

Andrew Peters

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EDUCATION and APPOINTMENTS

University of Minnesota

Postdoctoral Research Associate

Minneapolis, MN

Present

- Advisor: Timothy P. Lodge
- Research topic: Fundamental understanding of chain exchange and relaxation time in micelle forming ABA and BAB systems using rheology, SAXS, light scattering, and simulation tools.

Georgia Institute of Technology

Ph.D. Chemical and Biomolecular Engineering

Atlanta, GA

August 2015

- Advisor: Clifford L. Henderson
- Thesis topic: Mesoscale simulation of diblock copolymer phase separation and directed self-assembly processes for semiconductor manufacturing.

University of Maryland

B.S. Chemical Engineering; Philosophy Minor

College Park, MD

May 2010

- Advisor: Michael Zachariah
- Research Topic: Propagation velocities of thermite reactions using aluminum nanoparticles.

PUBLICATIONS

1. **Andrew J. Peters**, Timothy P. Lodge, “Comparison of Gel Relaxation Times and End-block Pullout Times in ABA Triblock Copolymer Networks” *Macromolecules*, 49, 7340-7349 (2016).
2. **Andrew J. Peters**, Richard A. Lawson, Benjamin D. Nation, Peter J. Ludovice, Clifford L. Henderson, “Calculations of the free energy of dislocation defects in lamellae forming diblock copolymers using thermodynamic integration” *J. Micro-Nanolith. Mem.* 15, 023505 (2016). (**Featured Article**)
3. **Andrew J. Peters**, Richard A. Lawson, Benjamin D. Nation, Peter J. Ludovice, Clifford L. Henderson, “Coarse-grained molecular dynamics modeling of the kinetics of lamellar block copolymer defect annealing” *J. Micro-Nanolith. Mem.* 15, 013508 (2016). (**Cover Article**)
4. **Andrew J. Peters**, Richard A. Lawson, Benjamin D. Nation, Peter J. Ludovice, Clifford L. Henderson, “Simulation study of the effect of molar mass dispersity on domain interfacial roughness in lamellae forming block copolymers for directed self-assembly” *Nanotechnology*, 26, 385301 (2015).
5. **Andrew J. Peters**, Benjamin D. Nation, Richard. A. Lawson, Peter J. Ludovice, Clifford L. Henderson, “Free energy difference of pitch variation and calculation of the order–disorder transition in block copolymer systems using thermodynamic integration” *Mat. Res. Express*, 2, 075301 (2015)
6. Richard Lawson, **Andrew Peters**, Benjamin Nation, Peter Ludovice, Clifford Henderson, “Simulation study of the effect of differences in block energy and density on the self-assembly of block copolymers” *J. Micro-Nanolith. Mem.*, 31, 031308, (2014).
7. **Andrew J. Peters**, Richard A. Lawson, Peter J. Ludovice, Clifford L. Henderson, “Detailed molecular dynamics studies of block copolymer directed self-assembly: Effect of guiding layer properties” *J. Vac. Sci. Technol. B*, 31, 06F302, (2013).

- **Andrew J. Peters**, Benjamin D. Nation, Daniel Nicoloso, Peter J. Ludovice, Clifford L. Henderson, “Protracted Colored Noise Dynamics in Molecular Dynamics Simulations of Block Copolymers” *In Preparation*.
- **Andrew J. Peters**, Timothy P. Lodge, “Chain Exchange Kinetics of Symmetric and Asymmetric BAB and ABB’ Triblock Polymers” *In Preparation*.

AWARDS and FELLOWSHIPS

- Cover Art Journal of Micro/Nanolithography, MEMS, and MOEMS 2016
- Featured Article Journal of Micro/Nanolithography, MEMS, and MOEMS 2016
- Georgia Tech Research and Innovation Conference Fellowship 2012 - 2013
- Best Paper at International Symposium on Lithography Extensions 2011

