Bradley D. Olsen

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EDUCATION

University of California Berkeley
Ph.D. in Chemical Engineering, December 2007. Minor in Physics.
Thesis: *Structure and Thermodynamics of Semiconducting Rod-Coil Block Copolymers*
Advisor: Prof. Rachel Segalman

Massachusetts Institute of Technology
S.B. in Chemical Engineering, June 2003. Minor in Economics.

RESEARCH APPOINTMENTS

Massachusetts Institute of Technology – Cambridge, MA
Associate Professor — *July 2016-Present*
Paul M. Cook Associate Professor — *July 2015-June 2016*
Paul M. Cook Assistant Professor — *July 2013-June 2015*
Assistant Professor — *Jan. 2013-Jun. 2013*
Raymond A. and Helen E. St. Laurent Assistant Professor — *Dec. 2009-Dec. 2012*
California Institute of Technology – Pasadena, CA
Labs of Profs. Dave Tirrell, Zhen-Gang Wang, and Julie Kornfield, Dept. of Chemical Engineering
Beckman Institute Postdoctoral Fellow — *Jan. 2008-Dec. 2009*
University of California Berkeley – Berkeley, CA
Lab of Prof. Rachel Segalman, Dept. of Chemical Engineering
Graduate Researcher — *Oct. 2003-Dec. 2007*
Massachusetts Institute of Technology – Cambridge, MA
Lab of Prof. Karen Gleason, Dept. of Chemical Engineering
Undergraduate Researcher — *Sept. 2000-June 2003*
Dow Chemical Company – Midland, MI
Intern – Polymer Foams Group — *May 2002-Aug. 2002*
W.R. Grace Construction Products – Cambridge, MA
Intern – Waterproofing Membranes Group — *May 2001-Aug. 2001*
General Mills – Golden Valley, MN
Intern – Analytical Chemistry Group — *April 1999-Aug. 2000*
Massachusetts Institute of Technology – Cambridge, MA
Lab of Prof. Ronald Prinn, Dept. of Earth, Atmospheric, and Planetary Science
Undergraduate Researcher — *Sept. 1999-May 2000*

HONORS AND AWARDS

- Kavli Emerging Leader in Chemistry Lecturer (2017)

- University of Delaware Dept. of Chemical Engineering Colburn Lecture (2016)
- Carnegie Mellon Dept. of Materials Science and Engineering Sigma-Aldrich Lecture (2016)
- Fellow, ACS Division of Polymer Chemistry (2016)
- AIChE Colburn Award (2015)
- Chemical and Engineering News Talented 12 Chemist (2015)
- DuPont Young Investigator Award (2015)
- Camille Dreyfus Teacher Scholar Award (2015)
- ACS PMSE Mark Young Scholar Award (2015)
- U.S.-Japan Kavli Frontiers of Science Participant (2014)
- Frontiers of Engineering Participant (2014)
- MIT Chemical Engineering Graduate Teaching Award (2014)
- Sloan Research Fellowship (2014)
- NSF CAREER Award (2013)
- ACS PMSE Young Investigators Symposium (2012)
- AFOSR YIP Award (2012)
- APS DPOLY/UKPPG Exchange Lecturer (2011)
- NIH NRSA Postdoctoral Fellow (2008-2009)
- Finalist, Padden Award in Polymer Physics (2008)
- Beckman Fellowship, Caltech (2008-2009)
- Poster Award, US/Taiwan Materials Symposium (2007)
- Rohm and Haas Travel Award (2005)
- People's Choice Poster Award, Berkeley Nanotechnology Forum (2005)
- Hertz Fellowship (2003-2007)
- Tau Beta Pi Fellowship (2003-2004)
- Sigma Xi (2003)
- AIChE Northeast Regional Conference Paper Competition, 2nd Place (2003)
- Alpha Chi Sigma Undergraduate Award (2003)
- Tau Beta Pi (2002)
- Dow Outstanding Junior Award (2002)
- Barry M. Goldwater Scholarship (2002)
- Paul E. Gray Undergraduate Research Fellowship (2001-2002)

PEER-REVIEWED PUBLICATIONS

* Publication from independent research career.
** Feature or special articles.

*87. "Loop Control of Gel Mechanics." Y. Gu, K. Kawamoto, M. Zhong, M. Chen, M.J.A. Hore, A.M. Jordan, L.T.J. Korley, B.D. Olsen, and J. Johnson. *Submitted.*
*86. "Relaxation Processes in Supramolecular Metallogels Based on Histidine-Nickel Coordination Bonds." S. Tang and B.D. Olsen. *Submitted.*
*85. "Kinetic Effects on Self-Assembly of Protein-Polymer Bioconjugates in Thin Films Prepared by Flow Coating." D. Chang and B.D. Olsen. *Submitted.*
*84. "Hydrogels that Actuate Selectively in Response to Organophosphates." E. Gkikas, R. Nagarajan, E. Wilusz, and B.D. Olsen. *Submitted.*
*83. "Complex Coacervate Core Micelles for the Dispersion and Stabilization of Organophosphate Hydrolase in Organic Solvents." C.E. Mills, A. Obermeyer, X. Dong, E. Kizilay, J. Walker, and B.D. Olsen. *Submitted.*
*82. "Material Properties of the Cyanobacterial Reserve Polymer Multi-L-Arginyl-Poly-L-Aspartate

(Cyanophycin)." N.A. Khlystov, W.R. Chan, A.M. Kunjapur, W. Shi, K.L.J. Prather, and B.D. Olsen. *Submitted.*

*81. "Quantifying Polymer Network Elasticity." M. Zhong, R. Wang, K. Kawamoto, B.D. Olsen, and J.A. Johnson. *Submitted.*

*80. "Three-Dimensional Ordered Antibody Arrays Through Self-Assembly of Antibody-Polymer Conjugates." X. Dong, A. Obermeyer, and B.D. Olsen. *Submitted.*

*79. "An Injectable Shear-Thinning Biomaterial for Endovascular Embolization." R.K. Avery, M. Akbari, H. Albadawi, B.D. Olsen, A. Khademhosseini, and R. Oklui. *Submitted.*

*78. "Self-Diffusion of Associating Star-Shaped Polymers." S. Tang, A. Habicht, S. Li, S. Seifert, and B.D. Olsen. *Macromolecules* **2016**, *ASAP online.*

*77. "The Effect of Protein Electrostatic Interactions on Globular Protein-Polymer Block Copolymer Self-Assembly." C.N. Lam and B.D. Olsen. *Biomacromolecules* **2016**, *ASAP online.*

*76. "Complex Coacervation of Supercharged Proteins With Polyelectrolytes." A.C. Obermeyer, C.E. Mills, X. Dong, and B.D. Olsen. *Soft Matter* **2016**, *12*, 3570-3581.

