

New Photopatterning Materials for Advanced Lithography

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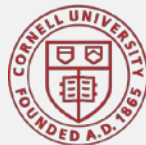
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Mentors: Kazunori Sakai, Seok-Heon Jung, Chris Alpha

Cornell NanoScale Science & Technology Facility,

Cornell University



Cornell
University



Next-Gen Lithography

- **Moving to shorter wavelengths**
 - 193 nm (ArF DUV) to 13.5 nm (EUV)
- **Industry is moving away from CARs, towards nanoparticle resists**
 - Bleeding effects at feature boundaries for CARs undesirable
 - Nanoparticle resists must be well-understood before they move to commercial production
- **Will require lithographic materials development**
 - Resists optimized for high-volume manufacturing, small feature patterning



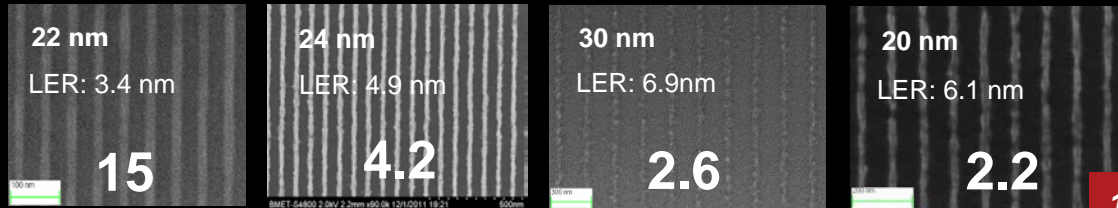
Resist Performance

Resist Design

Sensitivity

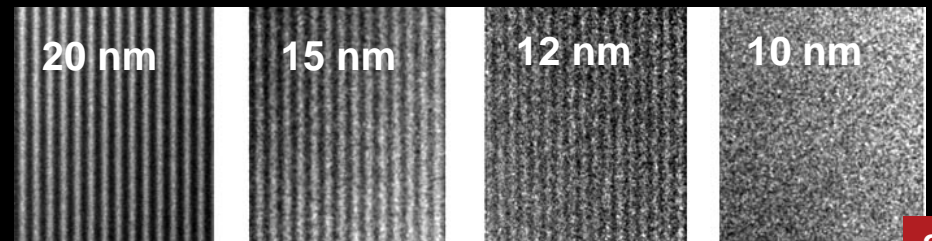
Resolution

Roughness

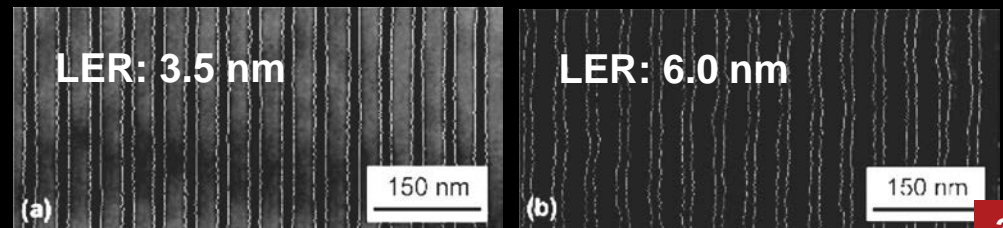


exposure dose (mJ/cm²)

