foot) is increasing LWR (quencher/ base impact)**
**Is there a way to minimize the effect?**

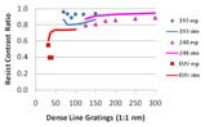
### LWR (EUV resist on Si vs BARC)




**Experimental measurements confirm that LWR is lower for the EUV resist exposed on a BARC compared to bare silicon**

## Resolution and Sensitivity

### Resist Contrast Ratio

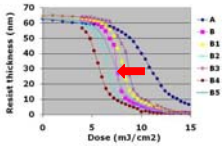


$$Contrast = \frac{EL}{10 * NILS}$$

**The acid diffusion length was found to be low for the polymer bound PAG resist**
**Even with a low acid diffusion level, the EUV contrast ratio falls to 0.6 at a feature size of 32 nm**

### Future Work

| | PAG | Quencher | Sensitizer |
|---|---|---|---|
| B | 1x | 1x | 1x |
| B1 | 1x | 1x | 0.5x |
| B2 | 1x | 1x | 1.5x |
| B3 | 0.5x | 1x | 1x |
| B4 | 1.5x | 1x | 1x |
| B5 | 1.5x | 1.5x | 1x |




**Our future plan is to create resist models for resist derivates with a higher sensitivity. What are the RLS tradeoffs?**

## Conclusions

**A single resist model is capable of describing the experimental behavior of a polymer bound PAG resist across 248 nm, 193 nm and EUV exposure wavelengths**
Validates optical properties, kinetics, dissolution and acid diffusion
Quantum efficiency ratio provides unique way to assess EUV resists

**EUV LWR is impacted by substrate effects (quencher/ base)**
LWR is lower on an under-layer compared to bare Si (acid depletion)

**This polymer bound PAG system has low acid diffusion, but the resist contrast ratio still falls at 32 nm (0.6)**
Simulation can be used to determine the "optimal" resist process that is required to boost contrast and extend resolution below 32 nm

## Acknowledgements

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