

## Timothy K. Minton

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### Research Interests

**General topics:** Gas-phase and gas-surface reaction dynamics. Shock layer chemistry and physics in hypersonic flows. Degradation and ablation of materials in low-Earth-orbital and atmospheric-entry environments. Gas-surface energy transfer relevant to satellite drag. Gas concentration in rarefied flows. Reactions in rocket exhaust plumes. Structure, reactivity, and transport at gas-liquid interfaces.

**Techniques:** Atomic and molecular beams, including hyperthermal beams. Crossed-beams scattering. Beam-surface scattering. Mass spectrometry. Temperature-programmed desorption. Laser-induced fluorescence (LIF). Resonance-enhanced multiphoton ionization (REMPI). Ion velocity-map imaging. Surface topographical analysis (AFM, SEM). Surface chemical analysis (XPS). Surface structural and chemical analysis by reactive atom scattering.

### Education

- 1980            B.S. Chemistry, *with Distinction in the Curriculum*  
 University of Illinois, Urbana-Champaign  
 Research Advisor: Professor Willis H. Flygare
- 1986            Ph.D. Physical Chemistry, University of California, Berkeley  
 Research Advisor: Professor Yuan T. Lee (Nobel Laureate)
- 9/86-6/88            Post-Doctoral Associate, University of Illinois, Urbana-Champaign  
 Research Advisor: Professor J. Douglas McDonald
- 7/88-10/89            Post-Doctoral Associate, University of Zürich, Switzerland  
 Research Advisor: Professor Dr. J. Robert Huber

### Professional Experience

- 8/20-Present            Professor, University of Colorado, Boulder, CO
- 2/17-Present            Member, Executive Advisory Board, Skeyeon, Inc.
- 9/10-Present            Associate Editor, *The Journal of Spacecraft and Rockets*
- 7/05-7/20            Professor, Montana State University, Bozeman, MT
- 5/05-12/19            Senior Editor, *The Journal of Physical Chemistry A/B/C*
- 1/13-1/16            Distinguished Research Fellow, Dalian Institute of Chemical Physics, Dalian, Liaoning, China
- 7/01-6/05            Associate Professor, Montana State University, Bozeman, MT
- 8/95-6/01            Assistant Professor, Chemistry, Montana State University, Bozeman, MT
- 9/94-8/95            Assistant Research Professor (60% FTE), Montana State University, Bozeman, MT
- 11/89-6/95            Member of Technical Staff, Jet Propulsion Laboratory, Pasadena, CA

**Honors**

1976-80	Aurora (Illinois) Foundation Undergraduate Scholarship
1979	University of Illinois Summer Fellowship
1995	NASA Monetary Award for the creative development of a technological contribution, "Semiconductor Etching by Hyperthermal Neutral Beams."
1996	MSU Alumni/Bozeman Chamber of Commerce Excellence Award
2002	Charles & Nora Wiley Award for Meritorious Research (MSU)
2002	Air Force Research Laboratory, In-House Project of the Quarter: "Space-Survivable Polymers Containing Polyhedral Oligomeric Silsesquioxanes (POSS)"
2004	Visiting Associate Professor at the James Franck Institute, University of Chicago
2010	Elected as a Fellow of the American Chemical Society
2011	Chinese Academy of Sciences: Senior International Scholar (6 mos., Jan. – June)
2012	Elected as a Fellow of the American Association for the Advancement of Science
2012	Chinese Academy of Sciences: Senior International Scholar (6 mos., Jan. – June)
2014	Chinese Academy of Sciences: Senior International Scholar (6 mos., Jan. – June) Chinese State Administration of Foreign Experts Affairs: "High-End Foreign Expert" Award
2015	Chinese State Administration of Foreign Experts Affairs: "High-End Foreign Expert" Award
2015	Elected as a Fellow of the American Physical Society
2016	Selected by the International Advisory Committee of the 30 <sup>th</sup> International Symposium on Rarefied Gas Dynamics to present the 12 <sup>th</sup> Lloyd Thomas Keynote Lecture
2017	Visiting Foreign Scholar, Dipartimento di Chimica, Biologia e Biotecnologie, University of Perugia, Italy
2022	Associate Fellow of the American Institute of Aeronautics and Astronautics

**Societies**

American Institute of Aeronautics and Astronautics, American Chemical Society, American Physical Society, American Association for the Advancement of Science

**Teaching Experience**

2023 (spring)	Undergraduate propulsion (ASEN 4013)
2022 (Fall)	Graduate molecular thermodynamics and kinetics (ASEN 5519)
2022 (Spring)	Undergraduate propulsion (ASEN 4013)
2021 (Fall)	Undergraduate propulsion (ASEN 4013)
2020 (Spring)	Graduate kinetics and reaction dynamics (CHMY 559)
2018 (Fall)	Undergraduate physical chemistry – quantum mechanics (CHMY 371) Undergraduate physical chemistry laboratory (CHMY 362 and 372)
2017 (Fall)	Undergraduate physical chemistry – quantum mechanics (CHMY 371) Undergraduate physical chemistry laboratory (CHMY 362 and 372)
2016 (Fall)	Undergraduate physical chemistry – quantum mechanics (CHMY 371) Undergraduate physical chemistry laboratory (CHMY 362 and 372)
2015 (Fall)	Undergraduate physical chemistry – quantum mechanics (CHMY 371) Undergraduate physical chemistry laboratory (CHMY 362 and 372)
2014 (Fall)	Undergraduate physical chemistry – quantum mechanics (CHMY 371) Undergraduate physical chemistry laboratory (CHMY 362 and 372)
2013 (Fall)	Undergraduate physical chemistry – quantum mechanics (CHMY 371) Graduate kinetics and reaction dynamics (CHMY 559)
2012 (Fall)	Undergraduate physical chemistry – quantum mechanics (CHMY 371)
2011 (Fall)	Undergraduate physical chemistry – quantum mechanics (CHMY 371)
2010 (Fall)	Undergraduate physical chemistry – quantum mechanics (CHMY 371)
2009 (Fall)	Undergraduate physical chemistry – quantum mechanics (CHMY 371)

