Georgia Tech Institute for Electronics and Nanotechnology

SENIC Southeastern Nanotechnology Infrastructure Corridor

Characterizing the Performance of Rapidly Degradable Polyaldehydes as Dry-Developing Photoresists

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SENIC REU Presentation

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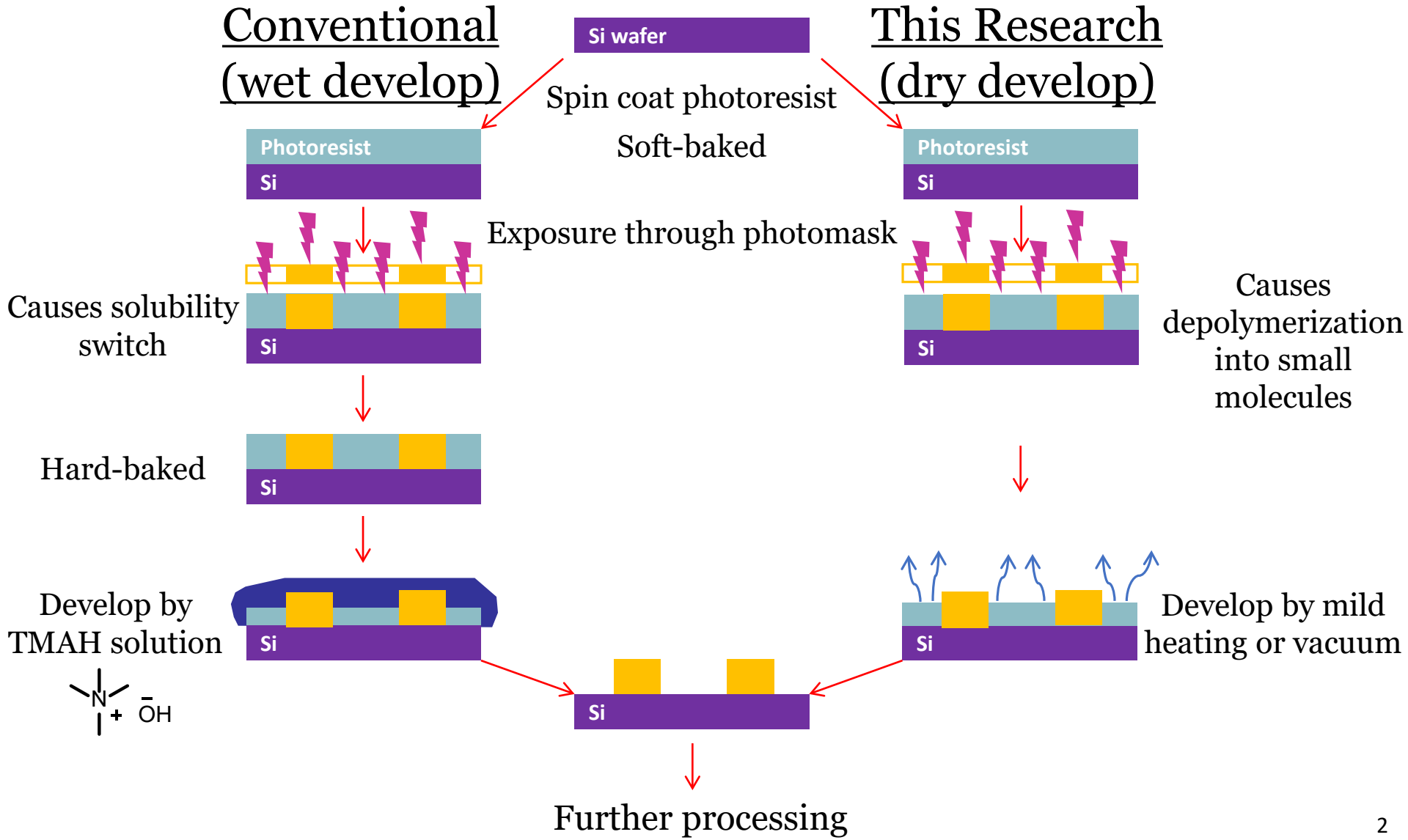
National Nanotechnology Coordinated Infrastructure

