

Mark P. Stoykovich

Department of Chemical and Biological Engineering
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EDUCATION

University of Wisconsin, Madison, WI.

Ph.D. in Chemical Engineering, May 2007.

Advisor: Professor Paul F. Nealey

Dissertation: *Directed self-assembly of block copolymers and ternary block copolymer/homopolymer blends on chemically patterned surfaces into device-oriented geometries*

Massachusetts Institute of Technology, Cambridge, MA.

B.S. in Chemical Engineering, June 2000.

B.S. in Chemistry, June 2000.

PROFESSIONAL EXPERIENCE

Assistant Professor 8/2008 -

University of Colorado, Boulder, CO.
Department of Chemical and Biological Engineering

Postdoctoral Research Associate 1/2007 – 6/2008

University of Illinois, Urbana-Champaign, IL.

Department of Materials Science and Engineering

Advisor: Professor John A. Rogers

- Fabricated hemispherical electronic eye cameras using stretchable and flexible Si circuits.
- Transfer printed Si elements onto complex 3D surfaces using PDMS films.

Research Assistant 9/2000 – 12/2006

University of Wisconsin, Madison, WI.

Department of Chemical and Biological Engineering

- Explored the directed self-assembly of block copolymers and blends on chemically nanopatterned substrates to achieve periodic and nonregular structures.
- Studied the phase behavior of polymer blends in thin films.
- Designed a combinatorial method for measuring the mechanical properties of polymers and photoresists over nanoscale dimensions using lithographically defined structures.

Teaching Assistant Spring and Fall semesters of 2002

University of Wisconsin, Madison, WI.

Department of Chemical and Biological Engineering

- Teaching assistant for 1) Chemical process thermodynamics and 2) Mass transfer operations.

Internship 6/2001 – 10/2001

Agere Systems, Murray Hill, NJ.

Advanced Lithography Division

- Performed electron beam lithography with 100 keV exposure tool.
- Completed nanoscale mechanical property measurements.

Undergraduate Researcher 5/2000 – 8/2000

Massachusetts Institute of Technology, Cambridge, MA.

Department of Chemical Engineering

Advisor: Professor Jackie Y. Ying

- Conducted research on doped cerium oxide nanoparticles for oxygen storage and catalysis.

Undergraduate Researcher 6/1999 – 8/1999

Virginia Tech, Blacksburg, VA.

Department of Materials Science and Engineering

Advisor: Professor Alfred C. Loos

- Studied the glass transition temperature of polymer-carbon fiber composites.

AWARDS AND HONORS

- Semiconductor Research Corporation (SRC) Graduate Fellowship (2003-2006).
- Finalist for the American Physical Society's Frank J. Padden, Jr. award for graduate student research in Polymer Physics (2006).
- Best paper in session at TECHCON (2005).
- SRC inventor recognition award (2004-2005).
- Best poster/presentation at the SRC Graduate Fellowship Conference (2004).
- Best presentation award at the SRC Review, University of Wisconsin (2002 and 2005).
- Merck Index Award for outstanding scholarship, Department of Chemistry, MIT (2000).

PROFESSIONAL ACTIVITIES

- Nano Picks reviewer for ACS Nanotation (2008-).
- Referee for Physical Review Letters, ACS Nano, Langmuir, Macromolecules, Advanced Materials.
- Judge for middle school science fair in Aurora, IL (2007).
- Community outreach volunteer for UW MRSEC at Engineering Expo (2005).
- Helped organize and perform demonstrations for local underrepresented high school students through the UW PEOPLE program (2003 and 2004).