sensitivity



feature size

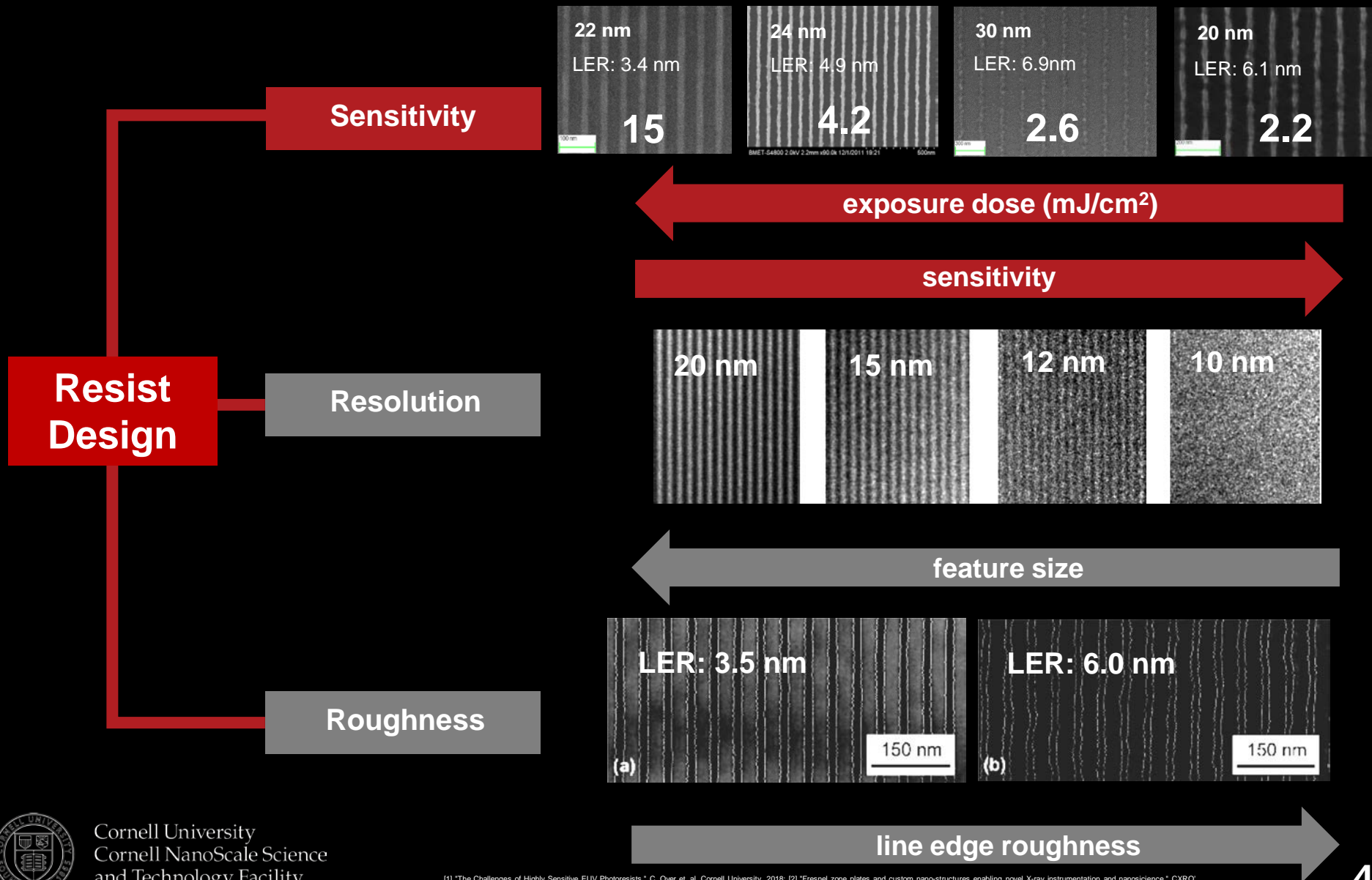


line edge roughness

[1] "The Challenges of Highly Sensitive EUV Photoresists," C. Over et. al, Cornell University, 2018; [2] "Fresnel zone plates and custom nano-structures enabling novel X-ray instrumentation and nanoscience," CXRO
[3] "Line Edge Roughness of Directed Self Assembly PS-PMMA Block Copolymers," C. Wang et. al, NIST

