Christopher L. Soles, Ph. D.

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Education

1998 **Ph.D., University of Michigan**, Materials Science and Engineering, Ann Arbor, MI
1993 **B.S., University of Michigan**, Materials Science and Engineering, Ann Arbor, MI
1993 **B.S., University of Michigan**, Mechanical and Engineering, Ann Arbor, MI

Professional Experience

2007-present **National Institute of Standards and Technology**, Group Leader, Functional Polymers Group, Materials Science & Engineering Division, Gaithersburg, MD

Direct a dynamic team of research scientists developing measurement solutions that facilitate U.S. innovation and industrial competitiveness in the development and use of polymeric and organic materials related to:

- Polymer membranes for ion transport, electrochemical energy storage and water filtration
- Materials and processes for semiconductor electronics manufacturing
- Printed and flexible electronics
- Polymer composites and mechanics

Responsibilities include strategic planning for a $3M per year research group, directing the research of approximately 25 Ph D level scientists, mentoring and career development for both senior NIST scientists and postdoctoral fellows, proposal writing, reporting to other agency funding sources, refereeing peer reviewed journals, and establishing and maintaining collaborations with academic and industrial partners.

2004-2007 **National Institute of Standards and Technology**, Project Leader, Nanostructured Materials Group, Polymers Division, Gaithersburg, MD

Work with industry, academia, and government agencies on fundamental measurement issues that will facilitate nanoimprint lithography as an economically viable lithographic patterning technology.

- X-ray methods to accurately quantify the physical dimensions in nanopatterned materials
- Limitations of polymeric materials in high-resolution nanoimprint patterning
- Stresses and stability issues in nanoimprinted structures
- Patterning of functional materials by nanoimprint lithography
- Porosity measurements in patterned nanoporous low-k interlevel dielectric materials

Responsibilities include managing a research team of 7 people, mentoring 5 postdocs, proposal writing, reporting to other agency funding sources, refereeing peer reviewed journals, and establishing and maintaining collaborations with academic and industrial partners.

2001-2004 **National Institute of Standards and Technology**, Research Engineer, Electronics Materials Group, Polymers Division, Gaithersburg, MD

Develop critically needed high-resolution metrologies to address state-of-the-art scientific issues that potentially hinder new technologies & industries. Specific interests included:

- Deep UV lithography & fundamentals of polymers confined to molecularly thin films
- Porosity measurements in nanoporous low-k interlevel dielectric materials
- Mechanical properties of lithographically patterned nanostructures
- Preservation of biochemical activity in biomaterials & proteinaceous pharmaceuticals
- Role of dynamics in macromolecular systems

Responsibilities include managing laboratories, guest researchers, proposal writing, reporting to other agency funding sources, refereeing peer reviewed journals, and establishing and maintaining collaborations with academic and industrial partners.

1999-2001 **National Institute of Standards and Technology**, NRC Postdoctoral Fellow, Electronics Materials Group, Polymers Division, Gaithersburg, MD

Obtained technical expertise with the following research areas and experimental tools:

- Physical properties of polymers in ultra-thin films and confined geometries
- Low frequency collective motions in macromolecules (proteins, polymers)
- Neutron scattering and reflectivity as both structural and dynamic probes
- Preserving biochemical activity in proteinaceous biomaterials & pharmaceuticals
- Structure-property relationships in silsesquioxane nano-composites

Awards and Honors

2019	ACS Team Innovation Award (V. Prabhu, C. Soles, E. Lin, W.-l. Wu)
2018	Past Chair Award, Polymeric Materials: Science & Engineering Division of the American Chemical Society
2017	Keynote Lecture, 1st Pan-American Polymer Conference (Sao Paulo, Brasil)
2016	Fellow, American Chemical Society
2011	Fellow, American Physical Society
2010	Arthur S. Flemming Award
2008	United States Department of Commerce Bronze Medal Award
2007	National Academy of Science delegate to the Japan-US Frontiers of Science (Kanagawa, Japan)
2007	Plenary Lecture for the Nanoprint & Nanoimprint Technology Conference (Paris, France)
2007	Invited speaker for the Polymers West Gordon Research Conference (Ventura, CA)
2006	United States Department of Commerce Silver Medal Award
2006	United States Department of Commerce Bronze Medal Award
2006	Presidential Early Career Award for Science & Engineering (PECASE)
2006	National Academy of Engineering delegate to the Indo-US Frontiers of Engineering (Agra, India)
2005	Keynote lecture for the Semiconductor International Nanoimprint Lithography Webcast
2004	National Academy of Engineering delegate to the Frontiers of Engineering (Irvine, CA)
2002	NIST Sigma Xi "Best Poster"
1999	NIST/National Research Council Postdoctoral Fellowship
1998	Horace H. Rackham Distinguished Dissertation Award nominee, University of Michigan
1997	Keynote Speaker at the Perkin Elmer Thermal Analysis Fall Seminar Series -Keynote Speaker
1997	University of Michigan, Macromolecular Science & Engineering 21st Symposium - "Outstanding Poster"
1997	University of Michigan Grad-SWE Poster Contest - "Best Content Poster"
1998	Horace H. Rackham School of Graduate Studies Pre-Doctoral Fellow
1996	3M Scholar for Excellence in Research
1995	Departmental Scholarship for Top-Five GPA
1995	Top Rated Teaching Assistant in Materials Science Department
1995	Michigan Materials Society Most Outstanding Teaching Assistant Award

Professional Service

2108	Congressional Briefing, House Committee on Science and Technology - Composites for Infrastructure
2017	NIST - NextFlex Workshop on Databases for Flexible Hybrid Electronics (with Zach Trautt, Scott Miller)
2017	Co-organizer (with Juan de Pablo) - Epoxy Modeling Summit, University of Chicago (ChiMAD, ARL, NIST)
2017	Invited Participant, Advancing & Accelerating Materials Innovation: Opening New Frontiers (NSF Workshop)
2017	Invited Participant, Solving Scientific Challenges with Coherent Soft X-rays (ALS Berkeley Workshop)
2017	Chair, Polymeric Materials: Science & Engineering Division of the American Chemical Society
2016	Invited Participant, NSF Workshop: Frontiers in Polymer Science and Engineering
2016-present	Technical Council, NextFlex -America's Flexible Hybrid Electronics Innovation in Manufacturing Institute
2016	Chair Elect, Polymeric Materials: Science & Engineering Division of the American Chemical Society
2015	Subject Matter Expert & Selection Official, Flexible Hybrid Electronics Innovation in Manufacturing Institute
2015	Vice Chair, Polymeric Materials: Science & Engineering Division of the American Chemical Society
2014	National Science Foundation, Panel Review (July)
2013-2014	Treasurer, Polymeric Materials: Science & Engineering Division of the American Chemical Society
2013-present	Industrial Advisory Board, UT Austin NASCENT Nanosystems Engineering Research Center (NSF)
2013	National Science Foundation, Panel Review (July)
2013	National Science Foundation, Panel Review (May)
2012-2013	American Physical Society Division of Polymer Physics, Fellow Committee
2012	Organizer, American Physical Society Division of Polymer Physics Short Course on "Industrial Polymer Physics"
2012	Organizer, Flexible Printed Electronics Metrology Workshop, Flex Tech Alliance, Gaithersburg, MD
2012	Organizer, US-Japan Workshop on "Advances in Organic/Inorganic Hybrid Materials," Ann Arbor, MI
2011	Organizer, Nanofabrication Technologies for Roll-to-Roll Processing Workshop, Boston, MA
2010	American Physical Society Division of Polymer Physics, Membership Committee
2010	Organizer, Advanced Data Analysis and Modeling Tools for Scattering Methods Workshop, Gaithersburg, MD
2009	Guest Editor of J. Polym. Sci. Part B: Polym. Phys., APS-DPOLY Special Issue
2007-2010	Technical Program Chair, Polymeric Materials: Science & Engineering Division of the American Chemical Society
2006-2012	Chair, Nanotechnology in Microlithography Panel, SPIE Advanced Lithography Conference
2001-2016	American Physical Society Division of Polymer Physics, March Meeting Abstract Sorter