CONFERENCE PROCEEDINGS

1. **Andrew J. Peters**, Richard A. Lawson, Benjamin D. Nation, Peter J. Ludovice and Clifford L. Henderson, “Coarse-grained molecular dynamics modeling of the kinetics of lamellar BCP defect annealing” Proc. SPIE, 9423, 94231Y, (2015).
2. Richard A. Lawson, **Andrew J. Peters**, Benjamin D. Nation, Peter J. Ludovice and Clifford L. Henderson, “Effect of χ_N and underlayer composition on self-assembly of thin films of block copolymers with energy asymmetric block” Proc. SPIE, 9423, 94231L, (2015).
3. Benjamin D. Nation, **Andrew J. Peters**, Richard A. Lawson, Peter J. Ludovice and Clifford L. Henderson, “Effect of chemoepitaxial guiding underlayer design on the pattern quality and shape of aligned lamellae for fabrication of line-space patterns” Proc. SPIE, 9423, 94231J, (2015).
4. **Andrew J. Peters**, Richard Lawson, Benjamin D. Nation, Peter J. Ludovice, Clifford L. Henderson, “Understanding defects in DSA: Calculation of free energies of block copolymer DSA systems via thermodynamic integration of a mesoscale block-copolymer model” Proc. SPIE, 9049, 90492E, (2014).
5. Benjamin Nation, **Andrew J. Peters**, Richard A. Lawson, Peter J. Ludovice, Clifford L. Henderson, “Effect of guiding layer topography on chemoepitaxially directed self-assembly of block copolymers for pattern density multiplication” Proc. SPIE, 9049, 90492K, (2014).
6. Benjamin Nation, **Andrew J. Peters**, Richard A. Lawson, Peter J. Ludovice, Clifford L. Henderson, “Predicting process windows for pattern density multiplication using block copolymer directed self-assembly in conjunction with chemoepitaxial guiding layers” Proc. SPIE, 9049, 90491C, (2014).
7. Richard A. Lawson, **Andrew J. Peters**, Benjamin Nation, Peter J. Ludovice, Clifford L. Henderson, “Simulation study of the effect of differences in block energy and density on the self-assembly of block copolymers” 9049, 90490S, (2014).
8. **Andrew J. Peters**, Richard Lawson, Peter J. Ludovice, Clifford L. Henderson, “Effects of block copolymer polydispersity and χ_N on pattern line edge roughness and line width roughness from directed self-assembly of diblock copolymers” Proc. SPIE, 8680, 868020, (2013).
9. Richard A. Lawson, **Andrew J. Peters**, Peter Ludovice, Clifford L. Henderson, “Tuning the domain size of block copolymers for directed self assembly using polymer blending: molecular dynamics simulation studies” Proc. SPIE, 8680, 86801Z, (2013).

10. Richard A. Lawson, **Andrew J. Peters**, Peter Ludovice, Clifford L. Henderson, "Coarse grained molecular dynamics model of block copolymer directed self-assembly" Proc. SPIE, 8680, 86801Y, (2013).
11. Nathan D. Jarnagin, Wei-Ming Yeh, Jing Cheng, **Andrew J. Peters**, Richard A. Lawson, Laren M. Tolbert, Clifford L. Henderson, "PS-b-PHOST as a high χ block copolymer for directed self-assembly: Properties, DSA, and novel methods for selective block removal " Proc. SPIE, 8680, 86801X, (2013).
12. **Andrew J. Peters**, Richard Lawson, Peter J. Ludovice, Clifford L. Henderson, "Detailed mesoscale dynamic simulation of block copolymer directed self-assembly processes: application of protracted colored noise dynamics," Proc. SPIE, 8323, 83231T, (2012).
13. Nathan D. Jarnagin, Jing Cheng, **Andrew J. Peters**, Wei-Ming Yeh, Richard A. Lawson, Laren M. Tolbert, Clifford L. Henderson, "Investigation of high χ block copolymers for directed self-assembly: synthesis and characterization of PS-b-PHOST," Proc. SPIE, 8323, 832310, (2012).
14. Jing Cheng , Richard A. Lawson , Wei-Ming Yeh , Nathan D. Jarnagin ,**Andrew J. Peters** , Laren M. Tolbert , Clifford L. Henderson, "Directed self-assembly of poly(styrene)-block-poly(acrylic acid) copolymers for sub-20nm pitch patterning," Proc. SPIE, 8323, 83232R, (2012).