2009 (Spring)	Undergraduate physical chemistry – thermodynamics and kinetics (CHEM 324)
2008 (Spring)	Undergraduate physical chemistry – thermodynamics and kinetics (CHEM 324)
2007 (Fall)	Undergraduate physical chemistry – quantum mechanics (CHEM 323)
2007 (Spring)	Undergraduate physical chemistry – thermodynamics and kinetics (CHEM 324)
2006 (Fall)	Undergraduate physical chemistry – quantum mechanics (CHEM 323)
2006 (Spring)	Undergraduate physical chemistry – thermodynamics and kinetics (CHEM 324) Graduate kinetics and reaction dynamics (CHEM 559)
2005 (Fall)	Undergraduate physical chemistry – quantum mechanics (CHEM 323)
2005 (Spring)	Undergraduate physical chemistry – thermodynamics and kinetics (CHEM 324) Undergraduate physical chemistry laboratory (CHEM 326)
2004 (Fall)	Undergraduate physical chemistry – quantum mechanics (CHEM 323) Individual problems – quantum mechanics (CHEM 470)
2004 (Spring)	Undergraduate physical chemistry – thermodynamics and kinetics (CHEM 324) Undergraduate seminar (CHEM 201) Individual problems – quantum mechanics (CHEM 470)
2003 (Fall)	Undergraduate physical chemistry – quantum mechanics (CHEM 323) Individual problems – literature review and presentation (CHEM 570)
2003 (Spring)	Undergraduate physical chemistry – thermodynamics and kinetics (CHEM 324) Undergraduate physical chemistry laboratory (CHEM 326)
2002 (Fall)	Undergraduate physical chemistry – quantum mechanics (CHEM 323)
2002 (Spring)	Graduate kinetics and reaction dynamics (CHEM 559) Undergraduate physical chemistry – thermodynamics and kinetics (CHEM 324)
2001 (Fall)	Undergraduate physical chemistry – quantum mechanics (CHEM 323)
2001 (Spring)	Undergraduate physical chemistry – thermodynamics and kinetics (CHEM 324) Undergraduate physical chemistry laboratory (CHEM 326)
2000 (Fall)	Undergraduate physical chemistry – quantum mechanics (CHEM 323)
2000 (Spring)	Graduate kinetics and reaction dynamics (CHEM 559) Undergraduate physical chemistry – thermodynamics and kinetics (CHEM 324)
1999 (Fall)	Undergraduate physical chemistry – quantum mechanics (CHEM 323)
1999 (Spring)	Undergraduate physical chemistry – thermodynamics and kinetics (CHEM 324) Undergraduate physical chemistry laboratory (CHEM 325)
1998 (Fall)	Undergraduate physical chemistry – quantum mechanics (CHEM 323) Undergraduate physical chemistry laboratory (CHEM 325)
1998 (Spring)	Undergraduate physical chemistry laboratories (CHEM 325 and 326) Graduate kinetics and reaction dynamics (CHEM 558) Undergraduate seminar (CHEM 400 and 200)
1997 (Fall)	Undergraduate physical chemistry laboratories (CHEM 302 and 325)
1997 (Spring)	Undergraduate physical chemistry laboratories (CHEM 325 and 326) Undergraduate seminar (CHEM 400 and 200)
1996 (Fall)	Physical chemistry laboratories (CHEM 302 and 325) Undergraduate seminar (CHEM 400 and 280)
1996 (Spring)	Physical chemistry laboratory (CHEM 325)
1995 (Fall)	Physical chemistry laboratory (CHEM 302)
1990 - present	Supervisor of research activities of postdoctoral associates and graduate students
1980 - 83	Teaching assistant (various assignments), general chemistry, UC Berkeley

## BOOK CHAPTERS (refereed)

1. "Dynamics of Atomic-Oxygen-Induced Polymer Degradation in Low Earth Orbit," T. K. Minton and D. J. Garton, in *Chemical Dynamics in Extreme Environments: Advanced Series in Physical Chemistry: Vol. 11*, R. A. Dressler, ed. (World Scientific, Singapore, 2001) pp. 420-489.
2. Tesa-Serrate, M. A.; Smoll, Jr., E. J.; Minton, T. K.; McKendrick, K. G. Atomic and Molecular Collisions at Liquid Surfaces. *Annu. Rev. Phys. Chem.* **2016**, *67*, 515-540.

## PATENTS

1. "Semiconductor Etching by Hyperthermal Neutral Beams," T. K. Minton and K. P. Giapis, U.S. Patent No. 5,883,005 (March 16, 1999).
2. "Atomic-Oxygen-Resistant, Low-Drag Coatings and Materials," T. K. Minton and T. E. Schwartzentruber, U.S. Patent No. 10,583,632 B2 (March 10, 2020).

## EDITORIALS

1. Minton, T. K.; Roussel, J.-F. Materials in a Space Environment. *ACS Appl. Mat. Interfaces* **2010**, *2*, 2687-2688.
2. Minton, T. K. Space Environmental Effects on Materials. *J. Spacecr. Rockets* **2016**, *53*, 1001.
3. Minton, T. K.; Mullin, A. S. Suitability of Technology-Driven Research for the Journal of Physical Chemistry C. *J. Phys. Chem. C* **2017**, *121*, 27254-27255.

## HIGHLIGHTS IN THE PRESS

1. "Etching of Polymer Optical Waveguides with Atomic Beams," T. K. Minton and J. W. Perry, *Federal Lab Laser Tech Briefs* **1994**, *2*, 58.
2. "Etching Semiconductors with Beams of Reactive Atoms," T. K. Minton, K. P. Giapis, and T. A. Moore, *NASA Tech Briefs*, March **1995**, p. 60.
3. "High Energy Surprises," J. Kemsley, *C&E News*, July 9, **2012**, *90*, p. 30.
4. "OH electron, where art thou?" M. H. Alexander, *Nature Chemistry (News and Views)* **2013**, *5*, 253-255.
5. "Baptism by Fire," R. Carroll, *NASA Technology Innovation*, **2018**, *V.18.1*, <https://viewer.aemmobile.adobe.com/index.html#project/20151817-e5ce-4721-aff0-65bc38c9679b/view/ti.18.1/article/18.1.Baptism.by.Fire>.

## REFEREED JOURNAL ARTICLES

1. Keenan, M. R.; Campbell, E. J.; Balle, T. J.; Buxton, L. W.; Minton, T. K.; Soper, P. D.; Flygare, W. H. Rotational Spectra and Molecular Structures of ArHBr and KrHBr. *J. Chem. Phys.* **1980**, *72*, 3070-3080.