*75. "Self-Assembly of Differently Shaped Protein-Polymer Conjugates Through Modification of the Bioconjugation Site." A. Huang and B.D. Olsen. *Macromolecular Rapid Communications* **2016**, *15*, 1268-1274.

*74. "Self-Assembly of Protein-Zwitterionic Polymer Bioconjugates Into Nanostructured Biomaterials." D. Chang and B.D. Olsen. *Polymer Chemistry* **2016**, *7*, 2410-2418.

*73. "Biosynthesis of Novel Glycolate-Containing Polymers From Glucose by Metabolically Engineered *Escherichia coli*." Z.-J. Li, K. Qiao, W. Shi, B. Pereira, H. Zhang, B.D. Olsen, and G. Stephanopoulos. *Metabolic Engineering* **2016**, *35*, 1-8.

*72. "Antiviral Agents from Multivalent Presentation of Sialyl Oligosaccharides on Brush Polymers." S. Tang, W. Puryear, B. Seifried, X. Dong, J. Runstadler, K. Ribbeck, and B.D. Olsen. *ACS Macro Letters* **2016**, *5*, 413-418.

*71. "Design of Globular-Coil Protein Fusions for Block Copolymer Self-Assembly." G. Qin, P. Perez, C.E. Mills, and B.D. Olsen. *Biomacromolecules* **2016**, *17*, 928-934.

*70. "Universal Cyclic Topology in Polymer Networks." R. Wang, A. Alexander-Katz, J.A. Johnson, and B.D. Olsen. *Physical Review Letters* **2016**, *116*, 188302.

*69. "Counting Primary Loops in Tetra and Mixed Functionality Click Hydrogels." K. Kawamoto, M. Zhong, R. Wang, B.D. Olsen, and J.A. Johnson. *Macromolecules* **2016**, *24*, 8980-8988.

*68. "Thermoresponsive and Mechanical Properties of Highly Concentrated Aqueous Poly(L-proline) Solutions." E. Gkikas, R.K. Avery, and B.D. Olsen. *Biomacromolecules* **2016**, *17*, 399-406.

*67. "Toughening of Thermoresponsive Arrested Networks of Elastin-Like Polypeptides to Engineer Biocompatible Tissue Scaffolds." M.J. Glassman, R.K. Avery, A. Khademhosseini, and B.D. Olsen. *Biomacromolecules* **2016**, *17*, 415-426.

*66. "Arrested Phase Separation of Elastin-Like Polypeptide Solutions Yields Stiff, Thermoresponsive Gels." M.J. Glassman and B.D. Olsen. *Biomacromolecules* **2015**, *16*, 3762-3773.

*65. "The Shape of Protein-Polymer Conjugates in Dilute Solution." C.N. Lam, D. Chang, M. Wang, W.-R. Chen, and B.D. Olsen. *J. Poly. Sci. A Polymer Chemistry* **2015**, *54*, 292-302.

*64. "A Highly Elastic and Rapidly Crosslinkable Elastin-Like Polypeptide-Based Hydrogel for Biomedical Applications." Y.-N. Zhang, R.K. Avery, Q. Vallmajo-Martin, A. Assman, A. Vegh, A. Memic, B.D. Olsen, N. Annabi, and A. Khademhosseini. *Advanced Functional Materials* **2015**, *25*, 4814-4826.

*63. "Crossover Between Activated Reptation and Arm Retraction Mechanisms in Entangled Rod-Coil Block Copolymers." M. Wang, A.E. Likhtman, and B.D. Olsen. *Journal of Chemical Physics* **2015**, *143*, 184904.

*62. "Anomalous Self-Diffusion and Sticky Rouse Dynamics in Associative Protein Hydrogels." S. Tang, M. Wang, and B.D. Olsen. *Journal of the American Chemical Society* **2015**, *137*, 3946-3957.

*61. "Artificially Engineered Protein Hydrogels Adapted From the Nucleoporin Nsp1 for Selective

Biomolecular Transport." M. Kim, W.G. Chen, M.J. Glassman, J.-W. Kang, K. Ribbeck, and B.D. Olsen. *Advanced Materials* **2015**, *27*, 4207-4212.

*60. "Scattering from Colloid-Polymer Conjugates with Excluded Volume Effect." X. Li, C.N. Lam, L.E. Sanchez-Diaz, G. Smith, B.D. Olsen, and W. Chen. *ACS Macro Letters* **2015**, *4*, 165-170.

*59. "Endblock Design Modulates the Assembly and Mechanics of Thermoresponsive, Dual-Associative Protein Gels." M.J. Glassman and B.D. Olsen. *Macromolecules* **2015**, *48*, 1832-1842.

*58. "Self-Diffusion and Constraint Release in Isotropic Entangled Rod-Coil Block Copolymers." M. Wang, K. Timachova, and B.D. Olsen. *Macromolecules* **2015**, *48*, 3121-3129.

*57. "Tube Curvature Slows Motion of Rod-Coil Block Copolymers Through Activated Reptation." M. Wang, A.E. Likhtman, and B.D. Olsen. *ACS Macro Letters* **2015**, *4*, 242-246.

*56. "Highly Active Biocatalytic Coatings from Protein-Polymer Diblock Copolymers." A. Huang, G. Qin, and B.D. Olsen. *ACS Applied Materials and Interfaces* **2015**, *7*, 14660-14669.

*55. "Synthesis and Application of Protein-Containing Block Copolymers." A.C. Obermeyer and B.D. Olsen. *ACS Macro Letters* **2015**, *4*, 101-110.

*54. "Topological Effects on Globular Protein-ELP Fusion Block Copolymer Self-Assembly." G. Qin, M.J. Glassman, C.N. Lam, D. Chang, E. Schiable, A. Hexemer, and B.D. Olsen. *Advanced Functional Materials* **2015**, *25*, 729-738.

*53. "Chain Configurations and Rate-Dependent Rheological Properties in Transient Networks." M.K. Sing, Z.G. Wang, G.H. McKinley, and B.D. Olsen. *Soft Matter* **2015**, *11*, 2085-2096.