NSF

Photolithography Process

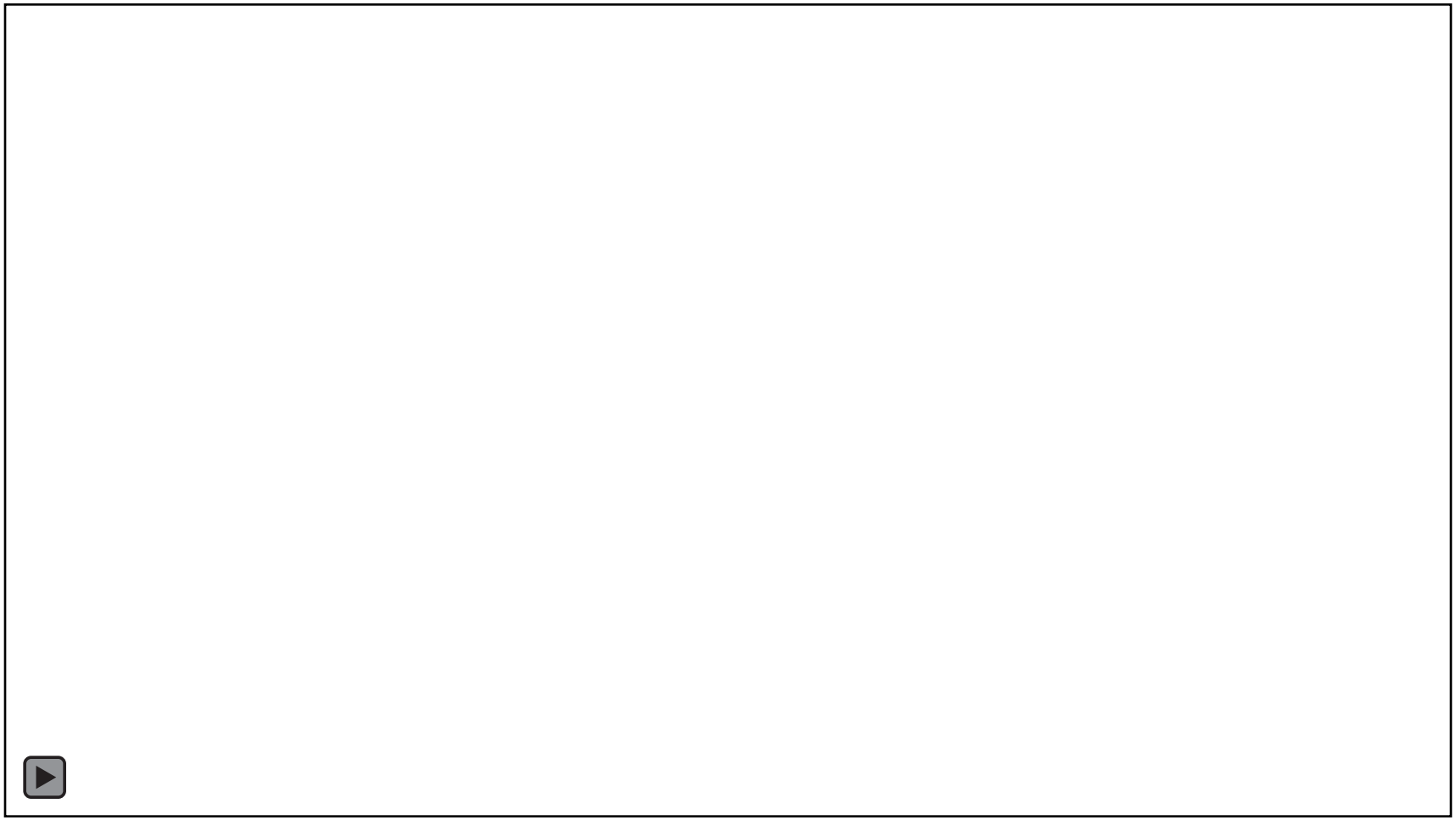


Photolithography Process

Project Goal

Characterize the performance of dry-developing photoresist materials

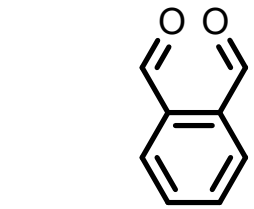
Real-Time Dry Develop Photoresist



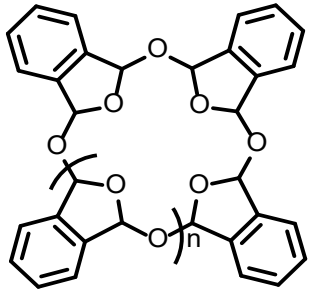
Polymer Degradation Enabled by Low Ceiling Temperature (T_C) Polymers

T_C defines the equilibrium temperature between monomer and polymer

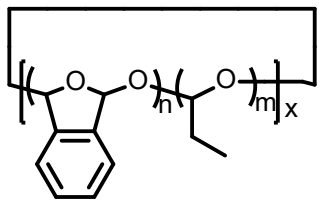
$$M_n + M \underset{T > T_C}{\overset{T < T_C}{\rightleftharpoons}} M_{n+1}$$



o-Phthalaldehyde
T_C = -40°C

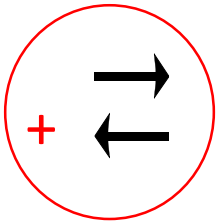


Homopolymer
p(PHA)

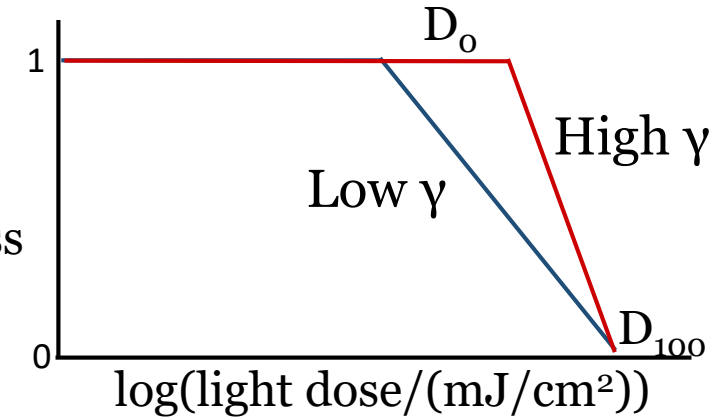


Copolymer
p(PHA-PA)