2. Legon, A. C.; Soper, P. D.; Keenan, M. R.; Minton, T. K.; Balle, T. J.; Flygare, W. H. The Rotational Spectra of Weakly Bound Dimers of Carbon Monoxide and the Hydrogen Halides HX (X = F, Cl, Br). *J. Chem. Phys.* **1980**, *73*, 583-584.
3. Keenan, M. R.; Minton, T. K.; Legon, A. C.; Balle, T. J.; Flygare, W. H. Microwave Spectrum and Molecular Structure of the Carbon Monoxide-Hydrogen Bromide Molecular Complex. *Proc. Natl. Acad. Sci.* **1980**, *77*, 5583-5587.
4. Minton, T. K.; Felder, P.; Brudzynski, R. J.; Lee, Y. T. Photodissociation of 1,2-Chloriodoethane at 266 and 248 nm; the Enthalpy of Formation of CH<sub>2</sub>ClCH<sub>2</sub>I. *J. Chem. Phys.* **1984**, *81*, 1759-1769.
5. Minton, T. K.; Nathanson, G. M.; Lee, Y. T. Photodissociation of CF<sub>2</sub>BrCH<sub>2</sub>I at 248, 266, and 308 nm. *J. Chem. Phys.* **1987**, *86*, 1991-2006.
6. Minton, T. K.; Nathanson, G. M.; Lee, Y. T. Photodissociation of CH<sub>2</sub>ClCH<sub>2</sub>I at 308 nm. *Laser Chem.* **1987**, *7*, 297-304.
7. Minton, T. K.; Kim, H. L.; McDonald, J. D. Rovibrational State Mixing in the C-H Stretch Fundamental Region of Norbornadiene. *J. Chem. Phys.* **1988**, *88*, 1539-1550.
8. Minton, T. K.; McDonald, J. D. Infrared Laser Induced Fluorescence Studies of State Mixing in Ground Electronic State Molecules. *Ber. Bunsenges. Phys. Chem.* **1988**, *92*, 350-361.
9. Kim, H. L.; Minton, T. K.; Ruoff, R. S.; Kulp, T. J.; McDonald, J. D. Rovibrational State Mixing in the Aldehyde C-H Stretch Fundamental Region of Acetaldehyde. *J. Chem. Phys.* **1988**, *89*, 3955-3961.
10. Minton, T. K.; Kim, H. L.; Reid, S. A.; McDonald, J. D. High Resolution Infrared Laser Induced Fluorescence Study of State Mixing in Methyl Formate. *J. Chem. Phys.* **1988**, *89*, 6550-6552.
11. Minton, T. K.; Reid, S. A.; Kim, H. L.; McDonald, J. D. A Scanning, Single Mode, LiNbO<sub>3</sub>, Optical Parametric Oscillator. *Opt. Commun.* **1989**, *69*, 289-293.
12. Nathanson, G. M.; Minton, T. K.; Shane, S. F.; Lee, Y. T. Ultraviolet Photodissociation and Thermochemistry of CH<sub>2</sub>BrCH<sub>2</sub>I, CF<sub>2</sub>BrCF<sub>2</sub>I, and CF<sub>2</sub>ICF<sub>2</sub>I. *J. Chem. Phys.* **1989**, *90*, 6157-6170.
13. Minton, T. K.; Felder, P.; Scales, R. C.; Huber, J. R. Photodissociation of C<sub>2</sub>F<sub>4</sub> at 193.3 nm; the Production of Triplet CF<sub>2</sub>(<sup>3</sup>B<sub>1</sub>). *Chem. Phys. Lett.* **1989**, *164*, 113-119.
14. Haas, B.-M.; Minton, T. K.; Felder, P.; Huber, J. R. Photodissociation of Acrolein and Propynal at 193 nm in a Molecular Beam. Primary and Secondary Reactions. *J. Phys. Chem.* **1991**, *95*, 5149-5159.
15. Minton, T. K.; Nelson, C. M.; Moore, T. A.; Okumura, M. Direct Observation of ClO from Chlorine Nitrate Photolysis. *Science* **1992**, *258*, 1342-1345.
16. King, M. E.; Nathanson, G. M.; Hanning-Lee, M. A.; Minton, T. K. Probing the Microscopic Corrugation of Liquid Surfaces with Gas-Liquid Collisions. *Phys. Rev. Lett.* **1993**, *70*, 1026-1029.
17. Nelson, C. M.; Moore, T. A.; Okumura, M.; Minton, T. K. Primary and Secondary Dissociation Pathways in the Ultraviolet Photolysis of Cl<sub>2</sub>O. *J. Chem. Phys.* **1994**, *100*, 8055-8064.

18. Walter, Th.; Bitto, H.; Minton, T. K.; Huber, J. R. UV-IR Double Resonance Spectroscopy of Jet-Cooled Propynal Detected by the Fluorescence Dip Method. *Chem. Phys. Lett.* **1994**, *231*, 64-69.
19. Giapis, K. P.; Moore, T. A.; Minton, T. K. Hyperthermal Neutral Beam Etching. *J. Vac. Sci. Technol. A* **1995**, *13*, 959-965.
20. Moore, T. A.; Okumura, M.; Tagawa, M.; Minton, T. K. Dissociation Dynamics of ClONO<sub>2</sub> and Relative Cl and ClO Product Yields following Photoexcitation at 308 nm. *Faraday Discuss.* **1995**, *100*, 295-307.
21. Nelson, C. M.; Moore, T. A.; Okumura, M.; Minton, T. K. Photodissociation of ClONO<sub>2</sub> at 193 and 248 nm. *Chem. Phys.* **1996**, *207*, 287-308.
22. Hwang, G. S.; Anderson, C. M.; Gordon, M. J.; Moore, T. A.; Minton, T. K.; Giapis, K. P. Gas-Surface Dynamics and Profile Evolution During Etching of Silicon. *Phys. Rev. Lett.* **1996**, *77*, 3049-3052.
23. Moore, T. A.; Okumura, M.; Minton, T. K. Photodissociation of Cl<sub>2</sub>O at 248 and 308 nm. *J. Chem. Phys.* **1997**, *107*, 3337-3338.
24. Minton, T. K.; Giapis, K. P.; Moore, T. A. Inelastic Scattering Dynamics of Hyperthermal Fluorine Atoms on a Fluorinated Silicon Surface. *J. Phys. Chem. A* **1997**, *101*, 6549-6555.
25. King, M. E.; Fiehrer, K. M.; Nathanson, G. M.; Minton, T. K. The Effects of Thermal Roughening on the Angular Distributions of Trapping and Scattering in Gas-Liquid Collisions. *J. Phys. Chem. A* **1997**, *101*, 6556-6561.
26. Garton, D. J.; Minton, T. K.; Alagia, M.; Balucani, N.; Casavecchia, P.; Volpi, G. G. Reactive Scattering of Ground-State and Electronically-Excited Oxygen Atoms on a Liquid Hydrocarbon Surface. *Faraday Discuss.* **1997**, *108*, 387-399.
27. Tagawa, M.; Ema, T.; Kinoshita, H.; Umeno, M.; Ohmae, N.; Minton, T. K. Formation of Thin Oxide Films on Room-Temperature Silicon (100) by Exposure to a Neutral Beam of Hyperthermal Atomic and Molecular Oxygen. *Jpn. J. Appl. Phys.* **1998**, *37*, L1455-L1457.
28. Moore, T. A.; Okumura, M.; Seale, J. W.; Minton, T. K. UV Photolysis of ClOOCl. *J. Phys. Chem. A* **1999**, *103*, 1691-1695.
29. Garton, D. J.; Minton, T. K.; Alagia, M.; Balucani, N.; Casavecchia, P.; Volpi, G. G. Comparative Dynamics of Cl(<sup>2</sup>P) and O(<sup>3</sup>P) Interactions with a Hydrocarbon Surface. *J. Chem. Phys.* **2000**, *112*, 5975-5984.
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31. Alimpiev, S.; Nikiforov, S.; Karavanskii, V.; Minton, T. K.; Sunner, J. On the Mechanism of Laser-Induced Desorption/Ionization of Organic Compounds from Etched Silicon and Carbon Surfaces. *J. Chem. Phys.* **2001**, *115*, 1891-1901.
32. Zhang, J.; Minton, T. K. Production of Volatile CO and CO<sub>2</sub> from Oxidized Polyethylene and Graphite Surfaces by Hyperthermal Atom-Surface Collisions. *High Perform. Polym.* **2001**, *13*, S467-S481.
33. Zhang, J.; Garton, D. J.; Minton, T. K. Reactive and Inelastic Scattering Dynamics of Hyperthermal Oxygen Atoms on a Saturated Hydrocarbon Surface. *J. Chem. Phys.* **2002**, *117*, 6239-6251.