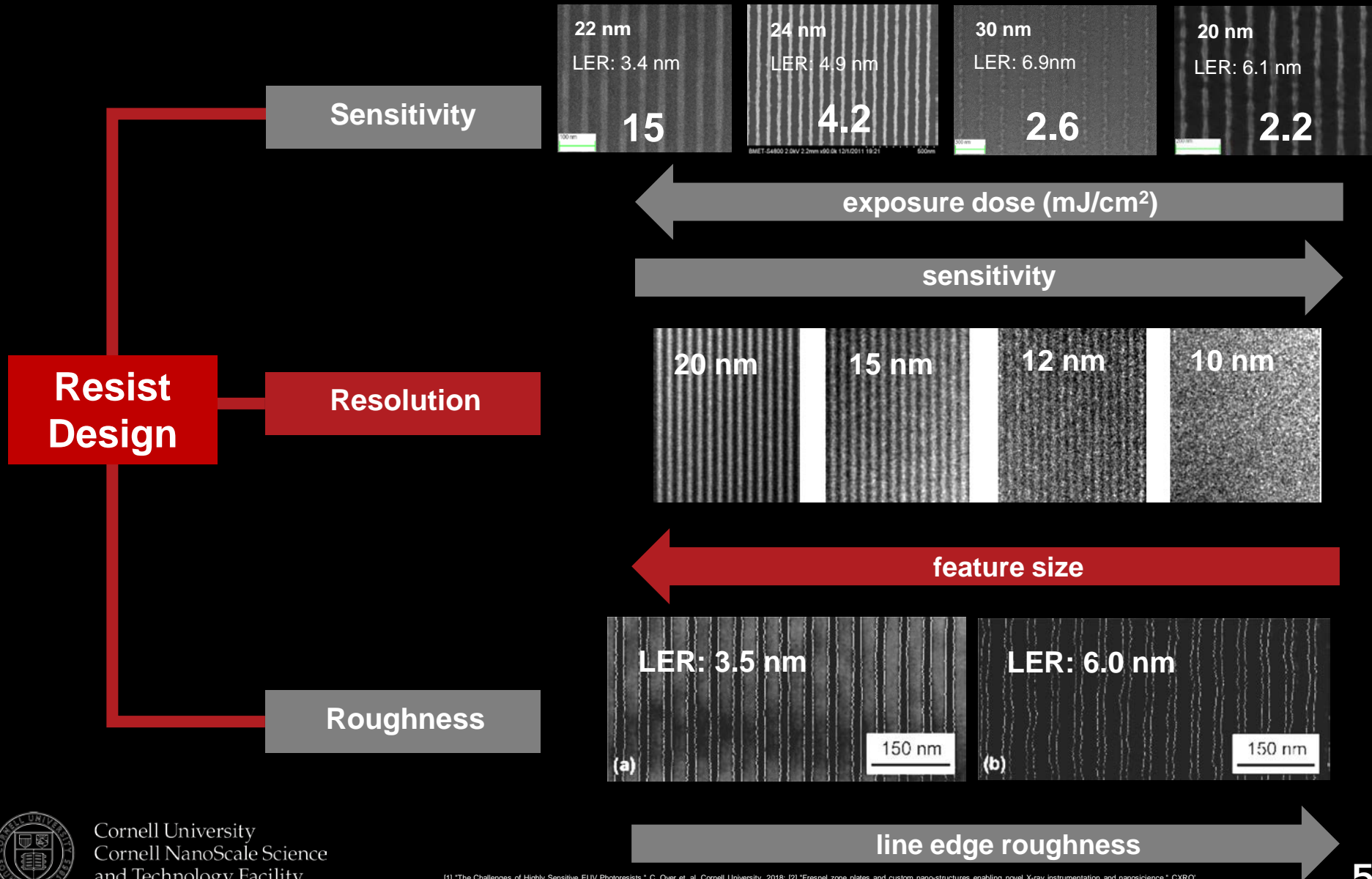


Resist Performance



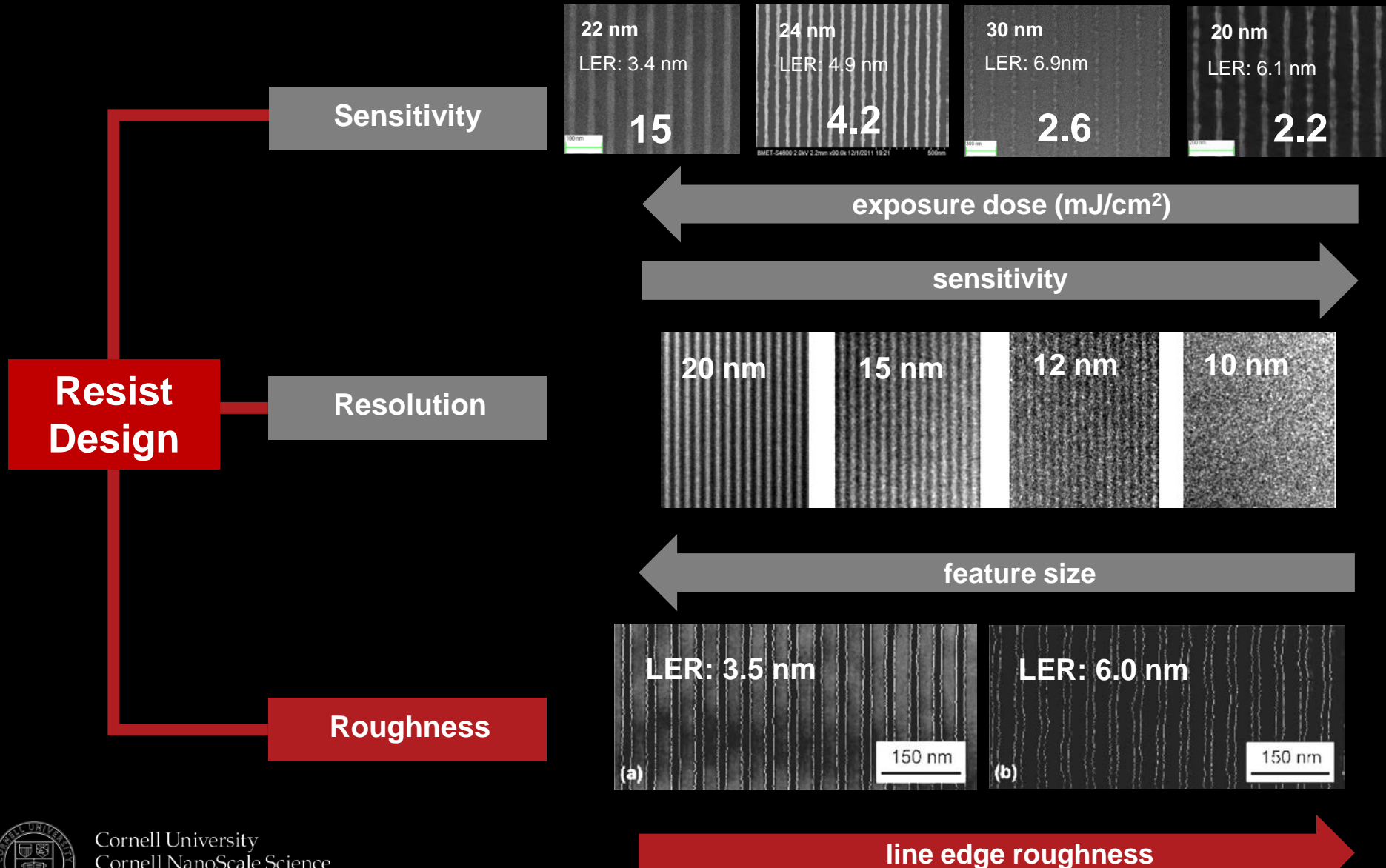
[1] "The Challenges of Highly Sensitive EUV Photoresists," C. Over et. al, Cornell University, 2018; [2] "Fresnel zone plates and custom nano-structures enabling novel X-ray instrumentation and nanoscience," CXRO
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Resist Performance



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Resist Performance



The Project

- **Challenge: optimizing next-generation lithographic resists**
- **Photoresists development**
 - **EUV Metal oxide nanoparticle (MO-NP) resists**
 - **Chemically amplified resists (CARs)**



The Project

- Challenge: optimizing next-generation lithographic resists
- Photoresists development
 - EUV Metal oxide nanoparticle (MO-NP) resists
 - Chemically amplified resists (CARs)



MO-NP Resists

Ingredients

- **Photoactive Compound**
 - i.e. photoacid generator
- **Metal oxide nanoparticles**
 - Zn-NC and Zr-MAA
- **Solvent**
 - i.e. PGMEA