*52. "Responsive Block Copolymer Photonics Triggered by Protein-Polyelectrolyte Coacervation." Y. Fan, S. Tang, E.L. Thomas, and B.D. Olsen. *ACS Nano* **2014**, *8*, 11467-11473.

*51. "Kinetics of Magnetic Field-Induced Orientational Ordering in Block Copolymer/Superparamagnetic Nanoparticle Composites." V. Raman, T.A. Hatton, and B.D. Olsen. *Macromolecular Rapid Communications* **2014**, *35*, 2005-2011.

*50. "Controlling Topological Entanglement in engineered Protein Hydrogels with a Variety of Thiol Coupling Chemistries." S. Tang and B.D. Olsen. *Frontiers in Chemistry* **2014**, *2*, 23.

*49. "Effect of Polymer Chemistry on Globular Protein-Polymer Block Copolymer Self-Assembly." D. Chang, C.N. Lam, and B.D. Olsen. *Polymer Chemistry* **2014**, *5*, 4884-4895.

*48. "Acid-Induced Microphase Separation in Thin Films of a Polyelectrolyte-Hydrophilic Diblock Copolymer." C.R. Stewart-Sloan and B.D. Olsen. *ACS Macro Letters* **2014**, *3*, 410-414.

*47. "Defects, Solvent Quality, and Photonic Response in Lamellar Block Copolymer Gels." Y. Fan, J.J. Walish, S. Tang, B.D. Olsen, and E.L. Thomas. *Macromolecules* **2014**, *47, 1130-1136.*

*46. "Phase Behavior of a Model Globular Protein-Polymer Diblock Copolymer." C.S. Thomas and B.D. Olsen. *Soft Matter* **2014**, *10*, 3093-3102.

*45. "Shear-Thinning Nanocomposite Hydrogels for the Treatment of Hemorrhage." A.K. Gaharwar, R.K. Avery, G. McKinley, A. Khademhosseini, and B.D. Olsen. *ACS Nano* **2014**, *8*, 9833-9842.

*44. "Enhanced Activity and Stability of Organophosphorous Hydrolase via Interaction with an Amphiphilic Polymer." M. Kim, E. Gkikas, A. Huang, J.W. Kang, R. Nagarajan, and B.D. Olsen. *Chem. Commun.* **2014**, *50*, 5345-5348.

*43. "Crossover Experiments Applied to Network Formation Reactions: Improved Strategies for Counting Elastically Inactive Molecular Defects in PEG Gels and Hyperbranched Polymers." H. Zhou, E.-M. Schon, M. Wang, M.J. Glassman, J. Liu, D.D. Diaz, B.D. Olsen, and J.A. Johnson. *J. Am. Chem. Soc.* **2014**, *136*, 9464-9470.

*42. "The Nature of Protein Interactions Governing Globular Protein-Polymer Block Copolymer Phase Behavior." C.N. Lam, M. Kim, C.S. Thomas, D. Chang, G. Sanoja, C.U. Okwara, and B.D. Olsen. *Biomacromolecules* **2014**, *15*, 1248-1258.

*41. "Oxidatively Responsive Chain Extension to Topologically Entangle Artificially Engineered Protein Hydrogels." S. Tang, M.J. Glassman, S. Li, S. Socrate, and B.D. Olsen. *Macromolecules* **2014** *47*, 791-799.

*40. "Gellan Gum Microgel-Reinforced Cell-Laden Gelatin Hydrogels." H. Shin, B.D. Olsen, and A.

Khademhosseini. *Journal of Materials Chemistry B* **2014**, *2*, 2508-2516.

39. "Engineering Materials from Protein." B.D. Olsen. *AIChE Journal* **2013, *59*, 3558-3568. [Invited perspective article, cover.]

*38. "Magnetic Field-Induced Morphological Transitions in Block Copolymer Nanocomposites." V. Raman, R. Sharma, B.D. Olsen, and T.A. Hatton. *ACS Macro Letters* **2013**, *2*, 655-569.

37. "Self-Assembly of Globular Protein Containing Block Copolymers." B.D. Olsen. *Macromolecular Chemistry and Physics* **2013, *214*, 1659-1668. [Invited research highlight.]

*36. "Diffusion of Rod-Coil Diblock Copolymers." M. Wang, K. Timachova, and B.D. Olsen. *Macromolecules* **2013**, *46*, 1651-1658.

*35. "The Effect of Small Molecule Osmolytes on the Self-Assembly and Functionality of Globular Protein Polymer Block Copolymers." C.S. Thomas, L. Xu, and B.D. Olsen. *Biomacromolecules* **2013**, *14*, 3064-3072.

34. "Structure and Mechanical Response of Protein Hydrogels Reinforced by Block Copolymer Self-Assembly." M. Glassman and B.D. Olsen. *Soft Matter* **2013, *29*, 6814-6823. [Young investigator's feature issue; selected as hot article for June 2013]

*33. "Site-Specific Conjugation of Proteins to RAFT Polymers via Expressed Protein Ligation." Y. Xia, S. Tang, and B.D. Olsen. *Chem. Comm.***2013**, *49*, 2566-2568.

32. "Physics of Engineered Protein Hydrogels." M. Kim, S. Tang, and B.D. Olsen. *Journal of Polymer Science B: Polymer Physics* **2013, *51*, 587-601. [Young investigator's feature issue.]

*31. "Experimental Measurement of Coil-Rod-Coil Block Copolymer Tracer Diffusion Through Entangled Coil Homopolymers." M. Wang, K. Timachova, and B.D. Olsen. *Macromolecules* **2013**, *46*, 1651-1658.

30. "Phase Transitions in Concentrated Solution Self-Assembly of Globular Protein-Polymer Block Copolymers." C.N. Lam and B.D. Olsen. *Soft Matter* **2013, *9*, 2393-2402. [Cover.]

29. "Reinforcement of Shear-Thinning Injectable Protein Hydrogels by Responsive Block Copolymer Self-Assembly". M.J. Glassman, S. Li, J. Chan, and B.D. Olsen. *Advanced Functional Materials* **2013, *23*, 1182-1193. [Cover.]

*28. "Coaxing Gels into Revealing Their Junction Connectivity: Counting Primary Loops in Polymer Networks." H. Zhou, J. Woo, A. Cok, M. Wang, B.D. Olsen, and J.A. Johnson. *Proceedings of the National Academy of Sciences of the USA* **2012**, *109*, 19119-19124.