34. Nicholson, K. T.; Minton, T. K.; Sibener, S. J. Temperature-Dependent Morphological Evolution of HOPG Graphite upon Exposure to Hyperthermal  $O(^3P)$  Atoms. *Progress in Organic Coatings* **2003**, *47*, 443-447.
35. Garton, D. J.; Minton, T. K.; Maiti, B.; Troya, D.; Schatz, G. C. A Crossed Molecular Beams Study of the  $O(^3P) + H_2$  Reaction: Comparison of Excitation Function with Accurate Quantum Reactive Scattering Calculations. *J. Chem. Phys.* **2003**, *118*, 1585-1588.
36. Garton, D. J.; Minton, T. K.; Troya, D.; Pascual, R.; Schatz, G. C. Hyperthermal Reactions of  $O(^3P)$  with Alkanes: Observation of Novel Reaction Pathways in Crossed-Beams and Theoretical Studies. *J. Phys. Chem. A* **2003**, *107*, 4583-4587.
37. Troya, D.; Pascual, R. Z.; Garton, D. J.; Minton, T. K.; Schatz, G. C. Theoretical Studies of the  $O(^3P) + Ethane$  Reaction. *J. Phys. Chem. A* **2003**, *107*, 7161-7169.
38. Troya, D.; Schatz, G. C.; Garton, D. J.; Brunsvold, A. L.; Minton, T. K. Crossed-Beams and Theoretical Studies of the  $O(^3P) + CH_4 \rightarrow H + OCH_3$  Reaction Excitation Function. *J. Chem. Phys.* **2004**, *120*, 731-739.
39. Braunstein, M.; Brunsvold, A. L.; Garton, D. J.; Minton, T. K. Measurements and Simulations of High Energy  $O(^3P) + Ar(^1S)$  Angular Scattering: Single- and Multi-Collision Regimes. *J. Chem. Phys.* **2004**, *120*, 2238-2246.
40. Minton, T. K.; Tagawa, M.; Nathanson, G. M. Energy Accommodation in Hyperthermal Gas-Surface Collisions: Relevance to Aerobraking in Planetary Atmospheres. *J. Spacecraft and Rockets* **2004**, *41*, 389-396.
41. Brunsvold, A. L.; Minton, T. K.; Gouzman, I.; Grossman, E.; Gonzalez, R. I. An Investigation of the Resistance of POSS Polyimide to Atomic Oxygen Attack. *High Perform. Polym.* **2004**, *16*, 303-318.
42. Nicholson, K. T.; Minton, T. K.; Sibener, S. J. Nucleation and Growth of Nanoscale to Microscale Cylindrical Pits in Highly-Ordered Pyrolytic Graphite upon Hyperthermal Atomic Oxygen Exposure. *High Perform. Polym.* **2004**, *16*, 197-206.
43. Brunsvold, A. L.; Garton, D. J.; Minton, T. K.; Troya, D.; Schatz, G. C. Crossed-Beams and Theoretical Studies of the Dynamics of Hyperthermal Collisions between Ar and Ethane. *J. Chem. Phys.* **2004**, *121*, 11702-11714.
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45. Nicholson, K. T.; Minton, T. K.; Sibener, S. J. Spatially Anisotropic Etching of Graphite by Hyperthermal Atomic Oxygen. *J. Phys. Chem. B* **2005**, *109*, 8476-8480.
46. Cline, J. A.; Minton, T. K.; Braunstein, M. Direct Simulation Monte Carlo Investigation of Hyperthermal Oxygen Beam Exposures. *J. Spacecraft and Rockets* **2005**, *42*, 810-816.
47. Garton, D. J.; Brunsvold, A. L.; Minton, T. K.; Troya, D.; Maiti, B.; Schatz, G. C. Experimental and Theoretical Investigations of the Inelastic and Reactive Scattering Dynamics of  $O(^3P) + D_2$ . *J. Phys. Chem. A* **2006**, *110*, 1327-1341.
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51. Zhang, J.; Upadhyaya, H. P.; Brunsvold, A. L.; Minton, T. K. Hyperthermal Reactions of O and O<sub>2</sub> with a Hydrocarbon Surface: Direct C–C Bond Breakage by O and H-Atom Abstraction by O<sub>2</sub>. *J. Phys. Chem. B* **2006**, *110*, 12500-12511.
52. Li, L.; Yang, J. C.; Minton, T. K. Morphological Changes at a Silver Surface Resulting from Exposure to Hyperthermal Atomic Oxygen. *J. Phys. Chem. C* **2007**, *111*, 6763-6771. [featured on journal cover]
53. Brunsvold, A. L.; Zhang, J.; Upadhyaya, H. P.; Minton, T. K.; Camden, J. P.; Paci, J. T.; Schatz, G. C. Crossed-Beams and Theoretical Studies of the O(<sup>3</sup>P) + H<sub>2</sub>O → HO<sub>2</sub> + H Reaction Excitation Function. *J. Phys. Chem. A* **2007**, *111*, 10907-10913.
54. Brunsvold, A. L.; Upadhyaya, H. P.; Zhang, J.; Cooper, R.; Minton, T. K.; Braunstein, M.; Duff, J. W. Dynamics of Hyperthermal Collisions of O(<sup>3</sup>P) and CO. *J. Phys. Chem. A* **2008**, *112*, 2192-2205.
55. Cooper, R.; Upadhyaya, H. P.; Minton, T. K.; Du, X.; George, S. M.; Berman, M. R. Protection of Polymer from Atomic-Oxygen Attack by Thin Coatings of Al<sub>2</sub>O<sub>3</sub> Prepared by Atomic Layer Deposition. *Thin Solid Films* **2008**, *516*, 4036-4039.
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61. Garton, D. J.; Minton, T. K.; Hu, W.; Schatz, G. C. Experimental and Theoretical Investigations of the Inelastic and Reactive Scattering Dynamics of O(<sup>3</sup>P) Collisions with Ethane. *J. Phys. Chem. A* **2009**, *113*, 4722-4738.
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4. "Protocol for Atomic Oxygen Testing of Materials in Ground-Based Facilities. Version Number 1," T. K. Minton, *JPL Publication 94-02*, April 1, 1994.
5. "Final Report on the NASA/JPL Evaluation of Oxygen Interactions with Materials (EOIM-3)," D. E. Brinza, S. Y. Chung, T. K. Minton, and R. H. Liang, *JPL Publication 94-31*, December 1994.