MO-NP Resists

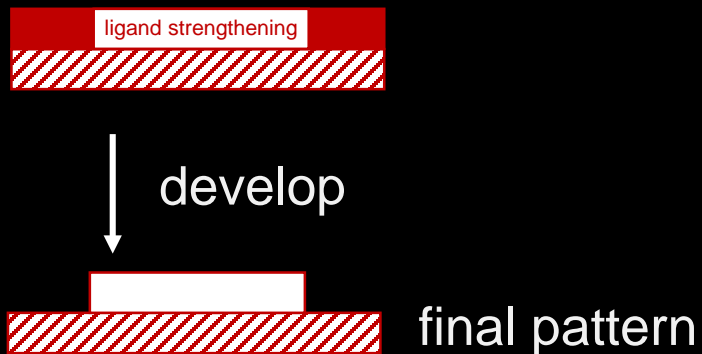
1. Apply Resist



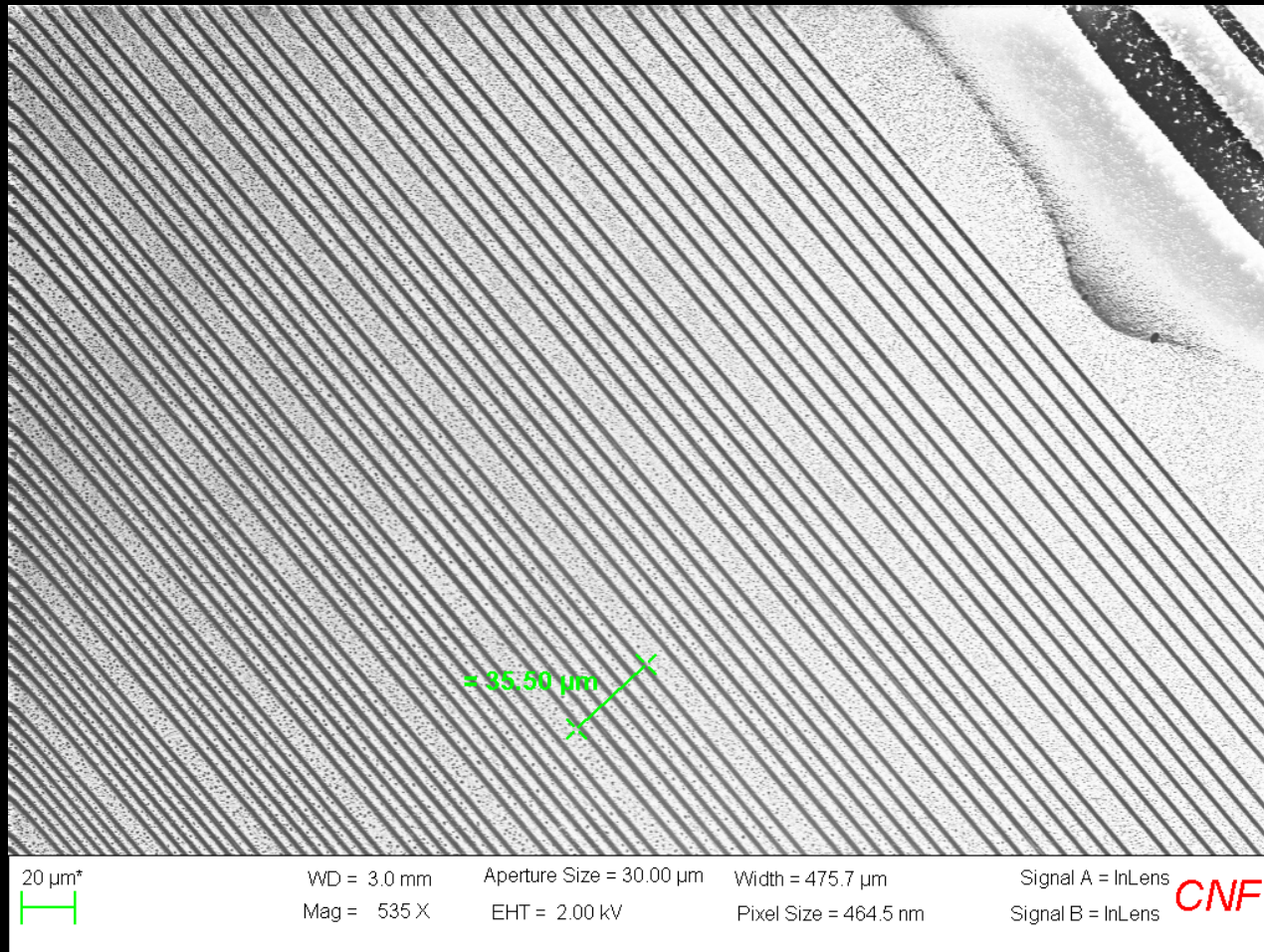
2. Ligand Chemistry



3. Develop



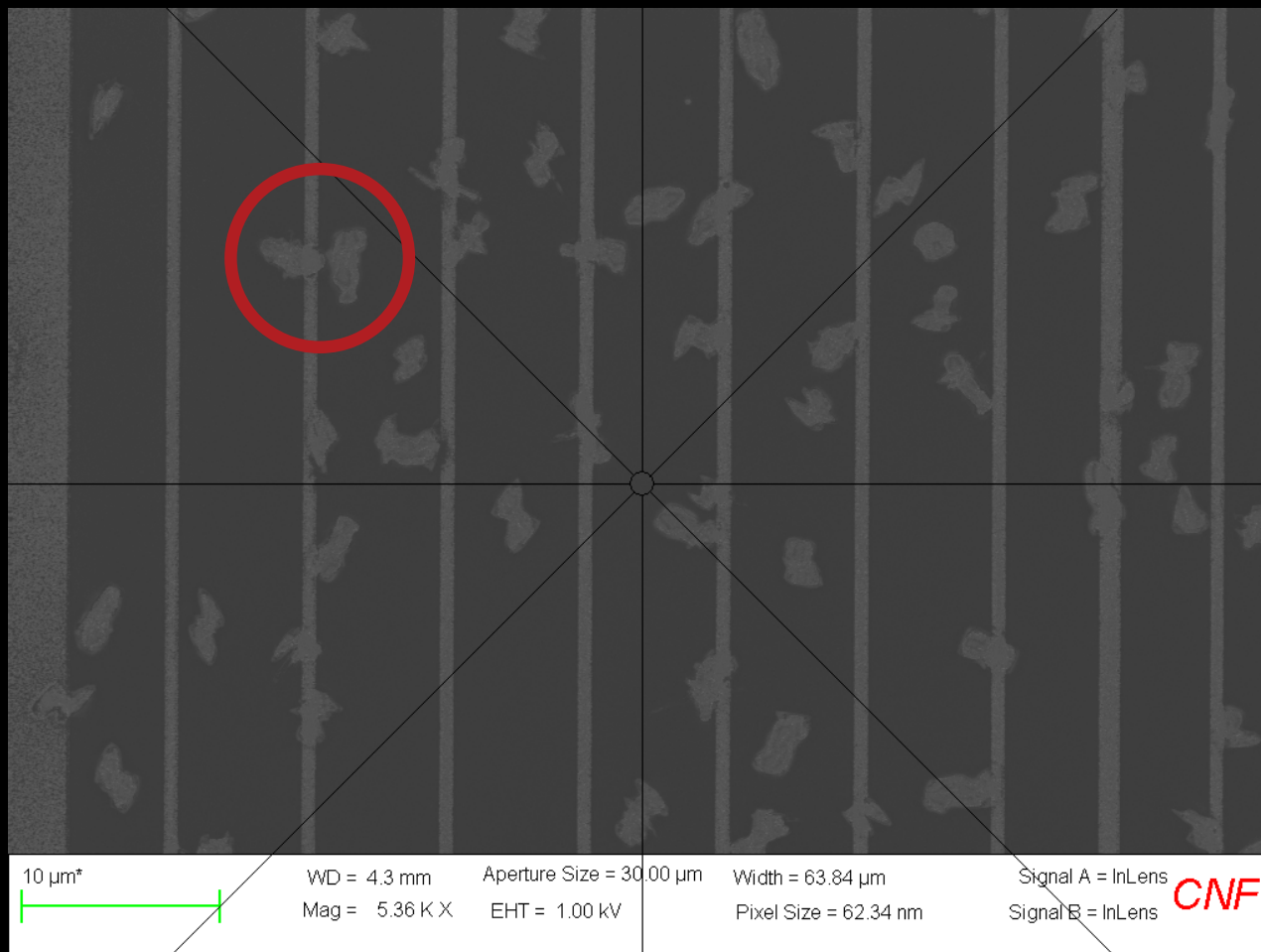
Results



Zn Metal Oxide NP



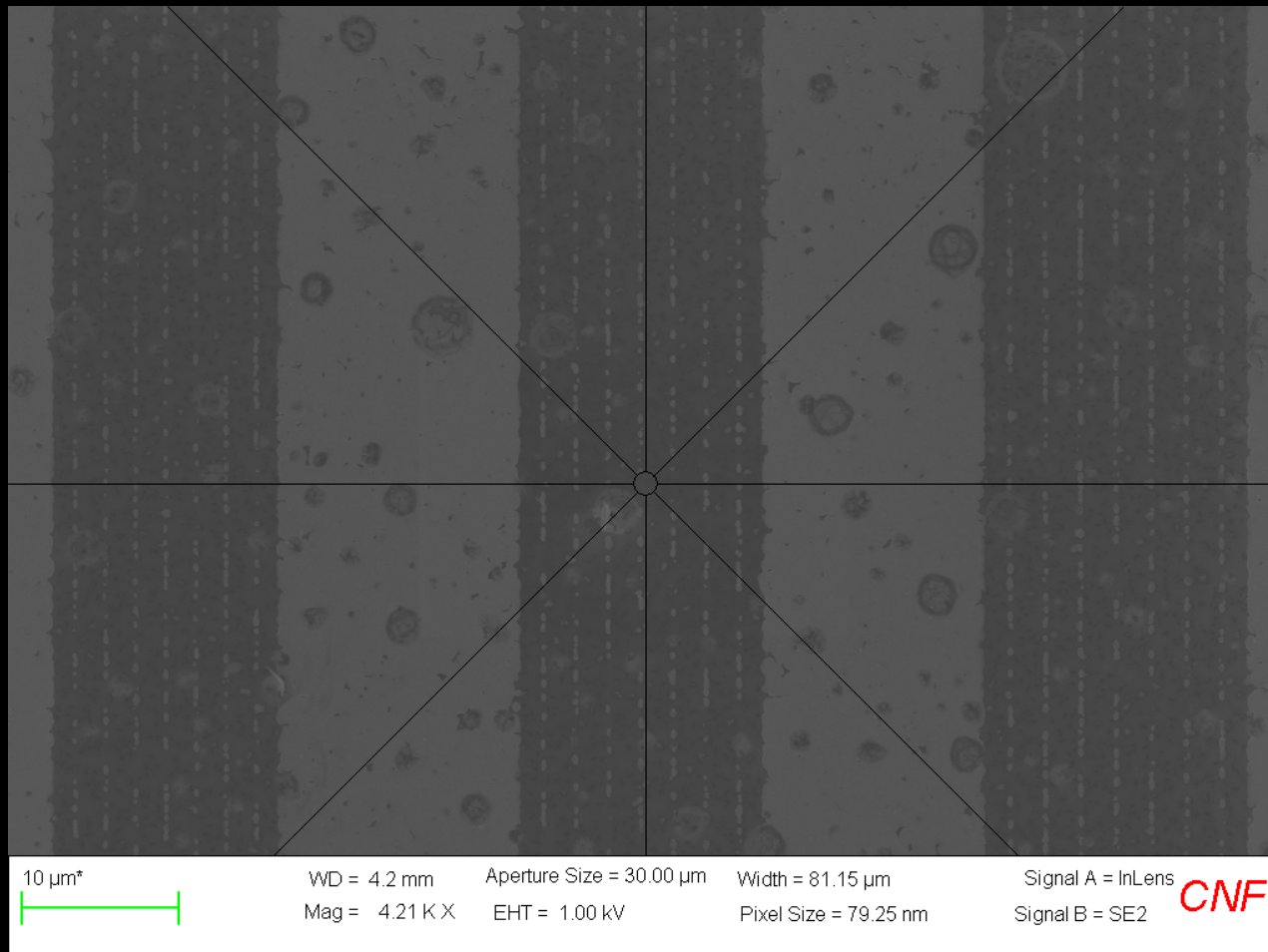
Results



Zn Metal Oxide NP



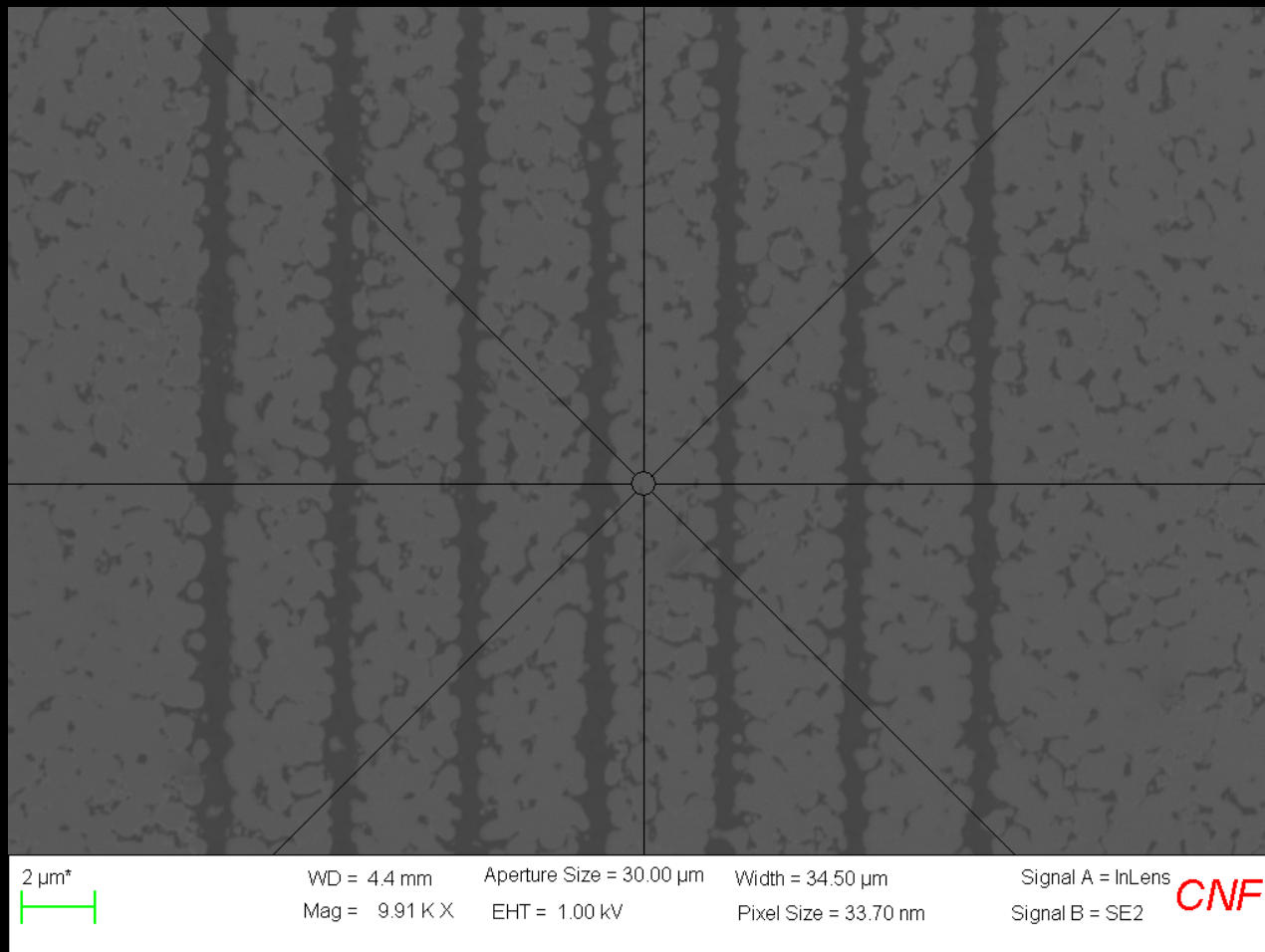
Results



Zr Metal Oxide NP