*27. "Long Range Ordering of Symmetric Block Copolymers by Chaining of Superparamagnetic Nanoparticles in External Magnetic Fields." V. Raman, A. Bose, B.D. Olsen, and T.A. Hatton. *Macromolecules* **2012**, *45*, 9373-9382.

*26. "Processing-Dependent Self-Assembly of Protein-Polymer Diblock Copolymers." C.S. Thomas, L. Xu, and B.D. Olsen. *Biomacromolecules*, **2012**, *13*, 2781-2792.

*25. "Nanopatterned Protein Films Directed by Ionic Complexation With Block Copolymers." B. Kim, C.N. Lam, and B.D. Olsen. *Macromolecules* **2012**, *45*, 4572-4580.

*24. "Cell-Laden Double Network Hydrogel With High Mechanical Strength." H. Shin, B.D. Olsen, and A. Khademhosseini. *Biomaterials* **2012**, *33*, 3143-3152.

*23. "Hindered Reptation in Entangled Rod-Coil Block Copolymers Due to Conformation Mismatch." M. Wang, A. Alexander-Katz, and B.D. Olsen. *ACS Macro Letters* **2012**, *1*, 676-680.

*22. "Solid-State Nanostructured Materials from Self-Assembly of a Globular Protein-Polymer Diblock Copolymer." C.S. Thomas, M.J. Glassman, and B.D. Olsen. *ACS Nano* **2011**, *5*, 5697-5707.

21. "Injectable Hydrogels from Telechelic Proteins by a Shear Banding Mechanism." B.D. Olsen, J.A. Kornfield, and D.A. Tirrell. *Macromolecules* **2010**, *43*, 9094-9099.

20. "Liquid Crystalline Orientation of Rod Blocks Within Lamellar Nanostructures from Rod-Coil Diblock Copolymers." B.D. Olsen, X. Gu, E. Gann, A. Hexemer, and R.A. Segalman. *Macromolecules* **2010**, *43*, 6531-6534.

19. "Efficient Synthesis of Narrowly Dispersed Brush Copolymers and Study of Their Assemblies: The Importance of Side Chain Arrangement." Y. Xia, B.D. Olsen, J.A. Kornfield, and R.H. Grubbs. *Journal of the American Chemical Society*, **2009**, *131*, 18525-18532.

18. "Rheological Properties and the Mechanical Signatures of Phase Transitions in Weakly Segregated Rod-Coil Block Copolymers." B.D. Olsen, N.P. Teclemariam, S.J. Muller, and R.A. Segalman. *Soft Matter* **2009**, *5*, 2453-2462.
17. "Near Surface and Internal Lamellar Structure and Orientation in Thin Films of Rod-Coil Block Copolymers." B.D. Olsen, X. Li, J. Wang, and R.A. Segalman. *Soft Matter* **2009**, *5*, 182-192.
16. "Universalization of the Phase Diagram for a Model Rod-Coil Diblock Copolymer." B.D. Olsen, M. Shah, V. Ganesan, and R.A. Segalman. *Macromolecules* **2008**, *41*, 6809-6817.
15. "Self-Assembly of Rod-Coil Block Copolymers." B.D. Olsen and R.A. Segalman. *Materials Science and Engineering R-Reports* **2008**, *62*, 37-66.
14. "Square Grains in Asymmetric Rod-Coil Block Copolymers." B.D. Olsen, M.F. Toney, and R.A. Segalman. *Langmuir* **2008**, *24*, 1604-1607.
13. "Crystalline Structure in Thin Films of DEH-PPV Homopolymer and PPV-b-PI Rod-Coil Block Copolymers." B.D. Olsen, D. Alcazar, V. Krikorian, M.F. Toney, E.L. Thomas, and R.A. Segalman. *Macromolecules* **2008**, *41*, 58-66.
12. "Hierarchical Nanostructure Control in Rod-Coil Block Copolymers with Magnetic Fields." Y. Tao, H. Zohar, B.D. Olsen, and R.A. Segalman. *Nano Letters* **2007**, *7*, 2742-2746.
11. "Nonlamellar Phases in Asymmetric Rod-Coil Block Copolymers at Increased Segregation Strengths." B.D. Olsen and R.A. Segalman. *Macromolecules* **2007**, *40*, 6922-6929.
10. "Domain Size Control by Self-Assembly of Rod-Coil Block Copolymers and Homopolymers Blends." Y. Tao, B.D. Olsen, V. Ganesan, and R.A. Segalman. *Macromolecules* **2007**, *40*, 3320-3327.
9. "Thin Film Structure of Symmetric Rod-Coil Block Copolymers." B.D. Olsen, X. Li, J. Wang, R.A. Segalman. *Macromolecules* **2007**, *40*, 3287-3295.
8. "Phase Transitions in Asymmetric Rod-Coil Block Copolymers." B.D. Olsen and R.A. Segalman. *Macromolecules* **2006**, *39*, 7078-7083.
7. "Higher Order Liquid Crystalline Structure in Low-Polydispersity DEH-PPV." B.D. Olsen, S.-Y. Jang, J.M. Lüning, and R.A. Segalman. *Macromolecules* **2006**, *39*, 4469-4479.
6. "Polymeric Nanocoatings by Hot-Wire Chemical Vapor Deposition (HWCVD)." K.K.S. Lau, Y. Mao, H.G. Pryce Lewis, S.K. Murthy, B.D. Olsen, L.S. Loo, and K.K. Gleason. *Thin Solid Films* **2006**, *501*, 211-215.
5. "Structure and Thermodynamics of Weakly Segregated Rod-Coil Block Copolymers." B.D. Olsen and R.A. Segalman. *Macromolecules* **2005**, *38*, 10127-10137.
4. "Peptide Attachment to Vapor Deposited Polymeric Thin Films." S.K. Murthy, B.D. Olsen, and K.K. Gleason. *Langmuir* **2004**, *20*, 4774-4776.
3. "Effect of Filament Temperature on the Chemical Vapor Deposition of Fluorocarbon-Organosilicon Copolymers." S.K. Murthy, B.D. Olsen, and K.K. Gleason. *J. App. Poly. Sci.* **2004,** *91*, 2176-2185.
2. "Making Thin Polymeric Materials, Including Fabrics, Microbicidal and Also Water-Repellent." J. Lin, S.K. Murthy, B.D. Olsen, K.K. Gleason, A.M. Klibanov. *Biotechnology Letters* **2003**, *25*, 1661-1665.
1. "Initiation of Cyclic Vinylmethylsiloxane Polymerization in a Hot-Filament Chemical Vapor Deposition Process." S.K. Murthy, B.D. Olsen, and K.K. Gleason. *Langmuir* **2002**, *18*, 6424-6428.