Exposure to
Photoacid
Generator (PAG)



Photoresist Performance Characteristics

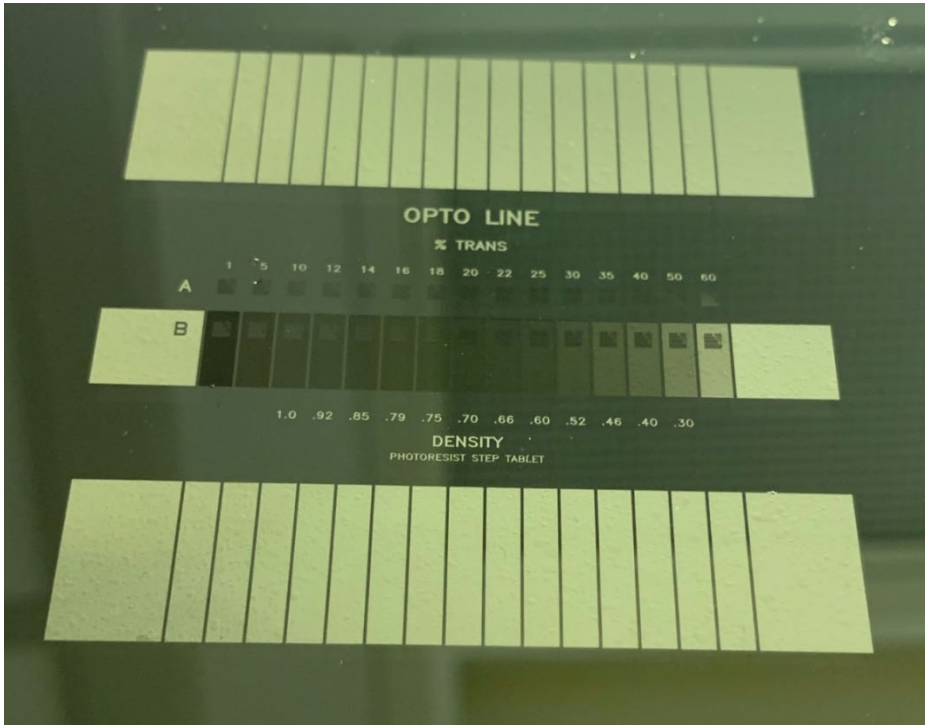


Normalized Film Thickness

Sensitivity, D_{100}

Contrast, $\gamma = \frac{1}{\log_{10}\frac{D_{100}}{D_0}}$

Commercial resists, γ ~ 2 - 5



Contrast Mask

- Full contrast curve with a single exposure
- After development, measure different film thicknesses via profilometry

Testing Parameters

Georgia Tech
CREATING THE NEXT

Polymers
- Homopolymer – p(PHA)
- Copolymer – p(PHA-PA)

Weight Percent PAG
- 1 and 5 percent

Exposure Dose (mJ/cm²)
- 0.1 – 100

Film thickness = 280 nm
Soft bake for 3 min @ 115°C

Thermal Development

Temperature
- 40 – 60°C

Time
- 0.5 – 5 min

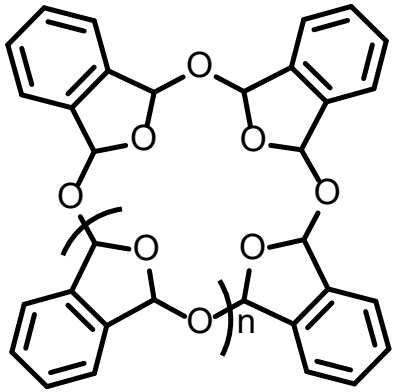
Vacuum Development

Total Pressure (torr)
- 254, 508, 750

Time
- 5 – 15 min

p(PHA) Development Results

	Vacuum	Thermal
5% PAG	High Pressure is better	Too Much Acid Diffusion
1% PAG	Does not fully develop	Lower temperature is better