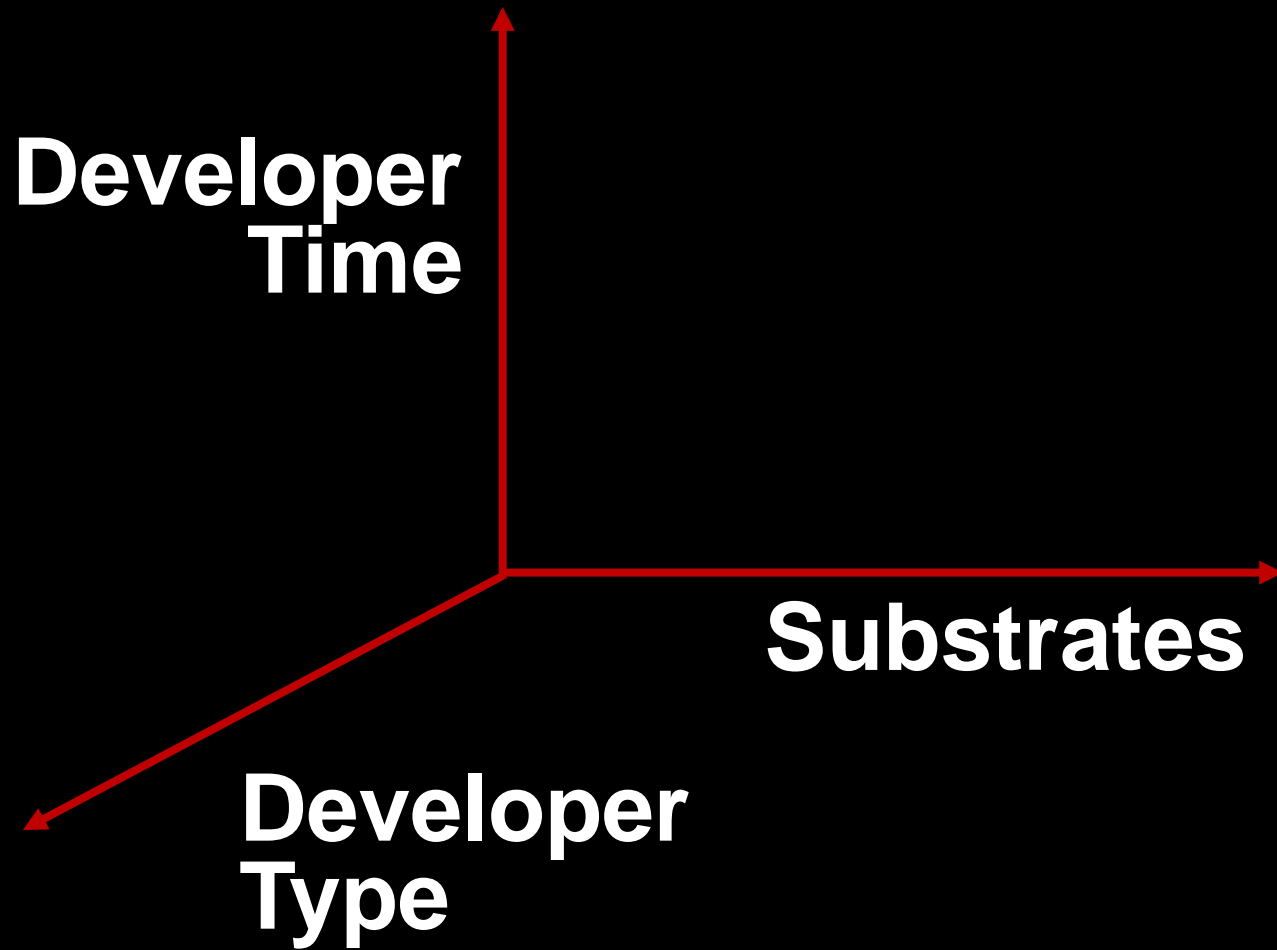
Results



Zr Metal Oxide NP



Future Work



The Project

- Challenge: optimizing next-generation lithographic resists
- Photoresists development
 - EUV Metal oxide nanoparticle (MO-NP) resists
 - Chemically amplified resists (CARs)



The Project

- **Challenge: optimizing next-generation lithographic resists**