BOOKS AND BOOK CHAPTERS

3. "Self-Assembly of Protein-Polymer Conjugates." X. Dong, A. Huang, A.C. Obermeyer, and B.D. Olsen. Chapter in Self-Assembled Nanomaterials. R. Nagarajan, Ed. Submitted.
2. "Physically Crosslinked Injectable Hydrogels." M.J. Glassman and B.D. Olsen. Chapter in Injectable Hydrogels for Tissue Regeneration. L. Nair, Ed. Imperial College Press, 2016.
1. "Protein Nanopatterning." C.N. Lam, D. Chang, and B.D. Olsen. Chapter in

Bionanotechnology: From Fundamental Principles to Applications, L. Dai and M. Zhang, Eds. In press.

INVITED PRESENTATIONS

* Plenary or keynote lecture.

99. "Thermodynamics of Globular Protein-Polymer Block Copolymers." Polymer Physics Gordon Research Conference, South Hadley, MA, July 25, 2016.
98. "Protein Materials Derived From Nucleoporins." Congress of the Brazilian Society for Cell Biology, São Paulo, Brazil, July 14, 2016.
97. "Bioactive Polymeric Materials." University of São Paulo Institute of Chemistry, São Paulo, Brazil, July 13, 2016.
96. "Theory for the Effect of Topological Defects In Polymer Networks." International Conference on Polymer Physics, Guiyang City, China, June 11, 2016.
95. "Engineering a Minimal Consensus Repeat From Nucleoporin Nsp1 for New Selective Biomaterials." Bioinspired Materials Gordon Research Conference, Les Diablerets, Switzerland, June 6, 2016.
94. "Revisiting the Physical Chemistry of Polymer Networks." Department of Chemical Engineering, University of California Santa Barbara, Goleta, CA, May 19, 2016.
93. "Revisiting the Physical Chemistry of Polymer Networks." Squishy Physics Seminar at Harvard University, Cambridge, MA, May 4, 2016.
92. "Bioactive Polymeric Materials." DuPont Industrial Biotechnology (Genencor), Palo Alto, CA, April 21, 2016.
91. "Charge Effects on the Self-Assembly of Protein Block Copolymer Nanostructures." American Physical Society March Meeting, Baltimore, MD, March 14, 2016.
90. "Protein Nanopatterning With Bioconjugate Block Copolymers." Department of Chemical Engineering, Tulane University, New Orleans, LA, February 12, 2016.
89. "Biochemistry and Engineering of New Materials." Estee Lauder Corp., Melville, NY, January 15, 2016.
88. "New Mode of Diffusion in Block Copolymers." Kramer Memorial Symposium, Santa Barbara, CA, January 7, 2016.
87. "Design of Self-Assembling Protein-Polymer Conjugates." Pacific Polymer Conference, Kauai, HI, December 12, 2015.
86. "Self-Diffusion in Physical Polymer Gels." Pacific Polymer Conference, Kauai, HI, December 12, 2015.
85. "Protein Nanopatterning with Block Copolymers." National Institute of Standards and Technology, Gaithersburg, MD, November 23, 2015.
84. "New Functionality and New Physics from Artificially Engineered Protein Gels." Universidade Federal do Rio Grande, Rio Grande, Brazil, October 6, 2015.
83. "New Functionality and New Physics from Artificially Engineered Protein Gels." Universidade Federal do Rio de Janeiro PEQ, Rio de Janeiro, Brazil, September 29, 2015.
82. "Self-Assembly of Enzyme-Polymer Conjugates and Fusion Proteins into Biologically Active Films." Brazil MRS Annual Meeting, Rio de Janeiro, Brazil, September 28, 2015.
81. "Biofunctionality in Synthetic Materials." DuPont Young Investigator Award Lecture, DuPont Corp., Wilmington, DE, September 25, 2015.
80. "Biofunctionality in Synthetic Materials." UNICAMP Faculdade de Engenheria Química, August 25, 2015.
79. "Self-Assembly of Bioconjugate and Fusion Protein Block Copolymers Containing Globular Proteins." Mark Young Scholar Award Lecture, ACS National Meeting, August 19, 2015.
78. "Nanostructuring Proteins and Block Copolymers Based on Ionic Interactions." ACS National

Meeting, Boston, MA, August 17, 2015.