Mentoring and Teaching

Postdoctoral Research Fellows		**Current Affiliation**
2020	Katherine Evan, NRC Postdoctoral Fellow, UC Berkeley	NIST
2018	Amanda Souna, Postdoctoral Fellow, U Maryland	NIST
2018	Marcos Hernandez-Reyes, NRC Postdoctoral Fellow, U Mass Amherst	NIST
2018	Peter Beaucage, NRC Postdoctoral Fellow, Cornell	NIST
2017	Kanae Ito, Postdoctoral Fellow, Fukuoka University	J-PARC
2017	Adam Burns, NRC Postdoctoral Fellow, Princeton	Exxon Mobil Research
2014	Bradley Frieberg, NRC Postdoctoral Fellow, U Michigan	General Motors Tech Center
2014	Jennifer Schaefer, NRC Postdoctoral Fellow, Cornell	Notre Dame **(professor)**
2013	Jacob Tarver, NRC Postdoctoral Fellow, Princeton	NIST
2012	Jenny Kim, NRC Postdoctoral Fellow, U Michigan	Corning
2010	Brandon Rowe, NRC Postdoctoral Fellow, UT Austin	Dow
2010	Cheol Jeong, Seoul National University	NIST
2010	Sangcheol Kim, UC Santa Barbara	Motorola
2010	Ming Liu, U Michigan	NC State
2009	Kenneth Kearns, NRC Postdoctoral Fellow, Wisconsin	Dow
2009	Brendan O'Conner, NRC Postdoctoral Fellow, U Michigan	NC State **(professor)**
2009	Scott Eastman, NRC Postdoctoral Fellow, U Mass Amherst	United Tech Research Company
2009	Marla McConnell, NRC Postdoctoral Fellow, U Penn	USPTO
2008	Jing Zhou, UC Berkeley	Yale (research **professor)**
2008	Jae Hwan Sim, Seoul National University	Dow
2008	Huagen Peng, U Michigan	Sound Exchange
2006	Kyle Alvine, NRC Postdoctoral Fellow, Harvard	Pacific Northwest National Lab
2005	Brian Okerberg, NRC Postdoctoral Fellow, Va Tech	PP&G
2005	Yifu Ding, U Akron	UC Boulder **(professor)**
2004	Hyun Wook Ro, Seoul National University	PP&G

Graduate Students		
2017	Jisoo Shin, University of Maryland	U Maryland Ph D program
2010	Jihoon Kang, Seoul National University	Samsung
2009	Sung Il Lee, Seoul National University	LG Chem
2007	Manish Kulkarni, IIT Kanpur	U Akron
2007	Whirang Cho, Seoul National University	NIST
2004	Jennifer Liu, U Michigan	UC Merced **(professor)**

Undergraduate Students		
2002	Angel Fuentes, U Puerto Rico, NIST SURF program	
2001	Ari Kay, UC Riverside, NIST SURF program	

High School Students		
2019	Jennifer Li, Richard Montgomery High School	
2014	Candy Kuo, Montgomery County Public Schools	U Maryland
2003	Michael Do, Howard County Public Schools	

Patents

2013 R. M. Laine, C. L. Soles, D. J. Krug, H. W. Ro, V. N. Popova-Gueorguieva, *Silsequioxane Derived Hard, Hyrophilic, and Thermally Stable Thin Films and Coatings for Tailorable Protective and Multi-Structured Surfaces and Interfaces*, US 8,535,761 B2

2018 V. O. Oleshko, C. L. Soles, J. J. McClelland, *Dry Prelithiation of Electrode Materials for Lithium Batteries and Capacitors by Controlled Dose Implantation of Lithium Ions*, in progress with the NIST Technology Partnership Office.

Publications

5,810 citations, h-index = 42

Book Chapters

1. *X-ray Reflectivity as a Powerful Metrology to Characterize Pores in Low-k Dielectric Films*, Christopher L. Soles, Hae-Jeong Lee, Ronald C. Hedden Da-wei Liu, Barry J. Bauer, and Wen-li Wu, in "Polymers for Micro- and Nanoelectronics" Ed. Q. Lin, R. A. Pearson, J. C. Hedrick, Oxford University Press, New York (2004) pg 209.

2. *Utilizing Near Edge X-ray Absorption Fine Structure to Probe Interfacial Issues in Photolithography*, Joseph L. Lenhart, Daniel A. Fischer, Sharadha Sambasivan, Eric K. Lin, Christopher L. Soles, Ronald L. Jones, Wen-li Wu, Dario L. Goldfarb, Marie Angelopolous, in "Polymers for Micro- and Nanoelectronics" Ed. Q. Lin, R. A. Pearson, J. C. Hedrick, Oxford University Press, New York (2004) pg 98.

3. *Correlation of the Reaction Front with Roughness in Chemically Amplified Photoresists*, Ronald L. Jones, Vivek M. Prabhu, Darío L. Goldfarb, Eric K. Lin, Christopher L. Soles, Joseph L. Lenhart, Wen-li Wu, and Marie Angelopoulos, in "Polymers for Micro- and Nanoelectronics" Ed. Q. Lin, R. A. Pearson, J. C. Hedrick, Oxford University Press, New York (2004) pg 86.

4. *Pore Characterization in low-k Dielectric Films using X-ray Reflectivity: X-ray Porosimetry*, C.L. Soles, H.J. Lee, E.K. Lin, and W.L. Wu, NIST Recommended Practice Guide, NIST Special Publication 960-13, July, 2004.

5. C.L. Soles, H.-J. Lee, B.D. Vogt, E.K. Lin, and W. Wu, "Structure Characterization of Nanoporous Interlevel Dielectric Thin Films With X-Ray and Neutron Radiation", in *Dielectric Films for Advanced Microelectronics*,Ed. Mikhail Baklanov, Martin Green, Karen Maex, John Wiley and Sons Publisher , West Sussex, England (2007) pg 100 -117.

6. *Peng H, Nieuwendaal R, and Soles CL (2012) Polymer Dynamics in Constrained Geometries.* In: Matyjaszewski K and Möller M (eds.) *Polymer Science: A Comprehensive Reference*, Vol 7, pp. 345–376. Amsterdam: Elsevier BV.
7. "Polyelectrolytes for Batteries and Fuel Cells," edited by Kirt A. Page, Christopher Soles, and James Runt, ACS Symposium Series, Volume 1096, American Chemical Society, Washington, DC (2012).

8. *Inelastic Neutron Scattering on Polymer Electrolytes for Lithium-Ion Batteries*, Hua-Gen Peng, Madhusudan Tyagi, Kirt A. Page, and Christopher L. Soles, in "Polymers for Energy Storage and Delivery: Polyelectrolytes for Batteries and Fuel Cells," Chapter 5, 2012, pp 67-90, ACS Symposium Series, Volume 1096. (peer reviewed book chapter)

9. *Structure and Properties of Proton Exchange Membrane Fuel Cells at Interfaces*, Sangcheol Kim, Kirt A. Page, and Christopher L. Soles, in "Polymers for Energy Storage and Delivery: Polyelectrolytes for Batteries and Fuel Cells," Chapter 16, 2012, pp 267-281, ACS Symposium Series, Volume 1096 (peer reviewed book chapter)

Peer Reviewed Manuscripts

1. *Effect of Limiting Chain Mobility on the Yielding and Crazing Behavior of Bisphenol-A Polycarbonate Derivatives*, C. J. G. Plummer, C. L. Soles, C. Xiao, J. Wu, H.-H. Kausch, and A. F. Yee, *Macromolecules*, **28** (1995) 7157.

2. *Density Fluctuations in Amorphous Systems: SAXS and PALS Results*, L. David, G. Vigier, S. Etienne, A. Faivre, C. L. Soles, and A. F. Yee, *Journal of Non-Crystalline Solids*, **235-237** (1998) 383.

3. *Highly Porous Polyhedral Silsesquioxane Polymers. Synthesis and Characterization*, Chunxin Zhang, Florence Babonneau, Christian Bonhomme, Richard M. Laine, Christopher L. Soles, Hristo A. Hristov, and Albert F. Yee, *Journal of the American Chemical Society*, **120** (1998) 8380.

4. *Contributions of the Nanovoid Structure to the Moisture Absorption Properties of Epoxy Resins*, C. L. Soles, F. T. Chang, B. A. Bolan, H. A. Hristov, D. W. Gidley, and A. F. Yee, *Journal of Polymer Science: Part B: Polymer Physics Edition*, **36** (1998) 3035.

5. *Contributions of the Nanovoid Structure to the Kinetics of Moisture Transport in Epoxy Resins*, Christopher L. Soles, Fernando T. Chang, David W. Gidley, and Albert F. Yee, *Journal of Polymer Science: Part B: Polymer Physics Edition*, **38** (2000) 776.

6. *A Molecular Model of Moisture Transport in Epoxy Resins*, Christopher L. Soles and Albert F. Yee, *Journal of Polymer Science: Part B: Polymer Physics Edition*, **38** (2000) 792.

7. C. L. Soles, E. K. Lin, W.-l. Wu, C. Zhang, and R. M. Laine, *Structural Evolution of Silsesquioxane-based Organic/Inorganic Nanocomposite Networks*, in "Organic/Inorganic Hybrid Materials", edited by R. M. Laine, C. Sanchez, E. Giannelis, and C. J. Brinker (Mat. Res. Soc. Proc., San Francisco, CA), **628** (2000) CC4.2.1.

8. *Correlations of the Boson Peak with Positron Annihilation in Series of Polycarbonate Copolymers*, Christopher L. Soles, Robert M. Dimeo, Dan A. Neumann, Alexander Kisliuk, Alexei P. Sokolov, Jianwei Liu, Albert F. Yee, and Wen-li Wu, *Macromolecules*, **34**, 4082 (2001).

9. *Characterization of Thin and Ultrathin Polymer Resist Films*, Dario L. Goldfarb, Qinghuang Lin, Marie Angelopoulos, Christopher L. Soles, Eric K. Lin, and Wen-Li Wu, *Proc. SPIE*, **4345**, 335 (2001).