PRESENTATIONS

1. "Nanoscale Ordered Soft Matter: Advanced Simulations Supplemented by Experiment" Michigan State Departmental Seminar, East Lansing, MI, March 2017.
2. "Nanoscale Ordered Soft Matter: Advanced Simulations Supplemented by Experiment" Louisiana Tech Seminar, Ruston, LA, February 2017.
3. "Rapid End-Block Pullout in ABA Triblock Polymer Gels" American Institute of Chemical Engineers Annual Conference 2016, San Francisco, CA, November 2016.
4. "Using rheology to study the relaxation times and chain exchange kinetics in an ABA triblock polymer gel" IPRIME Annual Meeting 2016. Minneapolis, MN, May 2016.
5. "Rheology and Relaxation Timescales of an ABA Triblock Polymer Gel" American Physical Society March Meeting 2016, Baltimore, MD, March 2016.
6. "Protracted Colored Noise Dynamics for Polymer Systems" American Institute of Chemical Engineers Annual Conference 2014, Atlanta, GA, November, 2014.
7. "Free Energy of Defects in Aligned Block Copolymer Systems Via Thermodynamic Integration of a Coarse Grained Block-Copolymer Model" American Institute of Chemical Engineers Annual Conference 2014, Atlanta, GA, November, 2014.
8. "Understanding Defect Annealing Kinetics in Self-Assembled Block Copolymers Using a Coarse Grained Block-Copolymer Model" American Institute of Chemical Engineers Annual Conference 2014, Atlanta, GA, November, 2014.
9. "Mesoscale Molecular Dynamics Simulations and Their Application to Understanding Block Copolymer Self-Assembly" Colloid & Soft Matter Bag Lunch Seminar Series at Georgia Tech. April 2014.
10. "Self Assembling Systems for Semiconductor Fabrication" Foresight Technical Conference: Integration, Palo Alto, CA, February 2014.

11. "Diblock Copolymer Directed Self-Assembly Line Roughness: Effects of Polydispersity and χN " American Institute of Chemical Engineers Annual Conference 2013, San Francisco, CA, November 2013.
12. "Detailed Molecular Dynamics Studies of Block Copolymer Directed Self-Assembly: Effect of Guiding Layer Properties" Conference on Electron, Ion, and Photon Beam Technology and Nanofabrication 2013, Nashville, TN, May 2013.
13. "Free Energy of Block Copolymer Systems Via Thermodynamic Integration of a Mesoscale Block-Copolymer Model" American Institute of Chemical Engineers Annual Conference 2013, San Francisco, CA, November 2013.
14. "Topographic Effects On Chemo-Epitaxy in Directed Self-Assembly of Block Copolymer Films" American Institute of Chemical Engineers Annual Conference 2013, San Francisco, CA, November 2013.
15. "Coarse Grained Molecular Dynamics Model of Block Copolymer Directed Self-Assembly" American Institute of Chemical Engineers Annual Conference 2013: Modeling and Simulation of Polymers , San Francisco, CA. November 2013.
16. "Tuning the Domain Size of Block Copolymers for Directed Self-Assembly Using Polymer Blending." American Institute of Chemical Engineers Annual Conference 2013, San Francisco, CA, November 2013.
17. "Fabrication of Complex Nanostructures using Directed Self Assembly of Block Copolymers" Georgia Tech Center for Organic Photonic and Electronics Industry Partners' Day, Atlanta, GA, April 2013.
18. "Simulation of Diblock Copolymer Directed Self Assembly Processes: Applications for Semiconductor Manufacturing" Georgia Tech Chemical and Biomolecular Engineering Graduate Research Symposium, Atlanta, GA, March 2013.
19. "Investigation of High χ Block Copolymer PS-b-PHOST: Sub 20 nm Patterning, Directed Self Assembly, and Selective Block Removal" Georgia Tech Chemical and Biomolecular Engineering Graduate Research Symposium, Atlanta, GA, March 2013.
20. "Nanolithography Based on the Directed Self-Assembly of Block Copolymers: Using Molecular Dynamics Simulations as a Predictive Learning Tool" Colloid & Soft Matter Bag Lunch Seminar Series at Georgia Tech, Atlanta, GA, January 2013.
21. "Molecular dynamics simulations of block copolymer directed self-assembly: Understanding the limits and guiding materials design" 2012 Litho Workshop. June 2012.
22. "Detailed Mesoscale Molecular Dynamics Simulation of Block Copolymer Phase Separation: Probing the Fundamentals of Directed Self-Assembly Processes" American Institute of Chemical Engineers Annual Conference 2012, Pittsburgh, PA, November 2012.
23. "Fundamentals of Diblock Copolymer Phase Separation and Directed Self-Assembly Processes: Detailed Analysis of Lamellae Formation" American Institute of Chemical Engineers Annual Conference 2012, Pittsburgh, PA, November 2012.
24. "Investigation of High χ Block Copolymers for Directed Self-Assembly: Selective Block Removal of PS-b-PHOST Patterns Via Selective ALD and Etch" American Institute of Chemical Engineers Annual Conference 2012, Pittsburgh, PA, November 2012.