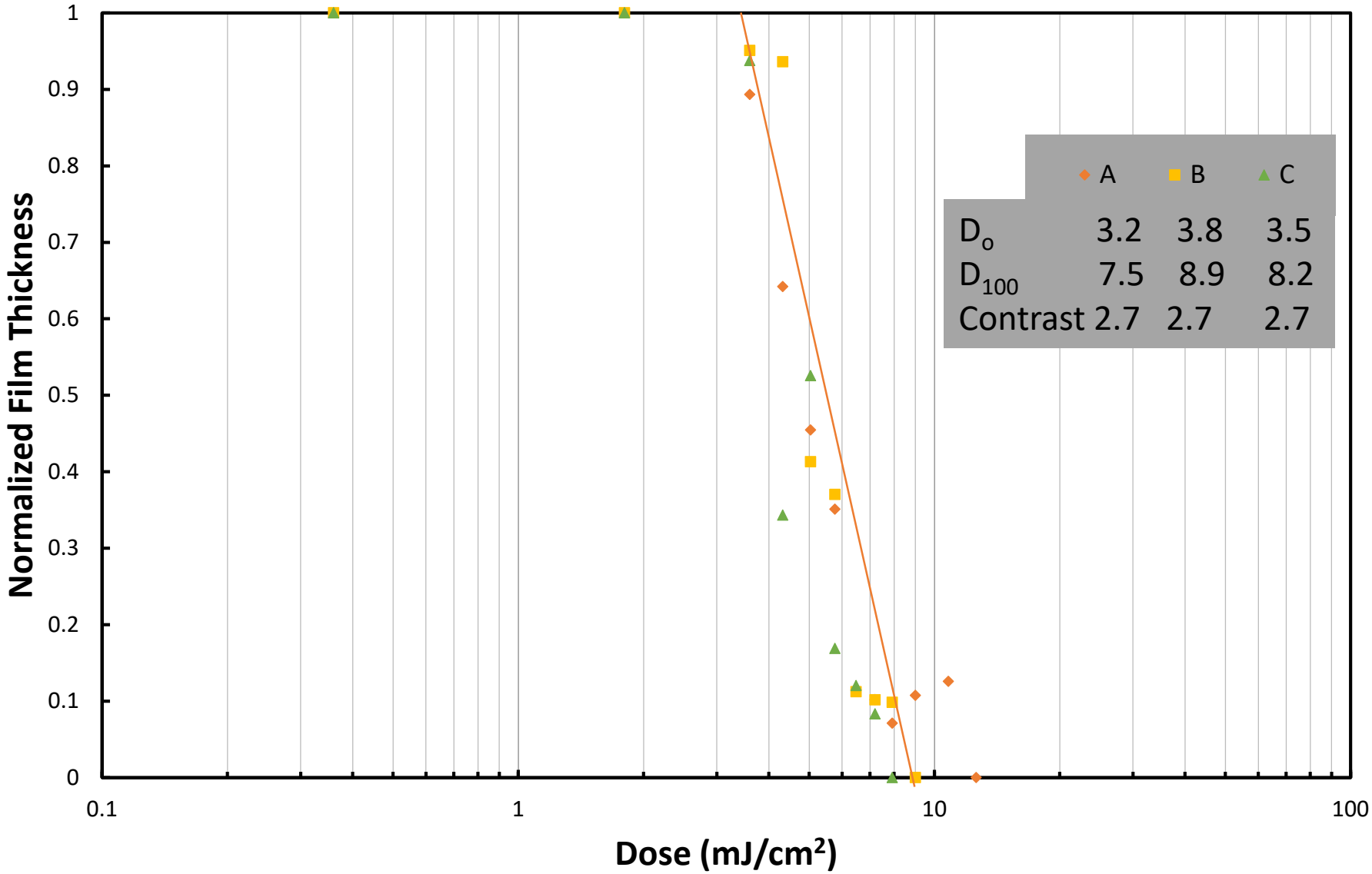
p(PHA) 5% PAG Vacuum Development

Pressure in vacuum oven
= 254 torr

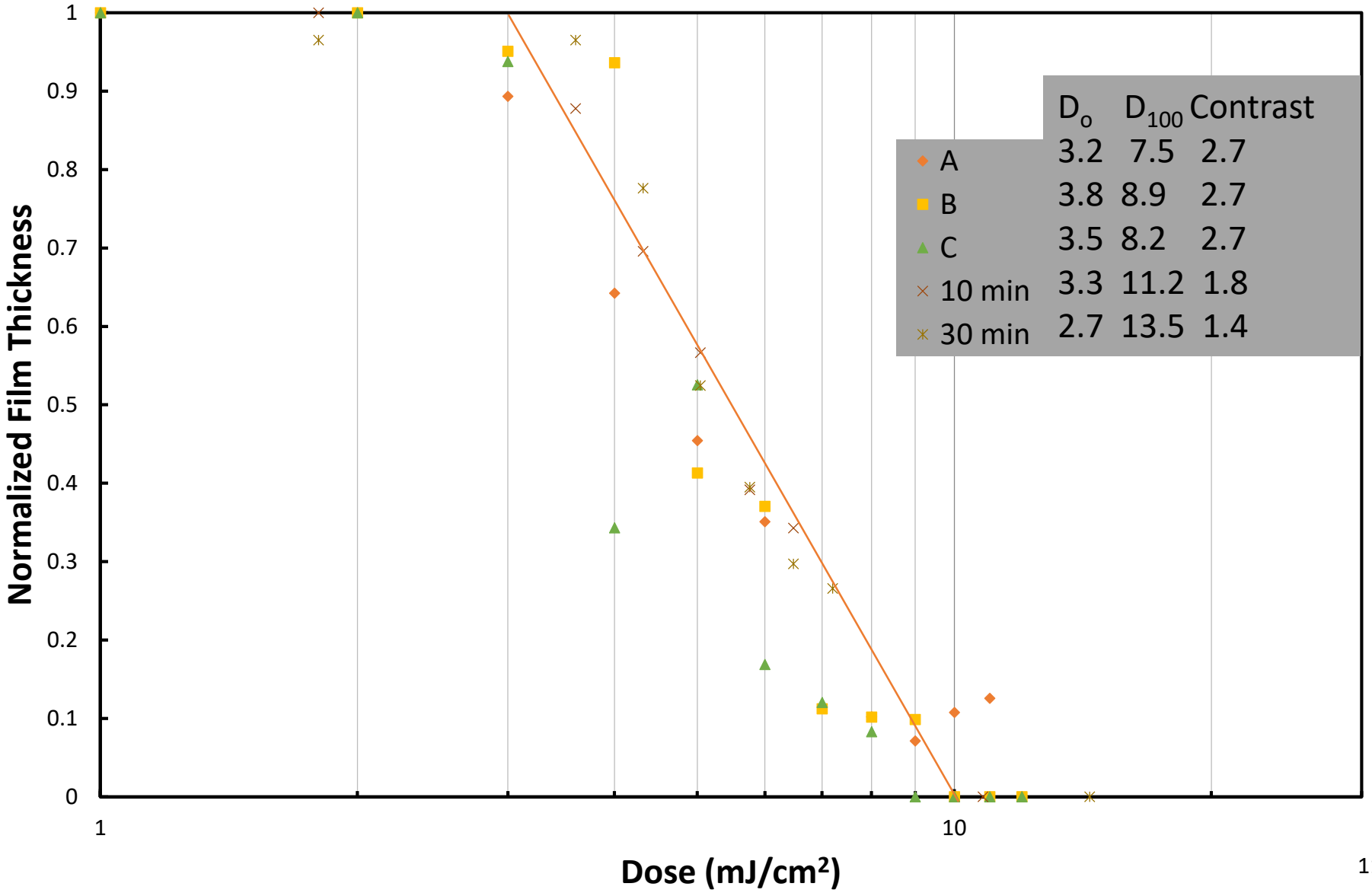
Increased vacuum pressure results in poorer patterns