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### STUDENT THESES (undergraduate theses not included)

1. "Oxidized Polystyrene Surfaces Produced by Plasma and Neutral Beam Methods: An X-Ray Photoelectron and Surface Derivatization Study," Terry L. Thompson, M.S. Thesis, December 1997.

2. "Reactive Scattering of Oxygen and Chlorine Atoms on Hydrocarbon Surfaces," Donna J. Garton, M.S. Thesis, August 1998.

3. "Etching of Hydrocarbon Polymers with Hyperthermal Neutral Beams," James W. Seale, M.S. Thesis, August 1998.

4. "Studies of Gas-Surface Interaction Dynamics with Hyperthermal Neutral Beams," Jianming Zhang, Ph.D. Thesis, August 2001.

5. "Temperature Dependence Study of FEP Teflon and Kapton H Erosion in a Simulated LEO Atomic-Oxygen Environment," Deanna M. Buczala, M.S. Thesis, May 2004.

6. "Hyperthermal Reactions of  $O(^3P)$  with Hydrogen and Methane," Donna J. Garton, Ph.D. Thesis, May 2004.

7. "Molecular Beam Studies of Hyperthermal Atomic Oxygen and Argon Interactions with Polymer Surfaces and Gas-Phase Molecules," Amy L. Brunsvold, Ph.D. Thesis, May 2007.

8. "Gas-Surface Interactions with  $sp^2$  Carbon in Extreme Environments," Vanessa J. Murray, Ph.D. Thesis, May 2018.

9. "Pyrolysis of Thermal Protection System Materials: Molar Yields of Volatile Products Derived from In Situ Mass Spectrometric Measurements," Brody K. Bessire, Ph.D. Thesis, May 2018.

10. "Reactive-Atom Scattering Dynamics and Liquid-Vacuum Interfacial Structure," Eric J. Smoll, Jr., Ph.D. Thesis, May 2019.

11. "Effect of Atomic Oxygen on Silicon-Carbon Systems in Extreme Environments," David Z. Chen, Ph.D. Thesis, April 2021.

### INVITED TALKS

1. "IR Laser Induced Fluorescence Studies of State Mixing: IVR in the Frequency Domain," Physikalisch-Chemisches Institut der Universität, Zürich, Switzerland, November 1988.

2. "Mechanisms of  $ClONO_2$  Decomposition in the Stratosphere," *Telluride Workshop on Chemical Physics in Atmospheric Sciences*, Telluride, CO, August 1992.

3. "Surface Reactions with Hyperthermal Oxygen Atoms," *Director's Topical Research Seminar*, Jet Propulsion Laboratory, Pasadena, CA, September 1992.

4. "Development of a Protocol for Atomic Oxygen Testing of Materials in Ground-Based Facilities," *2nd International Space Forum: Protection of Materials and Structures from the Low Earth Orbit Space Environment*, Toronto, Canada, February 1994.
5. "Interactions of Hyperthermal Atoms with Polymer and Silicon Surfaces: Scattering Dynamics and Etching," Department of Chemistry and Biochemistry, Montana State University, Bozeman, MT, June 1994.
6. "Novel Surface Modifications with Hyperthermal Neutral Beams," *Technical Advisory Meeting of the Center for Biofilm Engineering*, Montana State University, Bozeman, MT, March 7, 1996.
7. "Inelastic Scattering During Etching of Silicon with Hyperthermal Fluorine Atoms," Dipartimento di Chimica, Università di Perugia, Perugia, Italy, November 14, 1996.
8. "Inelastic Scattering During Etching of Silicon with Hyperthermal Fluorine Atoms," Physikalisch-Chemisches Institut der Universität Zürich, Zürich, Switzerland, November 22, 1996.
9. "Inelastic Scattering During Etching of Silicon with Hyperthermal Fluorine Atoms," Department of Chemistry, University of Montana, Missoula, MT, May 5, 1997.
10. "Atomic Oxygen Interactions with Saturated Hydrocarbon Surfaces," *1997 American Institute of Aeronautics and Astronautics Conference and Exhibit*, Huntsville, AL, September 23-25, 1997.
11. "Reactive Scattering of Atomic Oxygen and Chlorine from Hydrocarbon Surfaces," Dipartimento di Chimica, Università di Perugia, Perugia, Italy, December 19, 1997.
12. "Dynamics of Atomic-Oxygen-Induced Degradation of Materials," *4th International Conference on the Protection of Materials and Structures from the Low Earth Orbital Space Environment*, Toronto, Canada, April 23-24, 1998.
13. "Reactive Scattering of Atomic Oxygen on Hydrocarbon Surfaces," *AFOSR Molecular Dynamics Contractor's Meeting*, Monterey, CA, May 17-20, 1998.
14. "Reactive Scattering Dynamics of Fast Atoms with Hydrocarbon Surfaces: Initial and Steady-State Reactions," Department of Chemistry, Northwestern University, Evanston, IL, October 23, 1998.
15. "Reactive Scattering Dynamics of Fast Atoms with Hydrocarbon Surfaces: Initial and Steady-State Reactions," Department of Chemistry, University of Wisconsin, Madison, WI, October 27, 1998.
16. "Reactive Scattering Dynamics of Fast Atoms with Hydrocarbon Surfaces: Initial and Steady-State Reactions," Department of Chemistry, Ohio State University, Columbus, OH, October 30, 1998.
17. "Reactive Scattering Dynamics of Fast Atoms with Hydrocarbon Surfaces: Initial and Steady-State Reactions," Department of Chemistry and Biochemistry, University of California at San Diego, La Jolla, CA, May 28, 1999.
18. "Reactive and Inelastic Scattering Dynamics of Fast Oxygen Atoms with Hydrocarbon Surfaces," *1999 Gordon Research Conference on Dynamics at Surfaces*, Andover, NH, August 8-13, 1999.
19. "Dynamics of Polymer Etching at the Gas-Surface Interface," *218th American Chemical Society National Meeting*, New Orleans, LA, August 22-26, 1999.