PATENTS

6. "Stretchable and foldable electronic devices," John A. Rogers, Yonggang Huang, Heung Cho Ko, **Mark P. Stoykovich**, Won Mook Choi, Jizhou Song, Jong Hyun Ahn (pending 61/033,886 - filed March 2008).
5. "Optical systems fabricated by printing-based assembly," John A. Rogers, Ralph G. Nuzzo, Matthew Meitl, Etienne Menard, Alfred J. Baca, Michael Motala, Jong-Hyun Ahn, Sang-Il Park, Chang-Jae Yu, Heung Cho Ko, **Mark P. Stoykovich**, Jongseung Yoon (pending 11/981,380 - filed November 2007).
4. "Controlled buckling structures in semiconductor interconnects and nanomembranes for stretchable electronics," John A. Rogers, Ralph G. Nuzzo, Matthew Meitl, Etienne Menard, Keon Jae Lee, Dahl-Young Khang, Yugang Sun, Zhengtao Zhu, Heung Cho Ko, Andrew Carlson, Won Mook Choi, **Mark P. Stoykovich**, Hanqing Jiang, Young Huang (pending 11/851,182 - filed September 2007).
3. "Methods and compositions for forming patterns with isolated or discrete features using block copolymer materials," Paul F. Nealey, Juan J. de Pablo, **Mark P. Stoykovich**, Huiman Kang, Kostas Ch. Daoulas, Marcus Müller (pending 11/879,758 - filed July 2007).
2. "Fabrication of complex three-dimensional structures based on directed assembly of self-assembling materials on activated two-dimensional templates," Paul F. Nealey, **Mark P. Stoykovich**, Kostas Ch. Daoulas, Marcus Müller, Juan J. de Pablo, Sang-Min Park (pending 11/545,060 - filed October 2006).

1. "Methods and compositions for forming aperiodic patterned polymer films," Paul F. Nealey, Sang Ouk Kim, Erik W. Edwards, **Mark P. Stoykovich**, Juan J. de Pablo (pending 11/286,260 - filed November 2005).

PUBLICATIONS

27. H. C. Ko*, **M. P. Stoykovich***, J. Song, V. Malyarchuk, W. M. Choi, C. J. Yu, J. B. Geddes III, J. Xiao, S. Wang, Y. Huang, J. A. Rogers, "A hemispherical electronic eye camera based on compressible silicon optoelectronics," *Nature*, in press (2008) (*authors contributed equally).
26. S. M. Park, G. S. W. Craig, C. C. Liu, **M. P. Stoykovich**, Y. H. La, N. J. Ferrier, P. F. Nealey, "Directed assembly and characterization of hexagonal order of P(S-b-MMA) cylinders on chemical patterns," *Soft Matter*, in press (2008).
25. H. Kang, F. A. Detcheverry, A. N. Mangham, **M. P. Stoykovich**, K. Ch. Daoulas, R. J. Hamers, M. Müller, J. J. de Pablo, P. F. Nealey, "Hierarchical assembly of nanoparticle superstructures from block copolymer-nanoparticle composites," *Physical Review Letters*, 100, 148303 (2008).
24. K. Ch. Daoulas, M. Müller, **M. P. Stoykovich**, H. Kang, J. J. de Pablo, P. F. Nealey, "Directed copolymer assembly on chemical substrate patterns: A phenomenological and Single-Chain-in-Mean-Field simulations study of the influence of roughness in the substrate pattern," *Langmuir*, 24, 1284 (2008).
23. **M. P. Stoykovich**, K. Yoshimoto, P. F. Nealey, "Mechanical properties of polymer nanostructures: Measurements based on deformation in response to capillary forces," *Applied Physics A*, 90, 277 (2008).
22. **M. P. Stoykovich**, H. Kang, K. Ch. Daoulas, G. Liu, C.-C. Liu, J. J. de Pablo, M. Müller, P. F. Nealey, "Directed self-assembly of block copolymers for nanolithography: Fabrication of isolated features and essential integrated circuit geometries," *ACS Nano*, 1(3), 168 (2007) (**highlighted with cover illustration and perspectives article**).
21. Y.-H. La, **M. P. Stoykovich**, S.-M. Park, P. F. Nealey, "Directed assembly of cylinder-forming block copolymers into patterned structures to fabricate arrays of spherical domains and nanoparticles," *Chemistry of Materials*, 19, 4538 (2007).
20. H. R. Keymeulen, A. Diaz, H. H. Solak, C. David, F. Pfeiffer, B. D. Patterson, J. F. van der Veen, **M. P. Stoykovich**, P. F. Nealey, "Measurement of the x-ray dose-dependent glass transition temperature of structured polymer films by x-ray diffraction," *J. Applied Physics*, 102, 013528 (2007).
19. Y. Ekinici, H. H. Solak, C. Padeste, J. Gobrecht, **M. P. Stoykovich**, P. F. Nealey, "20 nm Line/space patterns in HSQ fabricated by EUV interference lithography," *Microelectronic Eng.*, 84(5-8), 700 (2007).
18. S.-M. Park, **M. P. Stoykovich**, R. Ruiz, Y. Zhang, C. T. Black, P. F. Nealey, "Directed assembly of lamellae-forming block copolymers using chemically and topographically patterned substrates," *Advanced Materials*, 19, 607 (2007).
17. E. W. Edwards, M. Müller, **M. P. Stoykovich**, H. H. Solak, J. J. de Pablo, P. F. Nealey, "Dimensions and shapes of block copolymer domains assembled on lithographically defined chemically patterned substrates," *Macromolecules*, 40(1), 90, (2007).
16. **M. P. Stoykovich**, E. W. Edwards, H. H. Solak, P. F. Nealey, "Phase behavior of symmetric ternary block copolymer – homopolymer blends in thin films and on chemically patterned surfaces," *Physical Review Letters*, 97, 147802 (2006).
15. K. Ch. Daoulas, M. Müller, **M. P. Stoykovich**, Y. J. Papakonstantopoulos, S.-M. Park, J. J. de Pablo, P. F. Nealey, H. H. Solak, "Directed assembly of copolymer materials on patterned substrates: Balance of simple symmetries in complex structures," *J. Poly. Sci. B: Poly. Phys.*, 44(18), 2589 (2006).