Pressure in vacuum oven
= 750 torr

p(PHA) 5% PAG Vacuum Development Contrast Curve

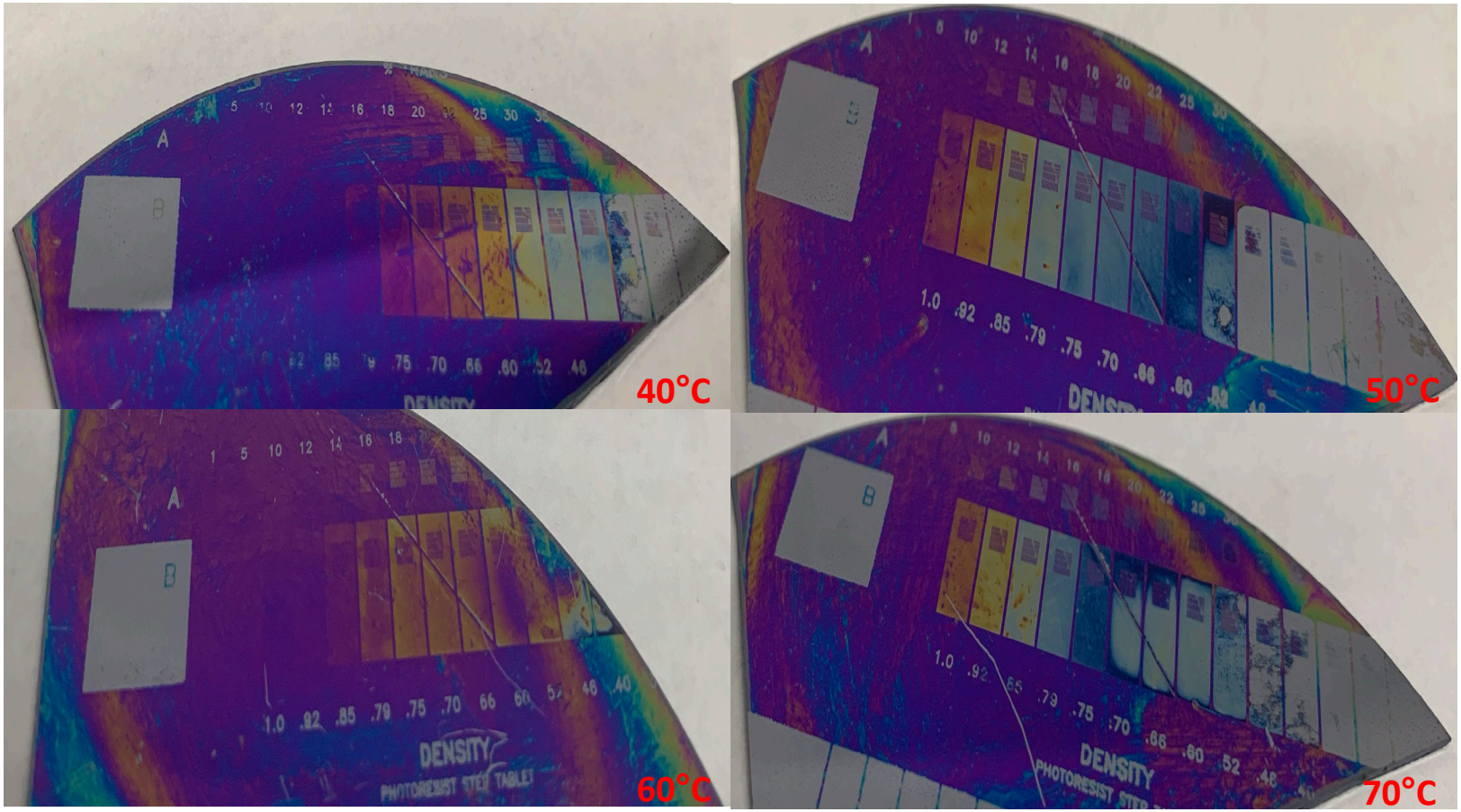


p(PHA) 5% PAG Vacuum Development Contrast Curve



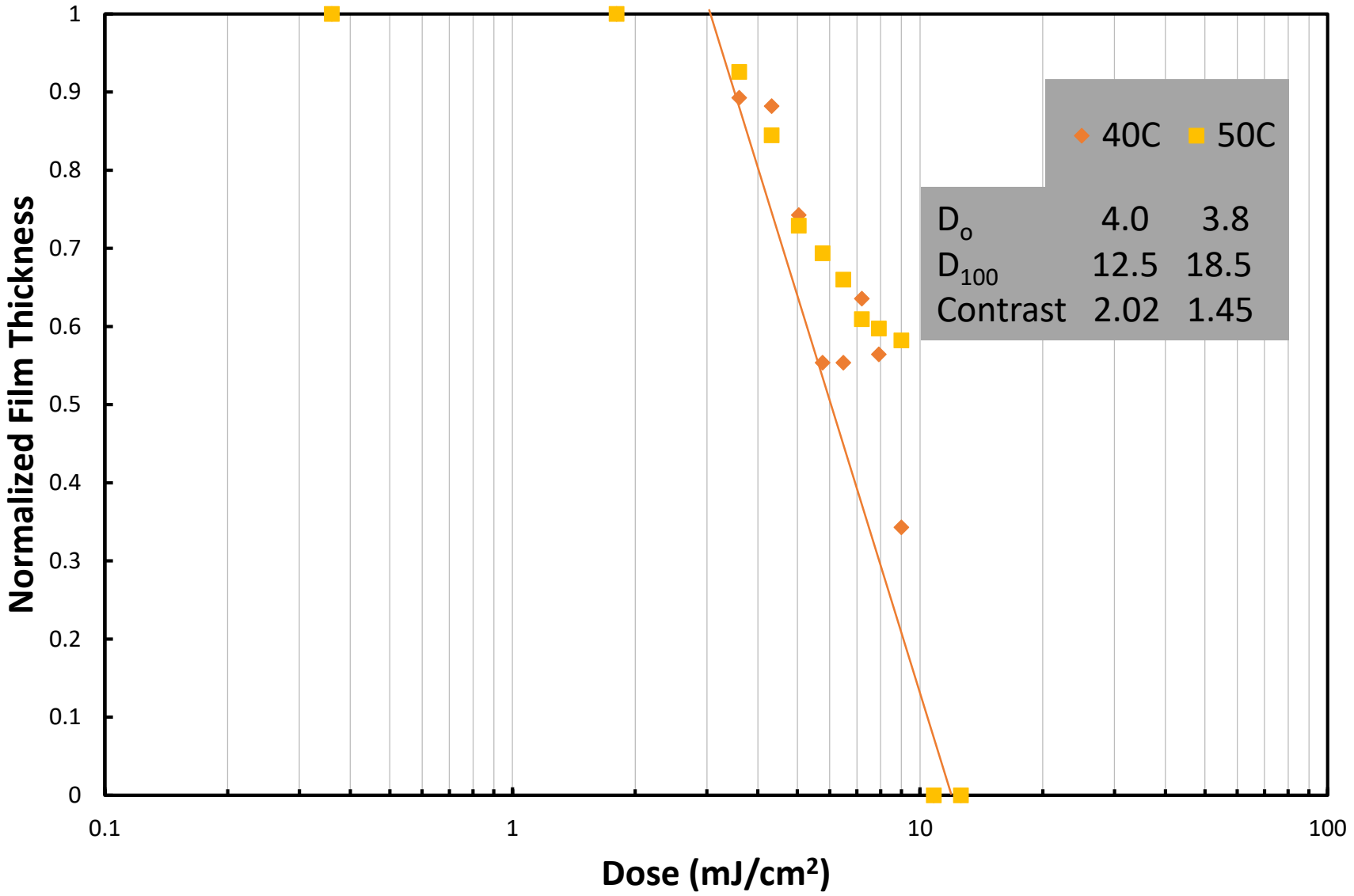
p(PHA) 1 % PAG Thermal Development

Development Time = 2 minutes



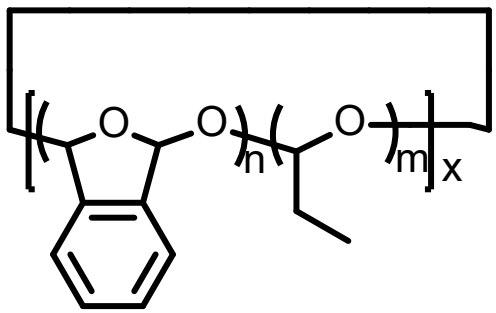
Lower temperatures result in better pattern fidelity
PHA monomer melts at 55°C