10. *Incoherent Neutron Scattering and the Dynamics of Confined Polycarbonate Films*, Christopher L. Soles, Jack F. Douglas, Wen-li Wu, and Robert M. Dimeo, *Phys. Rev. Lett.*, **88**, 7401 (2001).

11. *Correlations of Positron Annihilation and other Dynamic Properties in Glass Forming Substances*, Kia L. Ngai, Christopher L. Soles, Lirong Bao, and Albert F. Yee, *Phys. Rev. Lett.*, **87** (2001) 5901.

12. *Thin Film Confinement Effects on the Thermal Properties of Model Photoresist Polymers* , Soles, C. L., Lin, E. K., Lenhart, J. L., Jones, R. L., Wu, W.-L., Goldfarb, D., and Angelopoulos, M., *Journal of Vacuum Science and Technology B*, **19** (2001) 2690.

13. *Confinement Effects on the Spatial Extent of the Reaction Front in Ultrathin Chemically Amplified Resists* Goldfarb, D. L., Angelopoulos, M., Lin, E. K., Jones, R. L., Soles, C. L., Lenhart, J. L., and Wu, W. L., *Journal of Vacuum Science and Technology B*, **19,** 2699 (2001).

14. *Measurement of the Spatial Evolution of the Deprotection Reaction Front with Nanometer Resolution using Neutron Reflectometry,* E.K. Lin, C.L. Soles, D.L. Goldfarb, B.C. Trinque, S.D. Burns, R.L. Jones, J.L. Lenhart, M. Angelopoulos, C.G. Willson, S.K. Satija, and W.L. Wu, *Proc. SPIE* **4690**, (2002).

15. *Chain Conformation in Ultrathin Polymer Resists*, R. L. Jones, F. W. Starr, C. L. Soles, E. K. Lin, J. L. Lenhart, W. L. Wu, D. L. Goldfarb, M. Angelopoulos, *Proc. SPIE* **4689**, (2002).

16. *Combinatorial Methodology to Discovering the Material Factors Controlling Resist Line Edge Roughness, Shape, and Critical Dimension*, Lenhart, J. L., Jones, R. L., Lin, E. K., Soles, C. L., Wu, W. L., Goldfarb, D. L., and Angelopoulos, M. A, *Journal of Vacuum Science and Technology B* **20**, (2002) 704.

17. *Direct Measurement of the Reaction Front in Chemically Amplified Photoresists with Nanometer Resolution*, E. K. Lin, C. L. Soles, D. L. Goldfarb, B. C. Trinque, S. D. Burns, R. L. Jones, J. L. Lenhart, W.-l. Wu, C. G. Willson, M. Angelopolous, S. K. Satija, *Science* **297**, 372 (2002).

18. *Influence of Solvent on Dynamics and Stability of a Protein*, G. Caliskan, A. Kisliuk, A. M. Tsai, C. L. Soles and A. P. Sokolov, *J. Non-Cryst. Solids* **307-310**, 887 (2002).

19. P*ore Size Distributions in Low-K Dielectric Thin Films from X-ray Porosimetry*, H.-J. Lee, C. L. Soles, D.-w. Liu, B. J. Bauer and Wen-li Wu, *J. Polym. Sci. B Polym. Phys. B* **40**, 2170 (2002).

20. *A Broad Perspective on the Dynamics of Highly Confined Polymer Films,* C.L. Soles, J.F. Douglas, W.L. Wu, H. Peng, and D.W. Gidley, in *MRS Conference Proceedings*, **710** (2002) DD 3.7.1.

21. *Probing Surface and Bulk Chemistry in Resist Films Using NEXAFS*, J.L. Lenhart, R.L. Jones, E.K. Lin, C.L. Soles, W.L. Wu, D.A. Fischer, S. Sambasivan, D.L. Goldfarb, and M. Angelopoulos, *Journal of Vacuum Science & Technology B* **20** (2002) 2920.

22. *Incoherent Neutron Scattering and the Dynamics of Thin Film Photoresist Polymers*, Christopher L. Soles, Jack F. Douglas, Eric K. Lin, Joseph L. Lenhart, Ronald L. Jones, Wen-li Wu, Darío L. Goldfarb and Marie Angelopoulos, *J. Appl. Phys.* **93** (2003) 1978.

23. *Incoherent Neutron Scattering as a Probe of the Dynamics in Molecularly Thin Polymer Films,* C.L. Soles, J.F. Douglas, W.L. Wu, and R.M. Dimeo, *Macromolecules* **36**, 373 (2003).

24. *Protein Dynamics in Viscous Solvents*, G. Caliskan, A. Kisliuk, A. M. Tsai, C. L. Soles, A. P. Sokolov, *J. Chem. Phys.* **118**, 4230 (2003).

25. *Structural Characterization of Methylsilsesquioxane-Based Porous Low-k using X-ray Porosimetry*, H.J. Lee, C.L. Soles, D.W. Liu, B.J. Bauer, W.L. Wu, and E.K. Lin, *International Interconnect Technology Conference (IITC) Proceeding,* June, 2003, Burlingame, CA.

26. *X-ray Absorption Spectroscopy to Probe Interfacial Issues in Photolithography*, J.L. Lenhart, D.A. Fischer, S. Sambasivan, E.K. Lin, R.L. Jones, C.L. Soles, W.L. Wu, D.L. Goldfarb, and M. Angelopoulos, *Proc. SPIE* **5039**, 343 (2003).

27. *Polymer Dynamics and Diffusive Properties in Ultra-thin Photoresist Films,* C.L. Soles, R.L. Jones, J.L. Lenhart, V.M. Prabhu, W.L. Wu, E.K. Lin, D.L. Goldfarb, and M. Angelopoulos, *Proc. SPIE* **5039**, 366 (2003).

28. *Polyelectrolyte Effects in Model Photoresis Developer Solutions: Roles of Base Concentration and Added Salts*, V.M. Prabhu, R.L. Jones, E.K. Lin, C.L. Soles, W.L. Wu, D.L. Goldfarb, and M. Angelopoulos, *Proc. SPIE* **5039**, 404 (2003).

29. *Deprotection Volume Characteristics and Line Edge Morphology in Chemically Amplified Resists*, R.L. Jones, T.J. Hu, V.M. Prabhu, C.L. Soles, E.K. Lin, W.L. Wu, D.L. Goldfarb, M. Angelopoulos, B.C. Trinque, and C.G. Willson, *Proc. SPIE* **5039**, 1031 (2003).

30. *X-ray Reflectivity Porosimetry for the Characterization of Porous Low-k Dielectric Constant Thin Films*, C.L. Soles, H.J. Lee, R.C. Hedden, D.W. Liu, B.J. Bauer, and W.L. Wu, in *Characterization and Metrology for ULSI Technology 2003*, ed. G. G. Seiler, A. C. Diebold, T. J. Shaffner, R. McDonald, S. Zollner, R. Khosla, E. M. Secula, AIP Conference Proceedings **683** (2003) 576.

31. *Form of Deprotection in Chemically Amplified Resists*, R.L. Jones, T.J. Hu, V.M. Prabhu, C.L. Soles, E.K. Lin, W.L. Wu, D.L. Goldfarb, and M. Angelopoulos, in *Characterization and Metrology for ULSI Technology 2003*, ed. G. G. Seiler, A. C. Diebold, T. J. Shaffner, R. McDonald, S. Zollner, R. Khosla, E. M. Secula, AIP Conference Proceedings **683** (2003) 429.

32. *Measurement of Pore Size and Matrix Characteristics in Low-k Dielectrics by Neutron Contrast Variation*, R.C. Hedden, H.J. Lee, B.J. Bauer, C.L. Soles, W.L. Wu, and E.K. Lin, in Characterization and Metrology for ULSI Technology 2003, ed. G. G. Seiler, A. C. Diebold, T. J. Shaffner, R. McDonald, S. Zollner, R. Khosla, E. M. Secula, AIP Conference Proceedings **683** (2003) 567.

33. *Chemically Amplified Photoresists: Fundamental Properties and Limits of Applicability to Sub-100nm Lithography*, D.L. Goldfarb, E.K. Lin, C.L. Soles, B.C. Trinque, S.D. Burns, R.L. Jones, J.L. Lenhart, M. Angelopoulos, C.G. Willson, S.K. Satija, and W.L. Wu, *Microlithography World* (2003) http://sst.pennnet.com/Articles/Online_SubCategory.cfm?p=28&section=ONART&subsection=FEATA

34. *Brillouin Scattering Studies of Polymeric Nanostructures*, R. Hartschuh, Y. Ding, J. H. Roh, A. Kisliuk, A. P. Sokolov, C. L. Soles, W. L. Wu, and A. P. Mahorowala, *Journal of Polymer Science Part B: Polymer Physics* **42** (2004) 1106.

35. *Moisture Absorption and Absorption Kinetics in Polyelectrolyte Films: Influence of Film Thickness*, B.D. Vogt, C.L. Soles, H.J. Lee, E.K. Lin, and W.L. Wu, *Langmuir* **20** (2004) 1453.