25. "Poly(styrene)-b-Poly(acrylic acid) Block Copolymers: Phase Separation Behavior and Directed Self Assembly" American Institute of Chemical Engineers Annual Conference 2012, Pittsburgh, PA, November 2012.
26. "Detailed mesoscale dynamic simulation of block copolymer directed self-assembly processes: application of protracted colored noise dynamics" Georgia Tech Research and Innovation Conference, Atlanta, GA, February 2012.
27. "Directed Self-Assembly for sub-20 nm Pitch Patterning: Uncovering the Fundamentals and Developing Materials and Methods for High Resolution Patterning" SEMATECH 2011 Symposium on Lithography Extension, Miami, FL, November 2011.

RESEARCH EXPERIENCE

University of Minnesota

Minneapolis, MN

Postdoctoral Associate with Prof. Timothy Lodge

June 2015 - present

Project Title: "Chain Exchange and Relaxation times in Micelle Forming ABA and BAB Systems"

- Used rheology to find that ABA triblock polymers relax significantly faster than is to be expected based on previous diblock experiments. Explained this via dispersity and entropic effect in the midblock.
- Modeling of dispersity in ABA triblock polymer systems to show that higher dispersity polymers relax more quickly because the shorter chain ends are more likely to be sampled.
- Use of DPD simulations to find that BAB triblock polymers chain exchange significantly faster than equivalent AB diblock polymers. Asymmetry in the B blocks has little effect on chain exchange.

Georgia Institute of Technology

Atlanta, GA

Graduate Research Assistant with Prof. Clifford Henderson

2010 - 2015

Project Title: "Mesoscale Simulation of Diblock Copolymer Phase Separation and Directed Self Assembly Processes: Applications for Semiconductor Manufacturing"

- Developed coarse grained block copolymer models for use in molecular dynamics simulations of block copolymer phase separation.
- Investigated the effect of polymer properties and processing conditions on equilibrium defect density and defect removal kinetics. Defects are perhaps the primary hurdle to block copolymer directed self-assembly use in semiconductor fabrication.
- Investigated the effects of underlayer pattern quality, polymer interaction, and polymer dispersity on line roughness, a critical parameter in semiconductor lithography.

University of Maryland

College Park, MD

Undergraduate Research Assistant with Prof. Michael Zachariah

2008

Project Title: "Propagation velocities in thermite reactions using aluminum nanoparticles"

- Constructed an apparatus to safely initiate, propagate, and measure the reaction propagation velocity of various oxides and aluminum nanoparticles.
- Explored the effect of various oxides on the reaction propagation velocity.
- Designed and performed simulations to calculate reaction temperatures.

TEACHING EXPERIENCE

Teaching Fellow

2013

Georgia Institute of Technology; Numerical Methods

- Designed and delivered 12 lectures throughout the fall semester.
- Planned weekly homework assignments and quizzes. Planned a final project that incorporated various aspects of the class.

- Held weekly recitations to review lecture material.

MPACT (Mentorship Program for Aspiring Chemistry Teachers) Mentee

2017

University of Minnesota; Chemical Principles II

- Mentored by Prof. Michelle Driessen in a flipped general chemistry class.
- Assisted in exam preparation.
- Met with other mentees to share experiences and discuss articles on pedagogy.

Teaching Assistant (x3)

2012 - 2015

Georgia Institute of Technology: Chemical Process Control; Unit Operations Laboratory

- Held weekly recitations to review lecture material.
- Held weekly office hours for questions and review.
- Prepared and supervised weekly laboratory sections.

Research Supervisor for Undergraduate Students

2012 - 2015

Georgia Institute of Technology and University of Minnesota

- Supervised five students. Four in the area of block copolymer simulation and one in the area of rheology of ABA triblock polymer gels.
- Daniel Nicoloso (undergraduate student at Georgia Tech) won second place in the subdivision poster competition at the 2014 AIChE conference.
- Students presented posters at the national AIChE conference and at the Air Products Symposium.

Science Tutor for Underprivileged Students

2015

Atlanta, GA

- Tutored middle and high school students once a week on scientific topics.

PROFESSIONAL ACTIVITIES

- Reviewer for Optical Engineering
- Reviewer for Polymer
- AIChE Undergraduate Poster Competition Judge 2016 - present
- American Institute of Chemical Engineers 2008 - present
- APS (American Physical Society) 2016 - present
- SPIE – the International Society for Optics and Photonics 2011 - 2015
- Georgia Tech Presidents Undergraduate Research Awards Reviewer 2013

OTHER

President of FCGS graduate student group

2013 - 2015

Georgia Institute of Technology

- Organized weekly meetings and invited speaker talks.
- Organized outreach events.
- Coordinated with outside groups for large events (~1000 students).