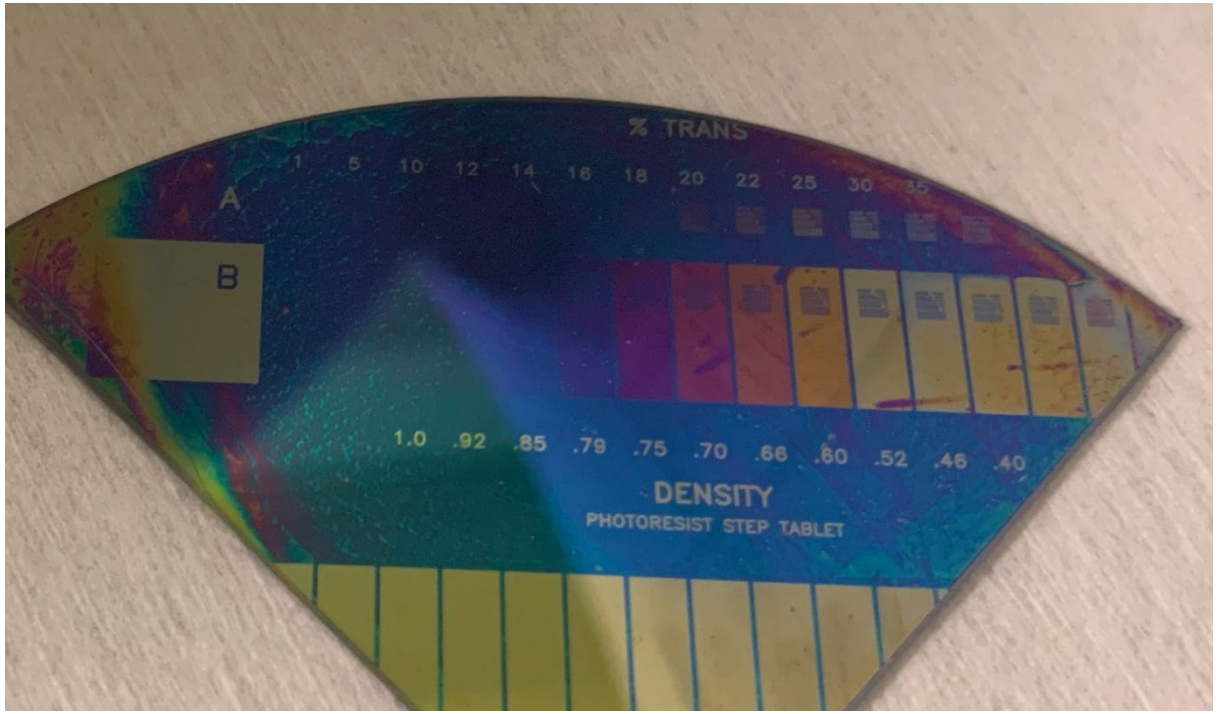
p(PHA) 1% PAG in Thermal Develop Contrast Curve



p(PHA-PA) 1% PAG Development

Pattern never fully developed with either thermal or vacuum development

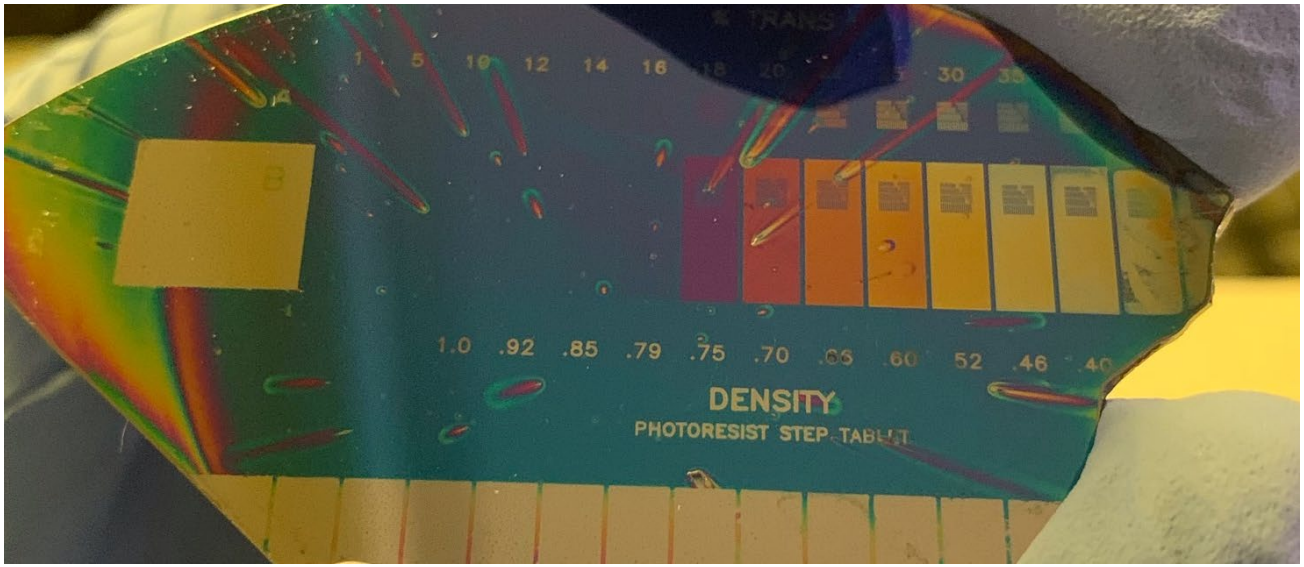




The lower molecular weight copolymer requires more acid to fully develop the pattern