77. "Strong and Tough Elastin Gels by Kinetically Arrested Phase Separation of Polymer Solutions." ACS National Meeting, Boston, MA, August 16, 2015.
76. "New Phenomena in the Diffusion of Complex Polymer Systems." ACS National Meeting, Boston, MA, August 16, 2015.
75. "New Function and New Phyiscs From Protein Polymers." Seoul National University Foreign Lecture, Seoul, Korea, July 9, 2015.
74. "New Function and New Physics From Artificially Engineered Protein Gels." Pohang Institute of Science and Technology Chemistry Seminar, Pohang, Korea, July 7, 2015.
73. "Self-Assembly of Bioconjugate and Fusion Block Copolymers Containing Globular Proteins." MRS Singapore Meeting, Singapore, July 1, 2015.
72. "Nanostructuring Proteins and Block Copolymers Based on Ionic Interactions." Telluride Science Research Conference on Polymer Physics, Telluride, CO, June 25, 2015.
71. "New Polymers from Natural Materials." Natura Corporation, Cabajur, SP, Brazil, May 15, 2015.
70. "Biofunctionalidade em Materiais Sintéticos." Brazil Challenge of Innovation Conference, São Paulo, Brazil, May 14, 2015.
69. "New Function and New Physics From Artificially Engineered Protein Gels." University of Warwick Department of Chemistry, Warwick, UK, May 1, 2015.
68. "New Physics in Associating Polymer Gels." Case Western Reserve University Department of Macromolecular Science and Engineering, Cleveland, OH, February 20, 2015.
67. "Self-Assembly and Biocatalysis With Globular Protein-Polymer Block Copolymers." University of Akron Department of Polymer Engineering, Akron, OH, February 19, 2015.
66. "Dynamics of Artificially Engineered Protein Gels Based on Coiled-Coil Associating Groups." American Institute of Chemical Engineers Annual Meeting, Atlanta, GA, November 20, 2014.
65. "Smart Mechanics and Biological Selectivity in Engineered Protein Hydrogels." Research Triangle MRSEC Seminar, Durham, NC, October 30, 2014.
64. "Mechanics of Protein Hydrogels." MIT Department of Mechanical Engineering, Cambridge, MA, October 21, 2014.
63. "Thermodynamics of Protein Block Copolymer Self-Assembly." Center for Integrated Nanotechnologies User Meeting, Santa Fe, NM, September 22, 2014.
62. "Smart Mechanics and Biological Selectivity in Engineered Protein Hydrogels." Yale University Department of Chemical Engineering, New Haven, CT, September 17, 2014.
61. "Self-Assembly and Biocatalysis With Globular Protein-Polymer Block Copolymers." University of Houston Department of Chemical Engineering, Houston, TX, September 5, 2014.
60. "Self-Assembly and Biocatalysis With Globular Protein-Polymer Block Copolymers." Rice University Department of Chemical Engineering, Houston, TX, September 4, 2014.
59. "Making Coiled-Coils Play New Tricks: Tough, Extensible, Responsive, and Bioselective Gels." SMART BioSyM Seminar, CREATE, Singapore, July 24, 2014.
58. "Making Coiled-Coils Play New Tricks: Tough, Extensible, Responsive, and Bioselective Gels." Nanyang Technological Unviersity, Singapore, July 22, 2014.
57. "Self-Assembly of Globular Protein-Polymer Block Copolymers." Ningbo University School of Chemical Engineering and Materials Science, Ningbo, China, June 13, 2014.
56. "Responsively Enhancing the Mechanics of Injectable Protein Hydrogels." Northwestern University Department of Chemical Engineering, Chicago, IL, May 15, 2014.
55. "Effect of Protein Interactions on the Self-Assembly of Globular Protein-Polymer Diblock Copolymers." American Chemical Society National Meeting, Dallas, TX, March 20, 2014.
54. "Solution Self-Assembly of Globular Protein-Polymer Conjugate Block Copolymers." American Physical Society March Meeting, Denver, CO, March 3, 2014.
53. "Self-Assembly of Globular Proteins into Biofunctional Nanomaterials." University of California Berkeley Department of Chemical Engineering, Berkeley, CA, February 19, 2014.
52. "What Governs the Self-Assembly of Protein-Polymer Conjugates?" Telluride Research Conference,

Telluride, CO, February 4, 2014.

51. "Bringing Biological Functionality Into Synthetic Materials." MIT-Japan Technology Conference, Tokyo, Japan, January 24, 2014.
50. "Bringing Biological Functionality Into Synthetic Materials." Teijin Corporation, Osaka, Japan, January 22, 2014.
49. "Self-Assembly of Globular Protein-Polymer Block Copolymers." Kyoto University, Kyoto, Japan, January 20, 2014.
*48. "Protein Nanomaterials from Bioconjugate Block Copolymer Self-Assembly." American Institute of Chemical Engineers Annual Meeting, San Francisco, CA, November 2013. [Plenary lecture.]
47. "Diffusion in Entangled Rod-Coil Block Copolymers." American Institute of Chemical Engineers Annual Meeting, San Francisco, CA, November 2013.
46. "Responsive Mechanical Enhancement of Protein Gels." Rensselaer Polytechnic Institute Department of Materials Science, Troy, NY, October 2013.
45. "Self-Assembly of Globular Protein-Polymer Block Copolymers." University of Maryland Biophysics Program, College Park, MD, October 2013.
44. "Responsive Mechanical Enhancement of Protein Gels." Harvard Frontiers in Biotechnology Lecture Series, Cambridge, MA, October 2013.
43. "Responsive Mechanical Enhancement of Protein Gels." Pennsylvania State University Department of Chemical Engineering, State College, PA, September 2013.
42. "Bringing Biological Functionality into Synthetic Materials." The Dow Chemical Company, Spring Hill, PA, June 2013.
41. "Nanomaterials from the Self-Assembly of Globular Proteins." Oak Ridge National Lab, Oak Ridge, TN, May 2013.
40. "Self-Assembly and Dynamics of Functional Polymers." MIT Excitonics Seminar Series, May 2013.
39. "Engineering Smart Mechanics Into Artificial Protein Polymers." University of Manchester, Manchester, UK, May 2013.
38. "Emerging Directions in Polymer Science." Reliance Technologies Corporation, Mumbai, India, March 2013.
37. "Emerging Directions in Polymer Science." Aditya Birla Group, Mumbai, India, March 2013.
36. "New Materials Concepts for Protein Encapsulation and Release." Dr. Reddy's Corporation, Hyderabad, India, March 2013.
*35. "Bringing Biological Functionality Into Synthetic Materials." Emerging Technologies Conference India, Bangalore India, March 2013. [Keynote lecture.]
34. "Self-Assembly of Globular Protein-Polymer Block Copolymers." University of Connecticut Department of Chemistry, January 2013.
33. "Self-Assembled Protein Nanomaterials." Union College Department of Physics and Astronomy, January 2013.
32. "Self-Assembly of Globular Protein-Polymer Block Copolymers." Purdue University Department of Chemical Engineering, January 2013.
31. "Self-Assembly of Block Copolymers Containing Globular Proteins." Macromolecular Materials Gordon Research Conference, Ventura, CA, January 2013.
30. "Responsive Gel-Gel Phase Transitions in Artificially Engineered Protein Hydrogels." Materials Research Society Fall Meeting, Boston, MA. November 2012.
*29. "Responsive Gel-Gel Phase Transitions in Artificially Engineered Protein Hydrogels." American Institute of Chemical Engineers Annual Meeting, Pittsburgh, PA. October 2012. [Plenary lecture.]
28. "Self-Assembly of Globular Protein-Polymer Block Copolymers." University of Rhode Island Department of Chemical Engineering, October 2012.
27. "Kinetic Processes for Nanostructure Self-Assembly in Globular Protein-Polymer Block Copolymers." American Chemical Society Fall Meeting, Philadelphia, PA. August 20, 2012.
26. "Responsive Gel-Gel Phase Transitions in Artificially Engineered Protein Hydrogels." International

Conference of Young Research on Advanced Materials, Singapore. July 6, 2012.