36. *Structural characterization of porous low-k thin films prepared by different techniques by x-ray porosimetry*, H.-J. Lee, C. L. Soles, D.-W. Liu, B. J. Bauer, E. K. Lin, W.-l. Wu, *J. Appl. Phys.* **95** (2004) 2355.

37. *Comparative Specular X-ray Reflectivity, Positron Annihilation Lifetime Spectroscopy and Incoherent Neutron Scattering Measurements of the Dynamics in Thin Polycarbonate Film*, C. L. Soles, J. F. Douglas, W.-l. Wu, H. Peng, D. W. Gidley, *Macromolecules* **37** (2004) 2890.

38. *Unusual Expansion and Contraction in Ultra-Thin Glassy Polycarbonate Films*, C. L. Soles, J. F. Douglas, W.-l. Wu, *Macromolecules* **37** (2004) 2901.

39. *Fast Dynamics and the Stabilization of Proteins: Binary Glasses of Trehalose and Glycerol*, M.T. Cicerone, C.L. Soles, *Biophysical Journal* **86** (2004) 3836.

40. *Dynamics of Thin Polymer Films: Recent Insights from Incoherent Neutron Scattering*, C. L. Soles, J. F. Douglas, W.-l. Wu, *J. Polym. Sci. Part B: Polym. Phys.* **42** (2004) 3128.

41. *Interfacial Effects on Moisture Absorption in Thin Polymer Films*, B. D. Vogt, C. L. Soles, R. L. Jones, C. Y. Wang, E. K. Lin, W. L. Wu, S. K. Satija, D. L. Goldfarb, and M. Angelopoulos, *Langmuir* **20**, (2004) 5285.

42. Structure *Characterization of Porous Interlevel Dielectric Films*, W. L. Wu, E. K. Lin, and C. L. Soles, *FUTURE FAB International* **17** (2004) 133.

43. *Characterization of Pore Structure in a Nanoporous Low-Dielectric Constant Thin Film by Neutron Scattering Porosimetry and X-ray Porosimetry*, R.C. Hedden, H.J. Lee, C.L. Soles, and B.J. Bauer, *Langmuir* **20** (2004) 6658.

44. *Pore Size Distributions in Low-k Dielectric Thin Films from SANS Porosimetry*, R. C. Hedden, H. J. Lee, C. L. Soles, and B. J. Bauer, *Polymeric Materials: Science & Engineering* **90** (2004) 494.

45. H.J. Lee, B.D. Vogt, C.L. Soles, D.W. Liu, B.J. Bauer, W.L. Wu, and E.K. Lin, "X-ray and Neutron Porosimetry as Powerful Methodologies for Determining Structural Characteristics of Porous Low-k Thin Films" in *Proceedings of the International Interconnect Technology Conference (IITC) 2004 Conference*, June, 2004, San Francisco, CA, 7803-8308, pg 136

46. V.M. Prabhu, M.X. Wang, E.L. Jablonski, C.L. Soles, B.D. Vogt, R.L. Jones, E.K. Lin, W.L. Wu, D.L. Goldfarb, M. Angelopoulos, and H. Ito, "Dissolution Fundamentals in Model 248 nm and 157 nm Photoresists" in *Advances in Imaging Materials and Processes*, Proceedings of the 13th International Conference on Photopolymers, Mid-Hudson Section of Society of Plastics Engineers, Brookfield, CT (2004) pg 211.

47. C.L. Soles, B.D. Vogt, R.L. Jones, V.M. Prabhu, W.L. Wu, E.K. Lin, D.L. Goldfarb, and M. Angelopoulos, "Dynamics, Diffusion and Dissolution in Ultra Thin Photoresist Films" in *Advances in Imaging Materials and Processes*, Proceedings of the 13th International Conference on Photopolymers, Mid-Hudson Section of Society of Plastics Engineers, Brookfield, CT (2004) pg 221.

48. B.D. Vogt, C.L. Soles, V.M. Prabhu, R.L. Jones, W.L. Wu, Lin, E.K., D.L. Goldfarb, and M. Angelopoulos, "Effect of Moisture on Thin Lithographic Films" in *Proceedings of the SPIE*, February 2004, 5376-6, Santa Clara, CA.

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Invited Presentations and Lectures

1. *What Neutron and X-ray Techniques Can Do for the Microelectronics Industry*, Christopher L. Soles, Eric K. Lin, and Wen-li Wu, invited talk at IBM, T. J. Watson Research Center, April 2000, Yorktown Heights, NY.

2. *The Dynamics of Macromolecules Confined by a Rigid Substrate*, C. L. Soles, invited talk at the NIH sponsored workshop on "Polymers in Nanoscopic Pores: Applications to Single Molecule Analysis and Metabolite Transport", April 16-18, 2001, National Institutes of Health, Bethesda, MD.

3. *Dynamics of Confined Polycarbonate Chains Probed by Incoherent Neutron Scattering*, C. L. Soles, J. F. Douglas, R. M. Dimeo, and W.-l. Wu, invited talk at the 2001 ACS National Meeting, Aug. 26, 2001, Chicago, IL.

4. *Neutrons as a Unique and Powerful Tool to Address Fundamental Issues in Sub-100 nm Lithography*, C. L Soles, E. K. Lin, J. L. Lenhart, R. L. Jones, W.-l. Wu, D. Goldfarb, and M. Angelopoulus, invited talk for the International Sematech 157 nm Resist Advisory Group Workshop, Sept. 11 & 12, 2001, Austin, TX.

5. *Structural Evolution in Silsesquioxane-based Inorganic/Organic Nanocomposite Networks*, C. Soles, E. Lin, W. Wu, C. Zhang, J. Choi, R. Laine, invited talk at the NSF-Funded Multiscale Simulation of Nanostructured Hybrid Materials kick-off meeting at the University of Michigan, Oct. 10, 2001, Ann Arbor, MI.

6. Con*finement Effects on Acid Transport in Ultrathin Chemically Amplified Photoresists*, Dario L. Goldfarb, Marie Angelopoulos, Brian Trinque, Sean D. Burns, C. Grant Willson, Eric K. Lin, Ronald L. Jones, Christopher L. Soles, Joseph L. Lenhart and Wen-li Wu, invited talk presented at the 2001 Fall MRS meeting, Nov. 26 to 30, Boston, MA.

7. *Understanding Physical Phenomena in Chemically Amplified Resists: Deprotection and the Sources of Interfacial Roughness,* D. L. Goldfarb, M. Angelopoulus, E. K. Lin, C. L. Soles, J. L. Lenhart, R. L. Jones, and Wen-li Wu invited talk at Electron, Ion, and Photon Beam Technology and Nanofabrication, May 2002, Anaheim, CA.

8. *Fundamental Understanding of Ultrathin Chemically Amplified Resist Properties: From Transport Phenomena to Roughness Control*, D. L. Goldfarb, M. Angelopoulus, E. K. Lin, C. L. Soles, J. L. Lenhart, R. L. Jones, and Wen-li Wu, invited talk for the DARPA Annual Conference, April 2002, New Orleans, LA.

9. *The Reaction Front in a Model Photoresist Examined with Neutron and X-ray Reflectivity*, E.K. Lin, C.L. Soles, D.L. Goldfarb, B.C. Trinque, S.D. Burns, R.L. Jones, J.L. Lenhart, M. Angelopoulos, C.G. Willson, S.K. Satija, and W.L. Wu, invited talk at Lucent Technologies, December 2001, Murray Hill, NJ.

10. *Pore Size Distributions in low-k Thin Films By X-ray Reflectivity*, Christopher Soles, Hae-Jeong Lee, Ronald Hedden, Da-Wei Liu, Barry Bauer, Wen-li Wu, invited talk, International SEMATECH, July 12, 2002, Austin TX.

11. *Overview of Microelectronic Research in the Electronics Materials Research Group*, Christopher L. Soles, Eric K. Lin, Jan Obrzut, B. J. Bauer, Wen-li Wu, invited poster for "NIST Day in Austin", July 30, 2002, Austin, TX.

12. *Dynamics in Thin Polymer Films: The Perspective from Neutrons, Positrons, and X-Rays*, C. L. Soles, invited talk, "Physics of Thin Films & Surfaces" workshop, Institute of Materials Research and Engineering, Singapore, January 13, 2003.

13. *Evolution of the Deprotection Reaction Front Profile in Chemically Amplified Photoresists*, C. L. Soles, invited talk, Institute of Materials Research and Engineering, Singapore, January 14, 2003.

14. *Low-K Dielectrics Characterization Research at the National Institute of Standards and Technology*, C. L. Soles, invited talk, Seoul National University, Seoul, Korea, January 20th, 2003.

15. *Nanoporous Low-k Film Characterization: X-ray Reflectivity and Neutron Scattering*, H.-J. Lee, R. C. Hedden, C. L. Soles, D.-W. Liu, B. J. Bauer, W.-l. Wu, E. K. Lin, invited talk at the International Sematech Low-k Porosimetry Workshop, June 5, 2003, Sunnyvale, CA.