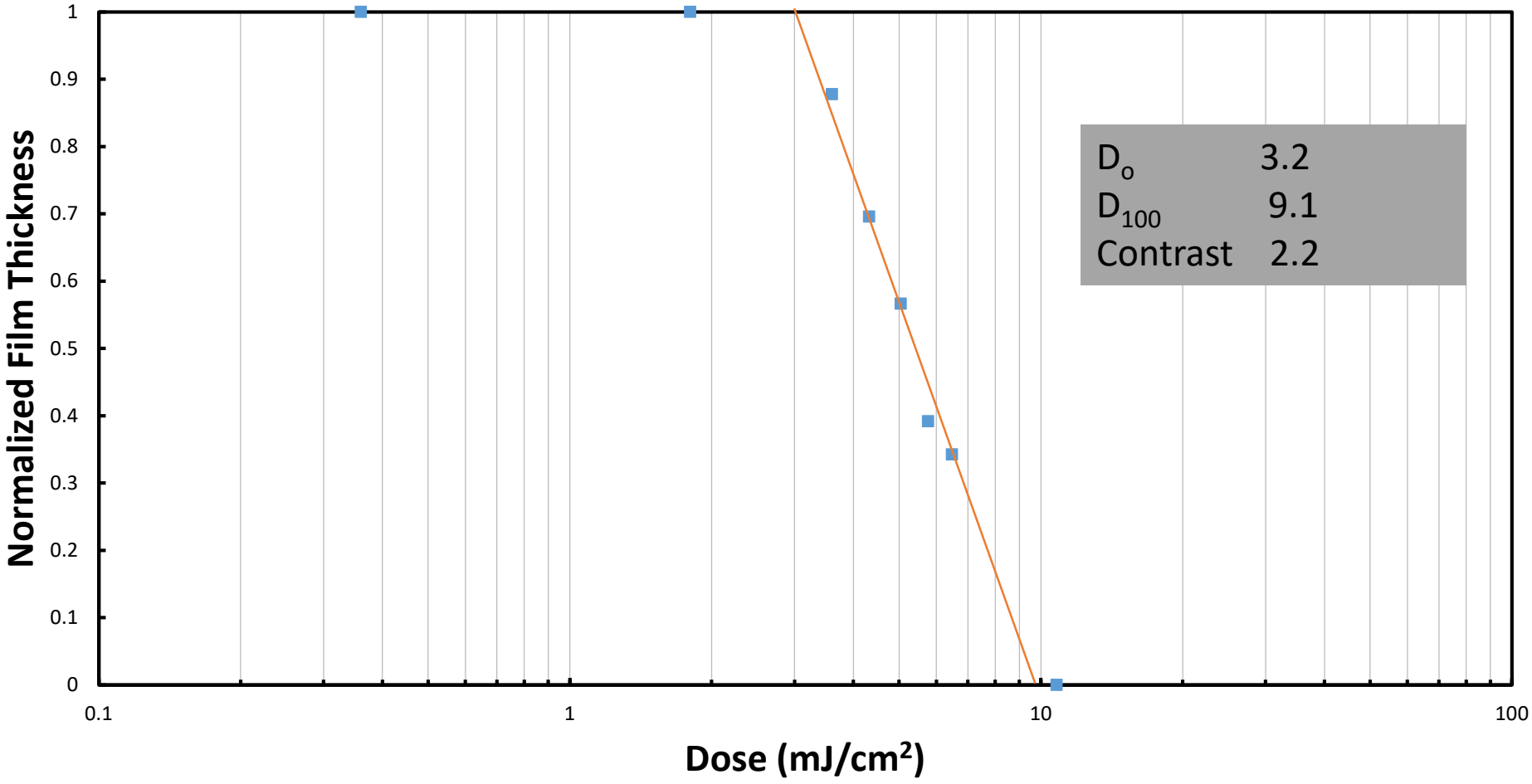
p(PHA-PA) 5% PAG Development

Vacuum development exhibited crisper features than thermal development

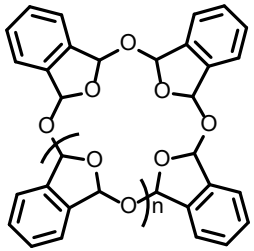


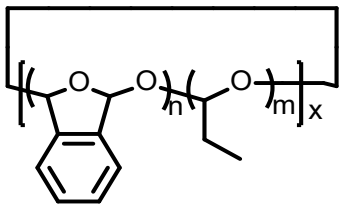
Similar to p(PHA), higher vacuum pressures resulted in poorer quality patterns

p(PHA-PA) 5% PAG Vacuum Development Contrast Curve



Results and Future steps





	Vacuum	Thermal	Vacuum	Thermal
5% PAG	High pressures are better	Poor pattern quality	High pressures are better	Poor pattern quality
1% PAG	Does not fully develop	Lower temperature is better	Too little PAG	Too little PAG

- Assess resolution limit of polyaldehydes
- Measure etch resistance of polymer
- Attempt pattern transfer processes

Acknowledgements

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