14. **M. P. Stoykovich**, P. F. Nealey, "Block copolymers and conventional lithography," *Materials Today*, 9(9), 20 (2006) (**invited review article**).
13. S. O. Kim, B. H. Kim, K. Kim, C. M. Koo, **M. P. Stoykovich**, P. F. Nealey, H. H. Solak, "Defect structure in thin films of a lamellar block copolymer self-assembled on neutral homogeneous and chemically nanopatterned surfaces," *Macromolecules*, 39(16), 5466 (2006).
12. E. W. Edwards, **M. P. Stoykovich**, H. H. Solak, P. F. Nealey, "Long-range order and orientation of cylinder-forming block copolymers on chemically nanopatterned striped surfaces," *Macromolecules*, 39(10), 3598 (2006).
11. K. Ch. Daoulas, M. Müller, **M. P. Stoykovich**, S.-M. Park, Y. J. Papakonstantopoulos, J. J. de Pablo, P. F. Nealey, H. H. Solak, "Fabrication of complex three-dimensional nanostructures from self-assembling block copolymer materials on two-dimensional chemically patterned templates with mismatched symmetry," *Physical Review Letters*, 96, 036104 (2006).
10. E. W. Edwards, **M. P. Stoykovich**, H. H. Solak, P. F. Nealey, "Binary blends of diblock copolymers as an efficient route to multiple length scales in perfect directed self-assembly of diblock copolymer thin films," *J. Vac. Sci. Technol. B*, 24(1), 340 (2006).
9. P. F. Nealey, E. W. Edwards, M. Müller, **M. P. Stoykovich**, H. H. Solak, J. J. de Pablo, "Self-assembling resists for nanolithography," *Proceedings of the 2005 IEEE International Electron Devices Meeting*, 356 (2006).
8. E. W. Edwards, **M. P. Stoykovich**, M. Müller, H. H. Solak, J. J. de Pablo, P. F. Nealey, "Mechanism and kinetics of ordering in diblock copolymer thin films on chemically nanopatterned substrates," *J. Poly. Sci. B: Poly. Phys.*, 43(23), 3444 (2005).
7. **M. P. Stoykovich**, M. Müller, S. O. Kim, H. H. Solak, E. W. Edwards, J. J. de Pablo, P. F. Nealey, "Directed assembly of block copolymer blends into nonregular device-oriented structures," *Science*, 308, 1442 (2005).
6. I. Junarsa, **M. P. Stoykovich**, P. F. Nealey, Y. Ma, F. Cerrina, H. H. Solak, "Hydrogen silsesquioxane as a high resolution negative-tone resist for extreme ultraviolet lithography," *J. Vac. Sci. Technol. B*, 23(1), 138 (2005).
5. K. Yoshimoto, **M. P. Stoykovich**, H. B. Cao, W. J. Drugan, J. J. de Pablo, P. F. Nealey, "A two-dimensional model of the deformation of photoresist structures using elastoplastic polymer properties," *J. Applied Physics*, 96, 1857 (2004).
4. S. O. Kim, H. H. Solak, **M. P. Stoykovich**, N. J. Ferrier, J. J. de Pablo, P. F. Nealey, "Epitaxial self-assembly of block copolymers on lithographically defined nanopatterned substrates," *Nature*, 424, 411 (2003) (**highlighted with news and views article**).
3. **M. P. Stoykovich**, H. B. Cao, K. Yoshimoto, L. E. Ocola, P. F. Nealey, "Deformation of nanoscopic polymer structures in response to well-defined capillary forces," *Advanced Materials*, 15(14), 1180 (2003).
2. P. F. Nealey, **M. P. Stoykovich**, K. Yoshimoto, H. B. Cao, "Nanolithographic Polymer Structures: Mechanical Properties," *The Encyclopedia of Materials: Science and Technology*, Elsevier Science Ltd., (2003).
1. T. A. Bullions, **M. P. Stoykovich**, J. E. McGrath, A. C. Loos, "Monitoring the reaction progress of a high-performance phenylethynyl-terminated poly(etherimide). Part II: Advancement of glass transition temperature," *Polymer Composites*, 23(4), 479 (2002).