16. *X-ray porosimetry for the Characterization of Nanoporous Films*, C. L. Soles, H. J. Lee, W. L. Wu, and E. K. Lin, invited talk at the First International Symposium on Standard Materials And Metrology for Nanotechnology (SMAM), March 2004, Tokyo Big Sight, Ariake, Tokyo, Japan.

17. *The Dynamics of Thin Polymer Films: Insights from Incoherent Neutron Scattering*, C. L. Soles, invited talk at Tokyo Institute of Technology, March 2004, Tokyo, Japan.

18. *The Dynamics of Thin Polymer Film: Insights from Incoherent Neutron Scattering*, C. L. Soles, invited talk at Tokyo University of Science, March 2004, Tokyo, Japan.

19. *The Dynamics of Thin Polymer Film: Insights from Incoherent Neutron Scattering*, C. L. Soles, invited talk at Texas A & M University, April 2004, College Station, TX.

20. *Structural characterization of porous inter-level dielectric films*, C. L. Soles, invited talk presented University of California, Irvine, Sept 13 2004, Irvine CA.

21. *High resolution shape metrology for nanoimprint lithography*, C. L. Soles, R. L. Jones, H.-J. Lee, W.-l. Wu, E. K. Lin, invited talk at the MEP Center Director's conference, October, 2004, NIST, Gaithersburg, MD.

22. *Nanoimprint Lithography: A New NIST Project*, C. L. Soles, R. L. Jones, H.-J. Lee, H. W. Ro, W.-l. Wu, E. K. Lin, invited talk at the NIST Combinatorial Methods Center NCMC-6: Advanced Materials Forum, November, 2004, Gaithersburg, MD.

23. *Metrology for and with Nanoimprint Lithography*, C. L. Soles, R. L. Jones, H.-J. Lee, H. W. Ro, W.-l. Wu, E. K. Lin, invited talk at the NIST MSEL Management Off-site Meeting, November, 2004, Boulder, CO.

24. *High Resolution Metrologies for Nanoimprint Lithography*, C. L. Soles, R. L. Jones, H.-J. Lee, H. W. Ro, W.-l. Wu, E. K. Lin, R. M. Reano, S. W. Pang, invited talk in the NIST Materials Reliability Division, November, 2004, Boulder, CO.

25. *The Thermal Stability of Imprinted Polymer Nanostructures*, C. L. Soles, R. L. Jones, H. W. Ro, E. K. Lin, A. Karim, W.-l. Wu, W. Hu, S. W. Pang, D. M. Casa, invited talk presented at the Materials Research Society (MRS) Fall Meeting, December, 2004, Boston, MA.

26. *Small Angle X-ray Scattering Metrology for Side Wall Angle and Cross Section of Nanometer Scale Line Gratings*, W. L. Wu, T. Hu, R. L. Jones, C. L. Soles, E. K. Lin, invited talk at the ULSI Metrology Conference, March, 2005, Richardson, TX.

27. *Dynamics and Diffusion in Thin Polymer Films*, C. L. Soles, J. F. Douglas, W.-l. Wu, invited talk presented at the National Meeting of the American Chemical Society (ACS), April, 2005, San Diego, CA.

28. *The Melting Behavior of Imprinted Polymer Nanostructures*, C.L. Soles, R.L. Jones, H.W. Ro, E.K. Lin, A. Karim, W. Wu, R.M. Reano, W. Hu, S.W. Pang, and D.M. Casa, invited talk at the National Meeting of the American Chemical Society (ACS), August, 2005, Washington, DC.

29. *Metrology for Nanoimprint Lithography*, invited talk at the 2005 NIST NIMS Combinatorial Nanomaterials Symposium, Dec. 6, 2005, Gaithersburg, MD.

30. *Nanoimprint Lithography*, C. L. Soles, F. Pease, S. Hector, a invited lecture & panel discussion for a Technology Webcast from the editors of Semiconductor International, Wednesday Dec. 7, 12 pm CST.

31. *X-ray Reflectivity to Characterize Interfaces in Nanostructured Coatings and Films*, C. L. Soles, invited talk at the NIST Building Fire Research Laboratory Polymer Interphases Consortium, Jan 24, 2006, Gaithersburg, MD.

32. *X-ray Scattering and Reflectivity as a Tool to Characterize Nanostructured Films*, C. L. Soles, invited talk presented at the Dow Corning Corporation Nano Materials Workshop, Feb 7, 2006, Midland, MI.

33. *Nanoimprint Lithography: Process Induced Stresses & Pattern Stability*, H W Ro, Y Ding, H-J Lee, D R Hines, R L Jones, E K Lin, A Karim, W-l Wu, C L Soles, invited talk at the 2006 March Meeting of the American Physical Society, March 2006, Baltimore, MD.

34. *Metrology for Nanoimprint Lithography*, C. L. Soles, invited poster at the 2006 Indo-US Frontiers of Engineering Symposium, March 2006, Agra, India.

35. *X-Ray Reflectivity as an Effective Interface Metrology for Nanotechnology*, C. L. Soles, invited talk at the National Meeting of the American Chemical Society (ACS), March, 2006, Atlanta, GA.

36. *Metrology & Materials Science for Nanoimprint Lithography*, Christopher L. Soles, invited talk at LG Chem, Daejon, Korea, Oct 9, 2006.

37. *Metrology & Materials Science for Nanoimprint Lithography*, Christopher L. Soles, invited talk at Samsung Advanced Institute of Technology, Suwon, Korea, Oct 10, 2006.

38. *Nanoimprint Lithography: Pattern Quality and Porosity Characteristics of Nanoporous Dielectric Insulators*, Christopher L. Soles, invited talk at the BK21 International Symposium on Macromolecular Science: Current Research Frontiers, Seoul National University, Seoul, Korea, Oct. 16, 2006.

39. *Metrology for Nanoimprint Technologies: Needs and Prospects*, C. L. Soles, H. W. Ro, Y. Ding, H. J. Lee, R. L. Jones, A. Karim, invited talk at the AVS 53rd International Symposium, San Francisco, CA, November, 2006.

40. *Stresses and Viscoelastic Effects in Nanoimprint Lithography Patterning*, Christopher L. Soles, invited talk presented at the 2007 Polymers West Gordon Research Conference, Ventura, CA, Jan. 7-12, 2007.

41. *Polymer Viscoelasticity and Residual Stress Effects on Nanoimprint Lithography*, Yifu Ding, H. Ro, B. Okerberg, K. Alvine, R. Jones, J. Douglas, C. Soles, A. Karim, invited talk presented at the 2007 Polymers West Gordon Research Conference – Graduate Research Symposium, Ventura, CA, Jan. 5-6, 2007.

42. *Metrology & Materials for Nanoimprint Lithography: Needs and Prospects*, Christopher L. Soles and Michael T. Postek, organizing chairs of a panel discussion (SPIE Special Event) at the SPIE Advanced Lithography Conference, February 2007, San Jose, CA.

43. *Stresses and Viscoelastic Effects in Nanoimprint Lithography Patterning*, Christopher L. Soles, invited talk presented at the Indian Institute of Technology, Kanpur, February, 2007, Kanpur, India.

44. *Nanoimprint Metrology and Materials Research at NIST*, Christopher L Soles, plenary lecture at the 6th International Conference on Nanoimprint and Nanoprint Technology, October, 2007, Paris, France.

45. *Nanoporous Ultralow-k Dielectric Insulator Materials Pattern Directly by Nanoimprint Lithography*, Christopher L. Soles, delegate and invited poster, Tenth Annual Japanese-American Frontiers of Science Symposium, December, 2007, Kanagawa, Japan.

46. *Nanoimprint Metrology & Materials Research at NIST*, Christopher L Soles, invited lecture at the Hitachi Materials Research Laboratory, December, 2007, Hitachi, Japan.

47. *Nanoporous Organosilicate Films and Nanostructures Patterned by Nanoimprint Lithograpy*, Christopher L Soles, invited lecture at the University of Michigan Department of Materials Science and Engineering, February, 2008, Ann Arbor, MI.

48. *Massively Parallel Tools for Nanotechnology: Applications in Lithography & Metrology*, Christopher L. Soles and Richard M. Silver, organizing chairs of a panel discussion (SPIE Special Event) at the SPIE Advanced Lithography Conference, February 2008, San Jose, CA.

49. *Metrology and Materials for Nanoimprint Technologies: Needs and Prospects*, Christopher L. Soles, invited lecture at the 2008 SPIE Advanced Lithography Conference, February, 2008, San Jose, CA.

50. *The Direct Patterning of Organosilicate Materials by Nanoimprint Lithography*, Christopher L. Soles, invited lecture at the 2008 ACS Hybrid Materials Workshop, March, 2008, Ventura, CA.

51. *Pattern Quality & Porosity Characteristics of Ultra-low Dielectric Insulator Films Directly Patterned by Nanoimprint Lithography*, Christopher L. Soles, invited talk at the 2008 7th ECS-International Semiconductor Technology Conference, March, 2008, Shanghai, China.