25. "Physics of Protein-Polymer Hybrid Block Copolymers and Complexes." Tsinghua University, Beijing, China, June 8, 2012.
24. "Physics of Protein-Polymer Hybrid Block Copolymers and Complexes." Peking University, Beijing, China, June 7, 2012.
23. "Self-Assembly of Block Copolymers Containing Globular Proteins." International Conference on Polymer Chemistry, Changchun, China. June 2012.
22. "Self-Assembled Nanomaterials from Globular Protein-Polymer Diblock Copolymers." American Chemical Society Spring Meeting, San Diego, CA. March 2012.
21. "Responsive Gel-Gel Phase Transitions in Artificially Engineered Protein Hydrogels." APS March Meeting, Boston, MA. February 2012.
20. "Self-Assembled Functional Polymers for Challenges in Energy Conversion." National Nanotechnology Infrastructure Network Computation in Energy Conference, Harvard University, Cambridge, MA. January 10, 2012.
19. "Injectable Protein Gels that Do Not Flow." Tufts University, Medford, MA. November 7, 2011.
18. "Self-Assembly of Globular Proteins Into Nanostructured Materials Using Block Copolymers." Institute for Complex Materials and Systems Outreach Symposium, Technical University of Eindhoven, Eindhoven, Netherlands. September 16, 2011.
17. "Engineering Protein-Based Materials: The Structure and Thermodynamics of Complex Polymers." DSM Chemelot Central Research, Geleen, Netherlands. September 15, 2011.
16. "Self-Assembly of Globular Proteins Into Nanostructured Plastics Using Block Copolymers." United Kingdom Polymer Physics Group Biannual Meeting, September 12, 2011.
15. "Self-Assembly of Globular Protein-Polymer Diblock Copolymers." Defense Threat Reduction Agency, Fort Belvoir, VA. June 21, 2011.
14. "Precision Soft Materials Engineering Enabled and Inspired by Proteins." DuPont Experimental Station, Wilmington, DE. June 1, 2011.
13. "Self-Assembly of Globular Protein-Polymer Diblock Copolymers." University of Massachusetts, Amherst, MA. May 12, 2011.
12. "Engineering the Mechanical Properties of Triblock and Multiblock Artificial Protein Polymer Hydrogels." University of Massachusetts, Lowell, MA. March 31, 2011.
11. "Block Copolymers for Nanostructured Functional Materials." Pall Corporation, Port Washington, NY. February 17, 2011.
10. "Engineering Protein-Based Hydrogels for Injectability and Toughness." Massachusetts Institute of Technology Program in Polymer Science and Technology Seminar Series, October 20, 2010.
9. "Precision Soft Materials Engineering Enabled by Protein Expression." Army Research Lab, January 28, 2010.
8. "The Effect of Chain Rigidity on the Self-Assembly of Functional Block Copolymers." University of Wisconsin Madison Department of Chemical and Biological Engineering, March 4, 2008.
7. "Towards a Universal Phase Diagram for Functional Rod-Coil Block Copolymers." Massachusetts Institute of Technology Department of Chemical Engineering, February 19, 2008.
6. "Towards a Universal Phase Diagram for Functional Rod-Coil Block Copolymers." Georgia Institute of Technology Department of Chemical and Biomolecular Engineering, February 13, 2008.
5. "Towards a Universal Phase Diagram for Functional Rod-Coil Block Copolymers." University of Delaware Department of Chemical Engineering, February 11, 2008.
4. "Towards a Universal Phase Diagram for Functional Rod-Coil Block Copolymers." University of Texas Austin Department of Chemical Engineering, February 7, 2008.
3. "The Effect of Chain Rigidity on the Self-Assembly of Functional Block Copolymers." North Carolina State University Department of Chemical and Biomolecular Engineering, February 4, 2008.
2. "Towards a Universal Phase Diagram for Functional Rod-Coil Block Copolymers." University of

California Los Angeles Department of Chemical and Biomolecular Engineering, February 1, 2008.

1. "Towards a Universal Phase Diagram for Functional Rod-Coil Block Copolymers." Carnegie Mellon University Department of Chemical Engineering, January 22, 2008.

PATENTS

1. U.S. Patent No. 8916683. "Nanostructured Physically Associating Hydrogels for Injectable, Responsive, and Tough Biomaterials." Bradley D. Olsen, Matthew J. Glassman, and Jacqueline Chan. Filing Date: October 5, 2011. Publication Date: December 23, 2014.
2. International PCT Patent Application No.: PCT/US2011/057941
Title: PROTEIN-BASED CONJUGATES AND SELF-ASSEMBLED NANOSTRUCTURES
Applicant: Massachusetts Institute of Technology
Filed: October 26, 2011
Priority Claim: U.S.S.N. 61/406,623
Inventor(s): Bradley D. Olsen and Carla S. Thomas
3. U.S. Application No.: 61/836761
Filing Date: June 19, 2013
Title: Injectable and Self-Healing Nanocomposite Hydrogels for the Treatment of Hemorrhagic Shock
Inventor(s): Akhilesh Gaharwar, Reginald Avery, Gareth McKinley, Ali Khadhemosseini, and Bradley Olsen
4. Provisional Patent Application U.S. Application No.: 62/015012
Applicant: Massachusetts Institute of Technology
Filed: June 20, 2014
Title: Artificially Engineered Protein Hydrogels to Mimic Nucleoporin Selective Gating
Inventor(s): Minkyu Kim and Bradley Olsen
5. U.S. Application No.: 62/161334
Filing Date: May 14, 2015
Title: High Molecular Weight, Post-Translationally Modified Proteins Brushes Through Tyrosine Modification Chemistry
Inventor(s): Brian Michael Seifried and Bradley D. Olsen
6. U.S. Application No.: 62/050823
Filing Date: September 16, 2014
Title: Block Copolymer Complex Coacervate Core Micelles for Enzymatic Catalysis in Organic Solvent
Inventor(s): Carolyn E. Mills, Allie C. Obermeyer, Xuehui Dong, and Bradley D. Olsen
7. U.S. Application No.: 62/254,771
Filing Date: November 13, 2015
Title: Biotoxin Sequestration by Engineered Nuclear Transporter and Nuclear Membrane Mimetic Hydrogel
Inventor(s): Minkyu Kim and Bradley Olsen
8. U.S. Application No.: 62/086,496
Filing Date: December 2, 2015
Entitled: THERMOREVERSIBLE HYDROGELS FROM THE ARRESTED PHASE SEPARATION OF ELASTIN-LIKE POLYPEPTIDES
Inventor(s): Matthew J. Glassman and Bradley D. Olsen