PRESENTATIONS

Invited Presentations (16 total) -

- 3rd Conference on Foundations of Nanoscience (Self-Assembled Architectures and Devices), Snowbird, UT (2006).
- North Carolina State University, Department of Chemical and Biomolecular Eng. (2006).
- MIT, Department of Chemical Engineering (2006).
- Sandia National Laboratories, Albuquerque, NM (2006).
- Rice University, Chemical and Biomolecular Engineering Department (2006).
- University of Michigan, Department of Chemical Engineering (2006).
- University of Colorado, Department of Chemical and Biological Engineering (2006).
- Yale University, Department of Chemical Engineering (2006).
- University of Connecticut, Polymer Program (2006).
- The Pennsylvania State University, Department of Chemical Engineering (2006).
- Northwestern University, Department of Chemical and Biological Engineering (2006).
- Los Alamos National Laboratory (2005).
- Center for Nanoscale Materials Users' Meeting at Argonne National Laboratory (2005).

Contributed Presentations (14 total) –

- American Physical Society (APS) March meeting (2008-2004,2002).
- American Chemical Society (ACS) spring national meeting (2007).
- Materials Research Society (MRS) Fall Meeting (2005).
- American Institute of Chemical Engineers (AIChE) Annual Meeting (2005).
- TECHCON (2005,2003).
- SPIE Microlithography 2004 – Advances in Resist Technology and Processing XXI (2004).
- Society for Experimental Mechanics Annual Conference on Applied Mechanics (2002).