52. *Porosity Characteristics of Ultralow Dielectric Insulator Films Directly Patterned by Nanoimprint Lithography*, Hyun Wook Ro, Hae-Jeong Lee, Ken-Ichi Nihara, Hiroshi Jinnai, David Gidley, Do Y. Yoon and Christopher L Soles, invited lecture at the 2008 Spring Materials Research Society National Meeting, March, 2008, San Franciso, CA

53. *Instability in Nanoimprinted Structures*, Kyle J. Alvine, Hyun Wook Ro, Yifu Ding, Brian Okerberg, Jack F. Douglas, Alamgir Karim, and Christopher L. Soles, invited lecture at the 2008 235th American Chemical Society National Meeting, April, 2008, New Orleans, LO.

54. *Microstructure foundations of high performance in organic semiconductors*, Christopher L Soles, invited lecture at the University of California, Irvine, May 2008, Irvine, CA

55. Optical vs Nanoimprint Lithography for High Resolution Patterning, Christopher L Soles, invited lecture at the University of California, Irvine, May 2008, Irvine, CA.

56. *Nanoimprint Lithography: The Impact of Polymer Viscoelasticity and Residual Stresses*, Christopher L. Soles, invited lecture at Seoul National University, Department of Chemistry, Sept 9, 2008, Seoul, Korea

57. *Inelastic Neutron Scattering and Confined Macromolecules: A Quantitative Methodology for Next Generation Photoresists and Biopharmaceuticals*, Christopher L. Soles, invited lecture at Seoul National University, Department of Chemical and Biological Engineering, Sept 8, 2008, Seoul, Korea

58. *Structure-Property Relationships in High Performance Organic Semiconductor Materials*, Christopher L Soles, plenary lecture at the 32nd Annual Macromolecular Science and Engineering Center's Sympoium: Optoelectronically Active Polymers with Precisely Controlled Morphologies, University of Michigan, October 23, 2008, Ann Arbor, MI.

59. *Porosity Characteristics of Ultra-Low Dielectric Insulator Films Directly Patterned by Nanoimprint Lithography*, Christopher L. Soles, invited lecture at Dow Corning, October 24, 2008, Midland, MI.

60. *Nanoimprint Lithography and the Role of Viscoelasticity in the Generation of Residual Stresses in Nanoscale Patterned Surfaces*, Christopher L. Soles, invited lecture at the 64th Annual Fall Scientific Meeting, Midland Regional Section of the ACS, October 24, 2008, Midland, MI.

61. *Measurements to Facilitate the Direct Patterning of Functional Organosilicate Materials with Nanoimprint Lithography*, Christopher L. Soles, invited lecture at the 3rd International Symposium on Polymer Science, November 2008, Nagoya, Japan.

62. *Critical Dimension Small Angle X-ray Scattering as a Quantitative Metrology for Nanopatterning*, Christopher L Soles, Chengqing Wang, Hyun Wook Ro, Hae-Jeong Lee, Kwan-Woo Choi and Wen-li Wu, invited lecture at the 2008 Fall Materials Research Society National Meeting, March, 2008, Boston, MA.

63. The Direct Patterning of Organosilicate Materials by Nanoimprint Lithography, Christopher L. Soles, invited talk at the 2009 US-Japan Workshop on "Future Trends in Organic-Inorganic Nanocomposite Hybrid Materials, May 12-16, 2009, Himeji, Japan.

64. Inelastic Neutron Scattering and Confined Macromolecules: A Quantitative Methodology for Next Generation Photoresists and Biopharmaceuticals, Christopher L. Soles, invited talk at Waseda University, Tokyo, May 17, 2009, Tokyo, Japan.

65. The Direct Patterning of Organosilicate Materials by Nanoimprint Lithography, Christopher L. Soles, invited talk at the University of Maryland, Department of Materials Science and Engineering, May XXX, 2009, College Park, MD.

66. The Direct Patterning of Organosilicate Materials by Nanoimprint Lithography, Christopher L. Soles, invited talk at Penn State University, Department of Materials Science and Engineering, June 30, 2009, State College, PA.

67. *The Direct Patterning of Organosilicate Materials by Nanoimprint Lithography*, Christopher L. Soles, invited talk at University of Akron, Department of Polymer Engineering, September 11, 2009, Akron, OH.

68. *Building a Multi-Disciplinary Research Program that Leverages our National Facilities: The Perspective of a Federal Government Laboratory User*, Christopher L. Soles, invited talk at the 2009 American Institute for Chemical Engineering (AIChE) National Meeting, Nashville, TN, November 9, 2009.

69. *Semiconductors and Scaling: The Future of Lithography in the Semiconductor Industry*, Christopher L. Soles, invited talk at the University of Colorado, Boulder, Department of Mechanical Engineering, December 10, 2009.

70. *Metrology for Nanoimprint Lithography: Needs & Prospects*, Christopher L. Soles, invited talk at the 2010 Synergies in NanoScale Manufacturing and Research Workshop, Cornell NanoScale Science and Technology Facility, Cornell, University, Ithaca NY, July 27-29.

71. *Incomplete Cross-linking of UV Nanoimprint Resists Confined in Nanoscale Spaces*, Sangcheol Kim, Hae-Jeong Lee, Christopher Soles, invited talk at the 2010 SPIE Advanced Lithography Conference, Feb 22-26, San Jose, CA.

72. *Nanotechnology in Microlithography Panel Discussion: Self-Assembling Molecules for Semiconductor*
73. *Patterning and Nanoelectronics*, Christopher L. Soles, Richard M. Silver, host, panel discussion at the 2010 SPIE Advanced Lithography Conference, Feb 22, San Jose, CA.

74. *Characterization Methods for Organic Photovoltaics*, Christopher L. Soles, invited talk at the Science Education in the 21st Century: Advantages, Pitfalls and Future Trends workshop, sponsored by the Japan Society for the Promotion of Science, March 12, 2010, Colorado State University, Fort Collins, CO.

75. *Organosilicate Materials for High Resolution Patterning*, Christopher L. Soles, invited talk in the special Dillion Medal Session honoring Lynn Loo at the 2010 March Meeting of the American Physical Society, March 16, 2010, Portland, OR.

76. *The Effects of Thin Films and Confinement on Nanopattering*, Christopher L. Soles, invited talk at the 2010 March Meeting of the American Physical Society, March 16, 2010, Portland, OR.

77. *The Direct Patterning of Organosilicate Interconnect Materials by Nanoimprint Lithography*, Christopher L. Soles, invited talk at the Spring MRS National Meeting, April 5-9, 2010, San Francisco, CA.

78. *The Direct Patterning of Organosilicate Interconnect Materials by Nanoimprint Lithography*, Christopher L. Soles, invited talk at the 217th Meeting of the Electrochemical Society, April 25-30, 2010, Vancouver, Canada.

79. *Phonons in Nanostructured Materials: The Important of Accurate Shape Measurements*, Christopher L. Soles, invited talk at the ICREA Phonon Engineering Workshop, May 24-29, Barcelona, Spain.

80. *The Direct Patterning of Organosilicate Interconnect Materials by Nanoimprint Lithography*, Christopher L. Soles, invited talk at the 2010 Chris Ober Ski Hut Meeting, June 14-16, 2010, Niagara Falls, NY.

81. *Research Overview of Electronics and Energy Materials Group*, Christopher L. Soles, invited talk at Argonne National Laboratory, Chemical Sciences and Engineering Division, Battery Research Group, Sept 2, 2010, Argonne, IL.

82. *Silsequioxanes in Nanoscale Patterning Applications*, Christopher L. Soles, invited webcast for Materials Today, January 2011, www.materialstoday.com.

83. *Silsequioxanes in Nanoscale Patterning Applications*, Christopher L. Soles, invited talk at U Penn Materials Science and Engineering Departmental Colloquium, February 17, 2011, Philadelphia, PA.

84. *Nanotechnology in Microlithography Panel Discussion: Leveraging Semiconductor Expertise in Nanotechnology and Patterning for Green Energy Solutions*, Christopher L. Soles, Bryan, Barnes, Richard M. Silver, host, panel discussion at the 2011 SPIE Advanced Lithography Conference, Feb 28, San Jose, CA.

85. *Interdiffusion in Model Bilayers of P3HT and PCBM for Organic Photovoltaics*, Hyun Wook Ro, Dean Delongchamp, and Christopher L. Soles, invited talk at the 2011 Spring ACS National Meeting, March 29, 2011, Anaheim, CA.

86. *Broadband Dielectric Spectroscopy and Quasi-Elastic Neutron Scattering on Single-Ion Polymer Conductors*, Hua-Gen Peng, Kirt A. Page, Chad R. Snyder, Christopher L. Soles, and Madhusudan Tyagi, Youmi Jeong, James Runt, invited talk at the 2011 Spring ACS National Meeting, March 29, 2011, Anaheim, CA.

87. Structures of Hydrated Nafion Membrane at Interfacial Boundaries, Sangcheol Kim, Joseph A. Dura, Kirt A. Page, Christopher L. Soles, invited talk at the 2011 Spring ACS National Meeting, March 29, 2011, Anaheim, CA.