TEACHING EXPERIENCE

Graduate Students Supervised (MIT):

Student	Years	Current Position
Andreia Araújo	2014-	
Reginald Avery	2012-	
Wui-Yarn (Daphne) Chan	2013-	
Dongsook Chang	2012-2015	Oak Ridge National Lab (postdoc)
Yin Fan	2012-2014	Applied Materials
Matthew Glassman	2009-2015	Exponent
Aaron Huang	2012-	
Christopher Lam	2010-2016	Oak Ridge National Lab (postdoc)
Shuaili Li	2014-	
Carolyn Mills	2013-	
Vinay Raman	2010-2013	Saudi Aramco
Irina Rasid	2015-	
Viviani Romani	2014-	
Brian Seifrield	2013-	
Michelle Sing	2011-	
Charlotte Stewart-Sloan	2012-2015	Wolf-Greenfield
Hursh Sureka	2015-	
Shengchang Tang	2010-2016	UC Boulder (postdoc)
Carla Thomas	2009-2013	3M
Helen Yao	2015-	
Muzhou Wang	2009-2014	Northwestern ChemE

Postdoctoral Scholars Supervised (MIT):

Postdoctoral Scholar	Years	Current Position
Xuehui Dong	2013-	
Thomas Dursch	2016-	
Akhilesh Gaharwar	2012-2013	Texas A&M Biomedical Engineering
Manos Gkikas	2012-2016	U. Mass Amherst Chem.
Angela Holmberg	2016-	
Bokyung Kim	2010-2012	Hyundai Motor Corp.
Minkyu Kim	2012-2016	U. Arizona Mat. Sci.
Ebru Kizilay	2013-2014	Yunsa Worsted and Woolen Prod.
Danielle Mai	2016-	
Allie Obermeyer	2014-2016	Columbia ChemE
Guokui Qin	2013-2015	Quad Technologies
Sybele Saska	2014, 2015-2016	UNESP (postdoc)
Weichao Shi	2014-2015	Harvard (postdoc)
Rui Wang	2015-	
Yan Xia	2011-2012	Stanford Chemistry
Yun Jung Yang	2015-	
Mingjiang Zhong	2013-2016	Yale ChemE

Visiting Students & Scholars (MIT):

Visiting Scholar	Years	Home Institution
Prof. Ana Vera Machado	2014-2015	University of Minho
Prof. Vilásia Martins	2014-2015	Federal University of Rio Grande
Prof. Jorge Ramirez	2016	University of Madrid
Prof. Bruno de Souza	2015-2016	Federal University of Santa Catarina
Tomasz Bochenski	2015	Masdar Institute
Chuanji Fang	2016	Masdar Institute
Takuya Suguri	2016-2018	Japan Synthetic Rubber

Undergraduate Researchers Supervised (MIT, Caltech, Berkeley): Alan Dang, Amy Wang, Audrey Pillsbury, Paige Omura, Chung-Yueh Lin, Zachary Michaud, Olivia Fiebig, Latha Uthayakumar, Romeo Flores, Chelsea Edwards, Julia Zhao, Sara (Cheli) Arussy, Noelle Colant, June Park, Paola Perez, Carley Michelle Allen, Xena Vronay-Ruggles, Fabiana Zappala, Ricardo Paez, Karleigh Morro, Ferdinand Dowouo, Amma Okwara, Victoria Wei, Rujia Zha, Abdullah Alsaeed, Nikita Khlystov, Share-Leigh Areneaud-Bernard, Katelyn Rossick, Gabriel Sanoja, Gina Noh, Melody Morris, Joubert Glover, Pritee Tembhekar, Liza Xu, Shuaili Li, Ksenia Timachova, Rachel Bowman, Justine Chia, Jacqueline Chan, Wendy Gu, Jiraksa Ratjatawan, Kevin Lee, Linda Lei, Cindy Lee, Renee Phillip, Douglas Ko

Instructor, Massachusetts Institute of Technology

Structure of Soft Matter (10.466/10.566)	Instructor, developed course
Polymer Synthesis (10.569)	Instructor
Chemical Engineering Thermodynamics (10.40)	Instructor
Introduction to Chemical Engineering (10.10)	Instructor
Molecule Builders (10.00)	Instructor, developed course
Kitchen Chemistry (5.S15)	Instructor

Instructor, Short Courses & Special Topics

Neutron Scattering in Soft Matter, Gels Unit, ORNL	Fall 2013
Short Course on Bioconjugates, UNESP	Fall 2014

Graduate Student Instructor, University of California Berkeley

Process Dynamics and Control (ChE 162)	Spring 2006
Introduction to Polymer Science (ChE 178)	Fall 2004

SERVICE

- Member of editorial board for *Soft Matter*
- Guest editor for *Macromolecular Chemistry and Physics*
- Associate editor for *Materials Science and Engineering Reviews*
- Journal reviewer for *Nature Communications, Macromolecules, Nano Letters, Polymer, Soft Matter, Chemical Society Reviews, Journal of Materials Chemistry, Proceedings of the National Academy of Sciences of the USA, Journal of Biomaterials Science Polymer Edition, Tissue Engineering, Biomacromolecules, Macromolecular Biosciences, Polymer International, Industrial and Engineering Chemistry, ACS Nano, ACS Macro Letters,* and *Langmuir*
- Proposal reviewer/panelist for Stanford Synchrotron Radiation Lab, Army Research Office, Air Force Office of Scientific Research, Molecular Foundry at the Lawrence Berkeley National Lab, National Science Foundation and Department of Energy Office of Basic Energy Sciences
- Member of the Lujan Neutron Sciences Center Materials Program Advisory Board (2013)
- Session chair/co-chair at the American Institute of Chemical Engineers Annual Meeting (2007, 2010-2013) and the American Physical Society (2008-2014)

- Symposium organizer for ACS Fall 2013 meeting
- Member of APS DPOLY Education Committee (2012-2013)
- Member at large of the ACS PMSE Executive committee (2013-2014); ACS PMSE programming chair (2015-2017)
- Vice-chair of AIChE Division 8a (Polymer Materials) (2013-2014) and Chair (2014-2015)
- Member of the MRS, ACS, APS, and AIChE