20. "Interactions of Atomic Oxygen with Hydrocarbon Surfaces: Initial and Steady-State Etching Reactions," Department of Chemistry and Biochemistry, Arizona State University, Tempe, AZ, January 13, 2000.
21. "Interactions of Atomic Oxygen with Hydrocarbon Surfaces: Initial and Steady-State Etching Reactions," Department of Chemistry, North Carolina State University, Raleigh, NC, February 3, 2000.
22. "Interactions of Atomic Oxygen with Hydrocarbon Surfaces: Initial and Steady-State Etching Reactions," Department of Biological, Chemical, and Physical Sciences, Illinois Institute of Technology, Chicago, IL, February 10, 2000.
23. "Dynamics of Atomic-Oxygen-Induced Erosion of Polymers in Low Earth Orbit," *220<sup>th</sup> American Chemical Society National Meeting*, Washington, DC, August 20-24, 2000.
24. "Gas-Surface Scattering Dynamics in Low Earth Orbit: Polymers under Atomic Oxygen Attack," Department of Chemistry, University of Illinois, Urbana, IL, September 20, 2000.
25. "Gas-Surface Scattering Dynamics in Low Earth Orbit: Polymers under Atomic Oxygen Attack," Department of Chemistry and Biochemistry, The University of Notre Dame, Notre Dame, IN, September 21, 2000.
26. "Gas-Surface Scattering Dynamics in Low Earth Orbit: Polymers under Atomic Oxygen Attack," Department of Chemistry and Biochemistry, University of California, Santa Barbara, CA, October 30, 2000.
27. "Gas-Surface Scattering Dynamics in Low Earth Orbit: Polymers under Atomic Oxygen Attack," Air Force Research Laboratory, Edwards AFB, CA, November 1, 2000.
28. "Gas-Surface Scattering Dynamics in Low Earth Orbit: Polymers under Atomic Oxygen Attack," University of Wisconsin, Milwaukee, February 9, 2001.
29. "Gas-Surface Scattering Dynamics in Low Earth Orbit: Polymers under Atomic Oxygen Attack," Tufts University, Medford, MA, February 21, 2001.
30. "Gas-Surface Scattering Dynamics in Low Earth Orbit: Polymers under Atomic Oxygen Attack," University of Illinois, Chicago, March 2, 2001.
31. "Collision-Induced Chemical Processes on a Chlorinated Surface," *221<sup>st</sup> American Chemical Society National Meeting*, San Diego, CA, April 1-5, 2001.
32. "Gas-Surface Scattering Dynamics in Low Earth Orbit: Polymers under Atomic Oxygen Attack," University of Utah, Salt Lake City, April 9, 2001.
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34. "Collision-Induced Chemical Processes on a Chlorinated Silicon Surface," *AFOSR Molecular Dynamics Contractor's Meeting*, Newport Beach, CA, May 21-23, 2001.
35. "Hyperthermal Reactions of Oxygen Atoms with Saturated Hydrocarbons," University of Oregon, Eugene, April 15, 2002.

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39. "Hyperthermal Reactions of  $O(^3P)$  with  $H_2$  and Saturated Hydrocarbons," *AFOSR Molecular Dynamics Contractor's Meeting*, San Diego, CA, May 18-20, 2003.
40. "Hyperthermal Reactions of  $O(^3P)$  with  $H_2$  and Saturated Hydrocarbons," *XX International Symposium on Molecular Beams*, Lisbon, Portugal, June 8-13, 2003.
41. "Hyperthermal  $O(^3P)$  Interactions: Characterization of an O-Atom Source, Model Reactions with Small Alkanes, and O-Atom Resistance of a POSS Polymer," Air Force Research Laboratory, Edwards AFB, CA, September 8, 2003.
42. "Reactive and Inelastic Scattering Dynamics of Hyperthermal Oxygen Atoms on a Liquid Hydrocarbon Surface," *American Physical Society Annual Meeting*, Montreal, Quebec, Canada, March 22-26, 2004.
43. "Hyperthermal Reactions of  $O(^3P)$  with Hydrogen and Methane," *227<sup>th</sup> American Chemical Society National Meeting*, Anaheim, CA, March 28 - April 1, 2004.
44. "Reaction Dynamics Relevant to Spacecraft in Low-Earth Orbit: Atomic-Oxygen Reactions with Gaseous and Surface Hydrocarbons," James Franck Institute Colloquium, The University of Chicago, Chicago, IL, June 1, 2004.
45. "Hyperthermal Reactions of  $O(^3P)$  with Hydrogen and Methane," *Dalian Institute of Chemical Physics Symposium on Molecular Dynamics (IV)*, Dalian, China, July 21-23, 2004.
46. "Reaction Dynamics Relevant to Spacecraft in Low-Earth Orbit: Atomic Oxygen Reactions with Gaseous and Surface Hydrocarbons," University of Hawaii, Manoa, October 11, 2004.
47. "Reaction Dynamics Relevant to Spacecraft and Missiles: Hyperthermal Atomic Oxygen Reactions," Montana State University, October 22, 2004.
48. "Reaction Dynamics Relevant to Spacecraft in Low-Earth Orbit: Atomic-Oxygen Reactions with Gaseous and Surface Hydrocarbons," University of California - Davis, November 16, 2004.
49. "Hyperthermal Reactions of  $O(^3P)$  with Hydrogen and Methane," *Gordon Research Conference on Molecular Energy Transfer*, Jan. 9-14, 2005.
50. "Laboratory Studies of Hyperthermal O-Atom Reactions," *2005 Maui Analysis of Upper Atmosphere Injections (MAUI) Space Experiment Workshop*, Wailea, Maui, HI, Sept. 5, 2005.
51. "Crossed-Beam and Beam-Surface Scattering Studies of Hyperthermal O and Ar Interactions," *International Symposium on Application of Quantum Beams 2005*, Kobe University, Kobe, Japan, Oct. 18-19, 2005.