88. *Quantitative Scattering as a Dimensional Metrology to Evaluate Self-Assembly and Nanofabrication Processes*, Christopher L. Soles, invited talk at the 2011 Dow Chemical Strategic University Symposium Series: Materials by Design, May 17, 2011, Dow Chemical Corporate Headquarters, Midland, MI.

89. *The Effects of Thin Films and Confinement on Thermal Nanoimprint Pattering*, Christopher L. Soles, invited talk at the 2011 Fall ACS National Meeting, August 31, 2011, Denver, CO.

90. *An Academic-Industry Workshop on Technologies for American Manufacturing Competitiveness*, Christopher Soles, James Watkins, Jeff Morse, workshop organizer and moderator at the Nanomanufacturing Summit 2011, Seaport Convention Center, Sept 27-28, 2011, Boston, MA.

91. *Silsequioxanes in Nanoscale Patterning Applications*, Christopher L. Soles, invited talk at the University of Pittsburg, Department of Chemical and Petroleum Engineering, October 28, 2011, Pittsburg, PA.

92. *Silsequioxanes in Nanoscale Patterning Applications*, Christopher L. Soles, invited talk at the Gwanju Institute of Science and Technology – World Class University / Waseda University – Global Center of Excellence: Joint International Symposium on Nano- and Meso-scopic Material Science and Chemistry, November 11-12, 2011, Tokyo, Japan.

93. *Interdiffusion in Model Bilayers of P3HT and PCBM for Organic Photovoltaics*, Christopher L. Soles, invited talk at the 12th Pacific Polymer Conference, November 13-17, 2011, Jeju Island, Korea.

94. *The Effects of Thin Film and Confinement on Thermal Nanoimprint Lithography Patterning*, Christopher L. Soles, invited talk at the 2011 International IRTG Symposium on Self-Organized Materials for Optoelectronics, November 18, 2011, Jeju Island, Korea.

95. *NIST and its Role in Facilitating Manufacturing*, Christopher L. Soles, invited talk at the 2012 Flexible Electronics & Displays Conference & Exhibition, February 6-9, 2012, Phoenix, AZ.

96. *Metrology Solutions for Integrated 3-D Memory and Logic Structures*, Christopher L. Soles, Bryan, Barnes, Richard M. Silver, host, panel discussion at the 2012 SPIE Advanced Lithography Conference, Feb 24-28, San Jose, CA.

97. *Case Studies in Polymer Physics from the Industrial Research World*, Christopher L. Soles and Karen I. Winey, invited co-organizer for the DPOLY Short Course at the 2012 American Physical Society March Meeting, February 25-26, 2012, Boston, MA.

98. *Interfacial, Thin Film, & Structure Measurements to Facilitate Polymer Nanomanufacturing*, Christopher L. Soles, invited talk at the 2012 American Physical Society March Meeting, February 27 – March 1, 2012, Boston, MA.

99. *Direct Correlations of Electrolyte Dynamics with Ion Mobility for Energy Storage Technologies*, Christopher L. Soles, Hua-Gen Peng, Chad R. Snyder, Kevin A. Masser, and Madhusudan Tyagi, invited talk at the 2012 Materials Research Society Meeting, April 9-12, 2012, San Francisco, CA.

100. *Impedance and Ion Mobility in Polymers for Electrochemical Energy Storage and Delivery Technologies*, Christopher L. Soles, invited talk at the Georgia Institute of Technology, School of Chemical & Biomolecular Engineering, April, 25, 2012, Atlanta, GA.

101. *US – Japan Workshop on Advances in Organic/Inorganic Hybrid Materials*, Christopher L. Soles, Jennifer Liu, Kimihiro Matsukawa, Ikuyoshi Tomita, workshop co-organizers, May 16-18, 2012, University of Michigan, Ann Arbor, MI.

102. *Inorganic Ions in Polymeric Transport Membranes: The Dynamic Origins of Interfacial and Bulk Impedance*, Christopher L. Soles, invited talk at the US – Japan Workshop on Advances in Organic/Inorganic Hybrid Materials, May 16-18, 2012, University of Michigan, Ann Arbor, MI.

103. *Case Studies in Polymer Science: Enabling New Technologies (Polymers & Advanced Lithography)*, Christopher L. Soles, invited talk at the US Patent Transfer Office, June 19, 2012, Arlington, VA.

104. *National Institute of Standards & Technology: Industry's National Laboratory*, Christopher L. Soles, invited talk at the 2012 Flex Tech Alliance – NIST Workshop on Flexible Printed Electronics Metrology – Status and Needs, September 12-13, 2012, Gaithersburg, MD.

105. *Microstructure basis for charge transport and device performance in polymer semiconductors for flexible electronics*, invited lecture for joint webex class between Cornell (Chris Ober) and SUNY Binghampton (Mark Poliks) on Flexible Electronics, November 6, 2012.

106. *Confinement, Neutrons and Transport in Thin Polymer Films*, invited lecture at Arizona State University, Department of Chemistry, Tempe, AZ, January 28, 2013.

107. *Interfacial Effects in Polymer Membranes for Clean Energy*, invited talk at the 2013 March Meeting of the American Physical Society, Baltimore, MD, March 19, 2013.

108. *Inelastic Neutron Scattering and Transport Phenomenon Polymeric Materials*, invited talk at the 2013 NCNR Summer School on Neutron Scattering, Gaithersburg, MD June 18, 2013.

109. *Lithographic Pattering: A Driver for the Semiconductor Industry*, invited talk in a nanotechnology class at the University of Maryland College of Engineering, College Park MD, November 5, 2013

110. *Impact of Dynamics at Surfaces and Interfaces in Functional Polymers*, invited talk and participant in DOE sponsored "Grand Challenges in Soft Matter Workshop" – organized by Fyl Pincus and Matt Tirrell – UC Santa Barbara, May 17, 2014.

111. *Fast Polymer Dynamics & Ion Transport in Model Single Ion Conductors*, invited talk at the 2014 Polymer Physics China meeting, Nanjing, China, June 10, 2014.

112. *Interfacial Effects in Polymer Membranes for Clean Energy*, invited talk at the 2014 IUPAC World Polymer Congress, Chiang Mai, Thailand, July 6-11, 2014 – TRAVEL CANCELLED DUE TO STATE DEPARTMENT WARNINGS

113. *Fast Polymer Dynamics & Ion Transport in Model Single Ion Conductors*, invited talk at the 2014 International Symposium on Polymer Materials Science, Akron, OH, July 28, 2014.

114. *Fast dynamics, structure, and transport in ion containing polymers*, invited talk at the 2014 American Chemical Society National Meeting, August 12, 2014, San Francisco, CA

115. *X-ray and neutron studies of the structure, dynamics, and transport properties of polyelectrolytes for energy applications*, invited talk at the 2014 American Chemical Society National Meeting, August 13, 2014, San Francisco, CA.

116. *A Roadmap for Engaging NIST on Flexible Hybrid Electronics*, invited talk at the 2015 Flexible Hybrid Electronics Proposers Day Meeting, February 19, 2015, Arlington VA.

117. *Probing molecular mechanisms underlying failure in semicrystalline polymers*, C. Snyder, C. Soles, invited talk at the 249th National Meeting of the American Chemical Society, March 25, 2015, Denver, CO.

118. *Thin Ionomer Films: The Effects of Thin Film Confinement on Structure, Dynamics, Stresses, and Transport*, invited talk at Penn State University, Materials Science and Engineering Department, April 14, 2015, College Station, PA.

119. *Beam Lines & Functional Polymers: Past, Present, & Future Needs*, invited talk at the Brookhaven National Laboratory NSLS-II Strategic Planning Workshop, Sept 24, 2015, Upton, NY.

120. *R&D in Nanotechnology, Future Applications, and Cross-Industry Collaboration*, invited panelist at "Rethink Disruption – Emerging Technologies Transforming Business and Society," an event sponsored by the *CTO Forum*, Nov 5, 2015, San Francisco, CA.

121. *Polymer Dynamics in Confinement*, invited talk, Materials Science and Engineering Division Brown Bag Lunch Seminar Series, Jan 6, 2016, NIST, Gaithersburg, MD.

122. *Watching the Ink Dry: In-situ Measurements to Monitor Film Formation and Function from Organic Semiconducting Inks*, invited talk, Electrical Engineering and Computer Science Department, University of Michigan, Jan 16, 2016, Ann Arbor, MI.

123. *Watching the Ink Dry: In-situ Measurements to Monitor Film Formation and Function from Organic Semiconducting Inks*, invited talk, NNN-A-Star Workshop on Nanomanufacturing, February 26, 2016, Singapore.

124. *Using Beamline Facilities to Optimize Processing: Integrated, Multi-Modal Synchrotron Studies on Flexible Hybrid Electronics*, workshop organizer and invited speaker, Round-Table Discussion on Coordinating Interagency (DoC-DoD-DoE) Shared-Use Facilities to Support Advanced Manufacturing Sciences, April 20 & 21, 2016, Brookhaven National Laboratory, Upton, NY.