- **Photoresists development**
 - EUV Metal oxide nanoparticle (MO-NP) resists
 - **Chemically amplified resists (CARs)**



Chemically Amplified Resists

Ingredients

- **Photoactive Compound**
 - i.e. photoacid generator
- **Polymer resin**
 - tert-Butyl methacrylate, isobornyl methacrylate, methacrylic acid
- **Dissolution Inhibitor**
- **Solvent**
 - i.e. PGMEA

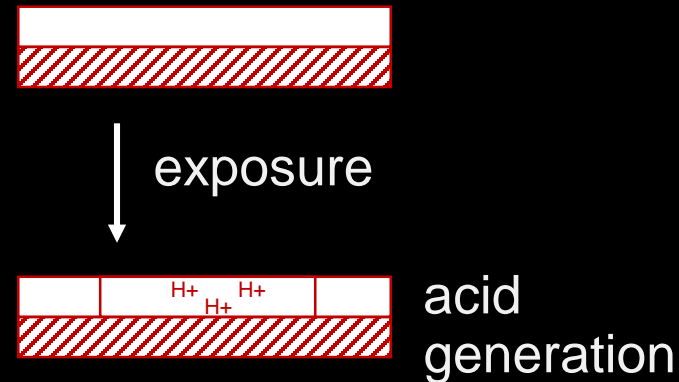


Chemically Amplified Resists

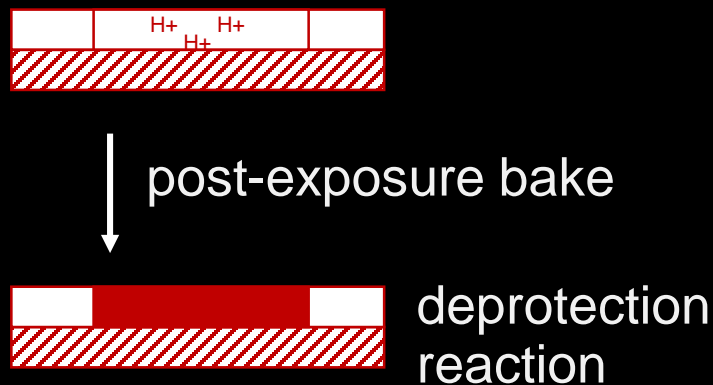
1. Apply Resist



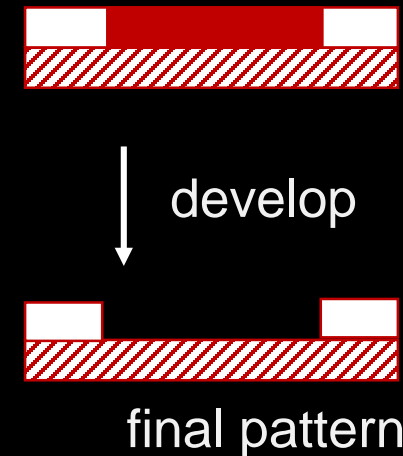
2. Acid Generation



3. Deprotection Reaction

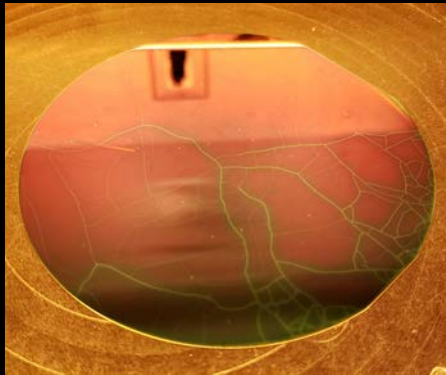


4. Develop



Results

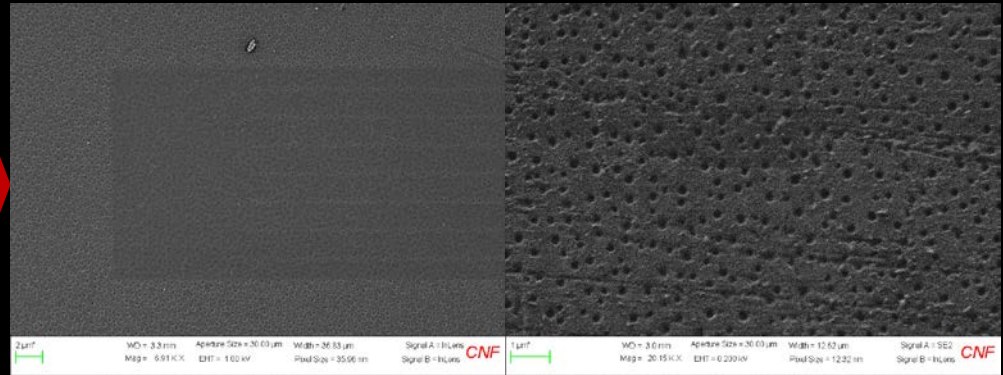
Late June



Resist "Fractures"