52. "Hyperthermal Reactions of Oxygen Atoms with Spacecraft Materials and Rocket Plumes," Texas Tech University, Lubbock, TX, October 4, 2006.
53. "Crossed-Beams Studies of Hyperthermal O(<sup>3</sup>P) Reactions," *Dalian Institute of Chemical Physics Symposium on Molecular Dynamics*, Dalian, China, October 18-21, 2006.
54. "Crossed-Beams Studies of Hyperthermal O(<sup>3</sup>P) Reactions," *Trends in Chemical Dynamics: From Small Molecules to Biomolecules*, Chiao Hsi, Yi-Lan County, Taiwan, December 10-15, 2006.
55. "Crossed-Beams Studies of Hyperthermal O(<sup>3</sup>P) Reactions," *AFOSR Molecular Dynamics Contractor's Meeting*, Irvine, CA, May 20-22, 2007.
56. "Laboratory Studies of Plume Chemistry: Hyperthermal O-atom Reactions," *Space Vehicle Engine Signature Workshop*, Wailea, Maui, HI, September 8, 2007.
57. "Reaction Dynamics in Low Earth Orbit: Atomic-Oxygen Reactions with Gases and Surfaces," North Dakota State University, Fargo, ND, September 20, 2007.
58. "Crossed-Beams and Theoretical Studies of Hyperthermal Reactions of O(<sup>3</sup>P) with HCl and H<sub>2</sub>O," *235th American Chemical Society National Meeting*, New Orleans, LA, April 6-10, 2008.
59. "On the Mechanisms of Hyperthermal O(<sup>3</sup>P) Reactions," *9th International Space Conference: Protection of Materials and Structures from Space Environment*, Toronto, Canada, May 20 - 23, 2008.
60. "Unusual Reaction Dynamics from Hyperthermal O(<sup>3</sup>P) Collisions," *Gordon Conference on Atomic and Molecular Interactions*, Colby Sawyer College, New London, NH, July 6-11, 2008.
61. "Atomic Oxygen Chemistry in Low Earth Orbit," Johns Hopkins University, Baltimore, MD, September 23, 2008.
62. "Atomic Oxygen Chemistry in Low Earth Orbit," University of Maryland, College Park, MD, September 24, 2008.
63. "Atomic Oxygen Chemistry in Low Earth Orbit," Dalian University of Technology, Dalian, P. R. China, October 13, 2008.
64. "Unusual Reaction dynamics from Hyperthermal O(<sup>3</sup>P) Collisions with HCl," *12th International Symposium on the Stereodynamics of Chemical Reactions*, Dalian, P. R. China, October 13-17, 2008.
65. "Atomic Oxygen Chemistry in Low Earth Orbit," Jilin University, Changchun, P. R. China, October 20, 2008.
66. "Atomic Oxygen Chemistry in Low Earth Orbit," Harbin Institute of Technology, Harbin, P. R. China, October 14, 2008.
67. "Unusual Reaction Dynamics from Hyperthermal O-Atom Collisions: O(<sup>3</sup>P) + DCCD → DCCO + D," *George C. Schatz 60th Birthday Symposium*, Northwestern University, Evanston, IL, April 17-18, 2009.
68. "Hyperthermal O(<sup>3</sup>P) Reaction Dynamics: Unusual Mechanisms That Do Not Follow The Minimum Energy Path," *XXIII International Symposium on Molecular Beams*, Dalian, China, June 1-5, 2009.



69. "Hyperthermal O(<sup>3</sup>P) Reaction Dynamics: Unusual Mechanisms That Do Not Follow The Minimum Energy Path," *XXI Conference on the Dynamics of Molecular Collisions*, Snowbird, Utah, July 6-10, 2009.
70. "Hyperthermal O(<sup>3</sup>P) Reaction Dynamics: Unusual Mechanisms That Do Not Follow The Minimum Energy Path," *30<sup>th</sup> International Symposium on Free Radicals*, Savonlinna, Finland, July 25-30, 2009.
71. "Atomic Oxygen Chemistry in Low Earth Orbit," Southern Illinois University, Carbondale, IL, October 16, 2009.
72. "Atomic Oxygen Chemistry on Materials in Low Earth Orbit," *Keynote Lecture at the 14<sup>th</sup> Israel Materials Engineering Conference*, Tel Aviv, Israel, December 13-14, 2009.
73. "Electronic Excitation in HCCO/DCCO Products from Hyperthermal Collisions of O(<sup>3</sup>P) with HCCH/DCCD," *3<sup>rd</sup> Asia Pacific Symposium on Radiation Chemistry and 10<sup>th</sup> Biennial Trombay Symposium on Radiation and Photochemistry (APSRC-TSRP-2010)*, Lonavala, India, September 13-17, 2010.
74. "Scattering Dynamics of Hyperthermal Oxygen Atoms on Ionic Liquid Surfaces: [emim][NTf<sub>2</sub>] and [C<sub>12</sub>mim][NTf<sub>2</sub>]," *1<sup>st</sup> International Workshop on Scattering of Atoms and Molecules from Surfaces*, Weizmann Institute, Rehovot, Israel, October 24-28, 2010
75. "High Product Excitation from Hyperthermal O(<sup>3</sup>P) Reactions," *International Chemical Congress of Pacific Basin Chemical Societies (Pacifichem)*, Honolulu, HI, December 15-20, 2010.
76. "Scattering Dynamics of Hyperthermal Oxygen Atoms on Ionic Liquid Surfaces: [emim][NTf<sub>2</sub>] and [C<sub>12</sub>mim][NTf<sub>2</sub>]," *241<sup>st</sup> American Chemical Society National Meeting and Exposition*, Anaheim, CA, March 27-31, 2011.
77. "Hyperthermal Atomic-Oxygen Reactions on Materials in Low Earth Orbit," Lanzhou Institute of Physics, Lanzhou, China, April 22, 2011.
78. "Etching of Diamond by Hyperthermal Atomic Oxygen," *242<sup>nd</sup> American Chemical Society National Meeting and Exposition*, Denver, CO, August 28 – September 1, 2011.
79. "Kinematics and Dynamics of Atomic-Beam Scattering on Liquid and Self-Assembled Monolayer Surfaces," *243<sup>rd</sup> American Chemical Society National Meeting*, San Diego, CA, March 25-29, 2012.
80. "Chemical Dynamics in the Gas Phase and at the Gas-Surface Interface," Oregon State University, Corvallis, Oregon, May 24, 2012.
81. "Kinematics and Dynamics of Atomic-Beam Scattering on Liquid and Self-Assembled Monolayer Surfaces," *Discussions of the Faraday Society 157*, Assisi, Italy, June 25-27, 2012.
82. "Molecular Beam-Surface Scattering Studies of Energy Transfer and Reactions at the Gas-Liquid Interface," University of Utah, Salt Lake City, UT, October 29, 2012.
83. "Unusual Dynamics in High-Energy Gas-Phase and Gas-Surface Collisions," Department of Chemistry and Biochemistry Seminar, Montana State University, Bozeman, MT, November 2, 2012.
84. "Unusual Dynamics in High-Energy Gas-Phase and Gas-Surface Collisions," NASA Ames Research Center, Mountain View, CA, February 8, 2013.