125. *Inverse Vulcanization for Enhanced Capacity Retention in Li-S Battery Systems*, invited talk at the 2016 Center for Research on Extreme Batteries (CREB) Annual Meeting, May 24, 2016, University of Maryland, College Park MD.

126. *Thin Ionomer Films: The Effects of Confinement on Structure, Dynamics, Stresses, and Transport*, invited talk, Seoul National University, June 23, 2016, Seoul Korea.

127. *Watching the Ink Dry: In-situ Measurements to Monitor Film Formation and Function from Organic Semiconducting Inks*, invited talk, SEMI Korea International Printed Electronics Conference, June 29, 2016, Seoul, Korea.

128. *Watching the Ink Dry: In-situ Measurements to Monitor Film Formation and Function from Organic Semiconducting Inks*, invited talk, Korean Institute of Industrial Technology, June 30, 2016, Ansan, Korea.

129. *Finding Your Niche in the Field of Polymer Physics*, August Bosse, Ralph Colby, Yueh-Lin Loo, Christopher Soles, invited panelist, 2016 Polymer Physics Graduate Research Symposium, Gordon Research Conference, Mount Holyoke, MA,

130. *Structured Polymer Conductors*, Christopher L. Soles, invited discussion leader, 2016 Polymer Physics Gordon Research Conference, Mount Holyoke, MA,

131. *Polymer Physics of Toughening*, Christopher L. Soles, invited lecture, Impact Mitigating Materials for Body Protection Workshop, University of Chicago, August 8, 2106, Chicago, IL.

132. *Printed and Flexible Electronics at NIST*, Christopher L. Soles and Dean M. DeLongchamp, invited display, NextFlex Open House, August 31, 2016, San Jose, CA.

133. *Dynamics and Transport in Polymer Membranes: The Relationship Between Fast Dynamics and Water Transport*, Christopher L. Soles, invited talk at the IUPAC International Conference on Advanced Polymeric Materials Commemorating the 40th Anniversary of the Polymer Society of Korea (PSK), Oct 4-7, 2016. Jeju, Korea.

134. *Dynamics and Transport in Polymer Membrane: The Relationship Between Fast Dynamics and Water Transport*, Bradley R. Frieberg, Jacob D. Tarver, Cheol Jeong, Madhusudan Tyagi, Edwin P. Chan, Christopher M. Stafford, Tsung-Han Tsai, WenXu Zhang, Bryan Coughlin, Christopher L. Soles, invited talk at Kyushu University, December 12, 2016, Fukuoka, Japan.

135. *The Effects of Thin Film Confinement on the Structure, Dynamics, Stresses, and Transport in Thin Ionomer Films*, Bradley Frieberg, Jacob Tarver, Cheol Jeong, Sangcheol Kim, Joe Dura, Madhusudan Tyagi, Edwin Chan, Christopher Stafford, Tsung-Han Tsai, Wen Xu Zhang, Bryan Coughlin, and Christopher Soles, invited talk at the 11th Society of Polymer Science Japan International Polymer Conference 2016, December 13-16, Fukuoka, Japan.

136. *Dynamics and Transport in Polymer Membranes: The Relationship Between Fast Dynamics and Water Transport*, Christopher L Soles, invited talk, NIST Center for Nanoscale Science and Technology, All-Hands Meeting, Feb 7, 2017, Gaithersburg, MD.

137. *The Relationship Between Structure, Fast Dynamics, and Water Transport in Polymer Membranes*, Christopher L. Soles, Keynote Lecture at the 1st Pan-American Polymer Conference, March 22-24, 2017, Guaraja, Sao Paulo, Brazil.

138. *PMSE/POLY Plenary Lecture and Awards Reception*, Christopher L. Soles & Marc A. Hillmyer, emcee, ACS National Meeting, April 5, 2017, San Francisco, CA.

139. *Molecular Packing, Dynamics, Transport, and Mechanics in Polymeric Materials*, Christopher L Soles, invited talk at SpaceX, May 26, 2017, Hawthorne, CA.

140. *Correlations Between Fast Dynamics and Toughness in Polymeric Materials*, Christopher L. Soles, invited talk, Army Research Laboratories, June 9, 2017, Aberdeen, MD.

141. *PMSE/POLY Plenary Lecture and Awards Reception*, Christopher L. Soles & Marc A. Hillmyer, emcee, ACS National Meeting, August 23, 2017, Washington, DC.

142. *Epoxy Modeling Summit: A Trilateral Coordination Meeting (ChiMAD, ARL, NIST)*, Christopher L. Soles and Juan J. de Pablo, Summit Organizer and Moderator, University of Chicago, September 15, 2017, Chicago, IL.

143. *Materials Matter - How to Optimize NIST Materials Characterization Capabilities for Flexible Electronics*, Dean M. DeLongchamp & Christopher L. Soles, invited speakers, NextFlex FLEXINAR, September 27, 2017.

144. *The Relationship Between Structure, Fast Dynamics, and Water Transport in Polymer Membranes*, Christopher L. Soles, Invited Lecture at the 7th Chinese Chemical Society Polymers Division / American Chemical Society Polymeric Materials: Science and Engineering Division Joint Symposium on Polymer Science and Engineering, October 13, 2017, Chengdu, China.

145. *The Effects of Thin Film Confinement on the Structure, Dynamics, Stresses, and Transport in Thin Ionomer Films*, Christopher L. Soles, Invited Lecture at the Tsinghua - US Polymer Symposium, Tsinghua University, October 16, 2017, Beijing, China.

146. *The Relationship Between Structure, Fast Dynamics, and Water Transport in Polymer Membranes*, Christopher L. Soles, Invited Lecture at ACS Polymers and Nanotechnology Workshop, December 17-20, 2017, San Diego, CA.

147. *Functional Polymers Research in the Materials Science and Engineering Division of NIST*, Christopher L. Soles, Invited Lecture, Cal Tech Department of Chemistry, March 9, 2018, Pasadena, CA.

148. *The coupling of polymer dynamics and water transport in cross-linked polymer membranes*, Christopher L. Soles, invited talk at the 255th American Chemical Society National Meeting, March 22, 2018, New Orleans, LA.

149. *The role of fast polymer dynamics as quantified by inelastic neutron scattering on the mechanical toughness on polymeric materials*, Christopher L. Soles, invited presentation at Materia, May 9, 2018, Pasadena, CA.

150. *Transport in confined polymer films: How chemically amplified photoresists at IBM helped spawn a decade of thin film transport research at NIST*, Christopher L. Soles, invited presentation at the American Chemical Society Meeting, August 20, 2018, Boston, MA.

151. *The Influence of Polymer Dynamics on the Functional Properties of Materials for Impact Mitigation and Transport Membranes: Status, Needs, and Opportunities*, Christopher L. Soles, invited presentation at the Oak Ridge National Laboratory workshop on "Soft Matter Dynamics at the Nano- to Meso-Scale," September 18, 2018, Oak Ridge, TN.

152. *Characterization and Measurement Needs in Polymeric Transport Membranes*, Christopher L. Soles, invited presentation at the "AIChE-ACS Molecular Properties Based Membrane Design Workshop," October 14 and 15, 2018, Pittsburgh, PA.

153. Critical Measurements to Enable the Use of Polymers in Membranes, Composites, & Impact Mitigation, Christopher L. Soles, invited lecture at Purdue University, February 6, 2019, West Layfayette, IN.

154. *Critical Measurements to Enable the Use of Polymers in Membranes, Composites, & Impact Mitigation*, Christopher L. Soles, invited lecture in the 2019 DPOLY Short Course, March Meeting of the American Physical Society, Boston MA, March 3, 2019.

155. *The Role of Fast Polymer Dynamics as Quantified by Inelastic Neutron Scattering on the Mechanical Toughness of Polymeric Materials*, Christopher L Soles, invited talk, ACS National Meeting, April 1-3, 2019, Orlando FL.

156. *High-rate deformation of auxetic disordered networks*, Edwin Chan, Juan De Pablo, Endao Han, Nidhi Pashine, Kieran Murphy, Daniel Reid, Meng Shen, Heinrich Jaeger, Sidney Nagel, Christopher Soles, invited talk, ACS National Meeting, April 1-3, 2019, Orlando FL.

157. *Solvent Evaporation Measurements for Printed and Flexible Electronics (a case study for multicomponent diffusion in polymer films)*, Christopher L. Soles, invited talk, US Army CCDC, June 13, 2019, Aberdeen MD.

158. *The Role of Fast Polymer Dynamics as Quantified by Inelastic Neutron Scattering on the Mechanical Toughness of Polymeric Materials*, Christopher L Soles, invited talk, NIST Interagency Workshop on Polymers for Impact Mitigation, August 19, 2019, Gaithersburg, MD.

159. *Polymers for Impact Mitigation: New Measurements Provide Insights into an Old Problem*, Christopher L. Soles, invited talk, Drexel University, Department of Materials Science and Engineering, November 6, 2019, Philadelphia, PA