*BARC
coating*

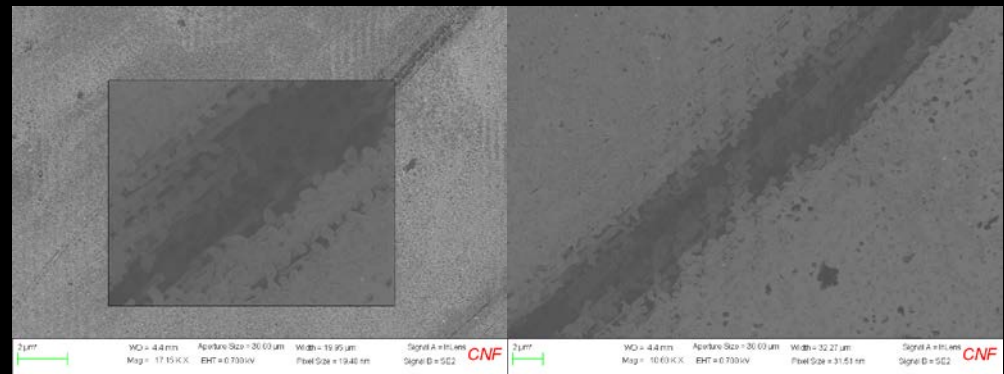
Early July



Porous defects, bad contrast

*Modify
Solvent*

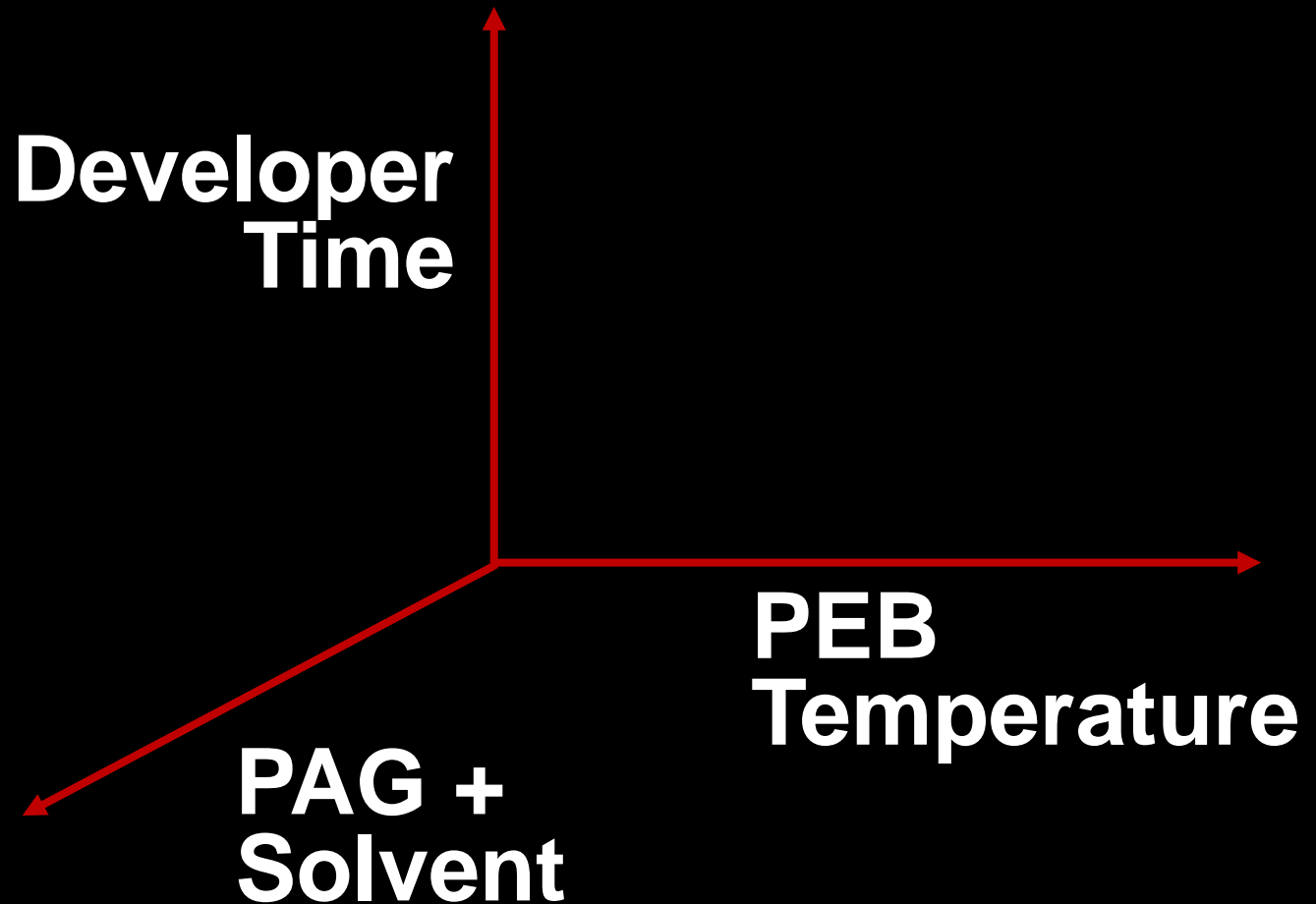
Mid-July



Still porous defects, bad contrast



Future Work



Conclusions

- **Zn and Zr MO-NPs can be used as photoresists**
 - More testing needed to address defects
- **Understanding PAG performance is difficult**
 - Future work needed to optimize process conditions and materials for best resist performance

Acknowledgements

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- **Cornell NanoScale Science & Technology Facility**
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- **Kazunori Sakai, Seok Heon Jung, Chris Alpha (Mentors)**
- **Melanie-Claire Mallison (CNF REU Program Coordinator)**
- **CNF Staff**



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