85. "Kinematics and Dynamics of O, Ar, and CO<sub>2</sub> Scattering on Liquid and Self-Assembled Monolayer Surfaces," *245<sup>th</sup> American Chemical Society National Meeting and Exposition*, New Orleans, LA, April 7-11, 2013.
86. "Molecular Beam-Surface Scattering Studies of Energy Transfer and Reactions at the Gas-Liquid Interface," *Gordon Research Conference on Chemical Reactions at Surfaces*, Les Diablerets, Switzerland, April 28 – May 3, 2013.
87. "Unusual Dynamics in High-Energy Gas-Phase and Gas-Surface Collisions," Institut für Physikalische Chemie, Georg-August University of Göttingen, Germany, May 6, 2013.
88. "Molecular Beam-Surface Scattering Studies of Energy Transfer and Reactions at the Gas-Liquid Interface," Lanzhou Institute of Chemical Physics, Lanzhou, China, June 24, 2013.
89. "Electronic Excitation in Hyperthermal Atomic Oxygen Reactions," *Dynamics of Molecular Collisions Conference*, Granlibakken, Nevada, July 7-12, 2013.
90. "Inelastic and Reactive Scattering Dynamics of Hyperthermal O Atoms on Carbon at High Temperatures," *Gordon Research Conference on Dynamics at Surfaces*, Newport, RI, August 11-16, 2013.
91. "Unusual Dynamics in Hyperthermal Collisions," *Workshop on VUV FELs in Molecular, Cluster, and Surface Science*, Dalian, China, September 23-27, 2013.
92. "Hyperthermal Atomic-Oxygen Reactions on Materials in Low Earth Orbit: from Scattering Dynamics to Material Erosion," AVIC Beijing Institute of Aeronautical Materials, Beijing, China, January 21, 2014.
93. "Hyperthermal Atomic-Oxygen Reactions on Materials in Low Earth Orbit," *11<sup>th</sup> International Conference on the Protection of Materials from the Space Environment*, Lijiang, Yunnan, China, May 19-23, 2014. [Plenary Lecture]
94. "Inelastic and Reactive Scattering Dynamics of Hyperthermal O Atoms on Vitreous Carbon at High Temperatures," *Gordon Research Conference on Atomic and Molecular Interactions*, Stonehill College, Easton, MA, July 13-17, 2014.
95. "Oxidation of Carbon at High Temperatures," Department of Chemistry and Biochemistry, University of Colorado, Boulder, CO, September 26, 2014.
96. "Oxidation of Carbon at High Temperatures," Department of Chemistry, Southern Illinois University, Carbondale, IL, October 10, 2014.
97. "Oxidation of Carbon at High Temperatures," Department of Physics, Dalian Maritime University, Dalian, China, November 7, 2014.
98. "Oxidation of Carbon at High Temperatures," Department of Chemistry, Chuncheon University, Chuncheon, South Korea, March 26, 2015.
99. "Oxidation of Carbon at High Temperatures," Department of Chemical Physics, University of Science and Technology of China, Hefei, China, April 8, 2015.
100. "Oxidation of Carbon at High Temperatures, Studied by Atomic Beam-Surface Collisions," School of Chemical Engineering and Technology, Tianjin University, Tianjin, China, June 17, 2015.

- 101.** “Oxidation of Carbon at High Temperatures and Pyrolysis of PICA,” NASA Ames Research Center, Mountain View, CA, August 20, 2015.
- 102.** “Oxidation of Carbon at High Temperatures, Studied by Atomic Beam-Surface Collisions,” Department of Chemistry, Washington State University, Pullman, WA, December 7, 2015.
- 103.** “Fundamental Interactions in Hypersonic Flows: Oxidation of Carbon at High Temperatures,” Department of Aerospace Engineering, University of Illinois, Champaign-Urbana, IL, May 2, 2016.
- 104.** “Uncovering the Chemical Processes during the Atmospheric Entry of a Carbon/Phenolic Ablator: Laboratory Studies by In Situ Mass Spectrometric and Molecular Beam Techniques,” NASA/Ames Research Center, Technical Interchange Meeting, Mountain View, CA, June 1, 2016.
- 105.** “Dynamics of Energetic Gas-Surface Collisions,” *12<sup>th</sup> Lloyd Thomas Memorial Lecture, 30<sup>th</sup> International Symposium on Rarefied Gas Dynamics*, University of Victoria, Victoria, British Columbia, Canada, July 10-15, 2016.
- 106.** “Gas-Surface Reaction Dynamics on Hot Carbon Surfaces, *1<sup>st</sup> EUCASS Aerospace Thematic Workshop: Collisions of Fast Particles with Surfaces*,” Aussois, France, September 12-16, 2016.
- 107.** “Fundamental Studies of Material Response in Atmospheric Entry Environments,” Department of Mechanical Engineering, University of Kentucky, Lexington, KY, November 11, 2016.
- 108.** “Dynamics of O-Atom Collisions on Hot Carbon Surfaces,” *64<sup>th</sup> Pacific Conference on Spectroscopy and Dynamics*, Pacific Grove, CA, January 19-22, 2017.
- 109.** “Dynamics of Energetic Gas-Surface Interactions,” Department of Chemistry, University of Illinois at Chicago, Chicago, Illinois, February 14, 2017.
- 110.** “Dynamics of Energetic Gas-Surface Collisions,” Dipartimento di Chimica, Biologia e Biotecnologie, Università degli Studi di Perugia, February 27, 2017.
- 111.** “Hyperthermal Atomic-Oxygen Reactions in Low Earth Orbit: From Scattering Dynamics to Material Erosion,” European Space Research and Technology Centre, Noordwijk, The Netherlands, March 24, 2017.
- 112.** “Dynamics of Energetic Gas-Surface Interactions,” Department of Chemistry, BYU-Idaho, Rexburg, Idaho, April 27, 2017.
- 113.** “Fundamental Studies of Material Response in Atmospheric Entry Environments,” *Applied Space Environments Conference*, Huntsville, Alabama, May 15-19, 2017.
- 114.** “Signatures of the Gas-Liquid Interface in Scattering Dynamics,” Gordon Research Conference on Dynamics at Surfaces, Newport, RI, July 30 – August 4, 2017.
- 115.** “Hyperthermal Atomic-Oxygen Reactions on Materials in Low Earth Orbit,” Department of Physics, East China University of Science and Technology, Shanghai, China, October 11, 2017.
- 116.** “Dynamics of O-Atom Collisions on Hot Carbon Surfaces,” Department of Chemistry, Fudan University, Shanghai, China, October 12, 2017.

- 117.** “Signatures of the Gas-Liquid Interface in Scattering Dynamics,” Department of Chemistry, Fudan University, Shanghai, China, October 12, 2017.
- 118.** “Molecular Beam Scattering Studies of Carbon Oxidation at High Temperatures,” *American Institute of Aeronautics and Astronautics Scitech Forum*, Kissimmee, FL, January 8-12, 2018.
- 119.** “Hyperthermal Atomic-Oxygen Reactions on Materials in Low Earth Orbit: from Scattering Dynamics to Material Erosion,” Centre National D’Etudes Spatiales (CNES), Toulouse, France, April 12, 2018.
- 120.** “Probing the Structure of an Ionic Liquid Interface by Reactive-Atom Scattering,” *10<sup>th</sup> Singapore International Chemistry Conference (SICC-10)*, National University of Singapore, December 16-19, 2018.
- 121.** “Studies of Gas-Surface Interactions Applied to Space Technology,” Department of Mechanical Engineering, University of Kentucky, Lexington, KY, February 21, 2019.
- 122.** “Molecular Beam Studies of Carbon and Silicon Carbide Ablation by Atomic Oxygen,” Spectral Energies, Dayton, OH, March 29, 2019.
- 123.** “Studies of Gas-Surface Interactions Applied to Space Technology,” College of Chemistry, Beijing Normal University, Beijing, China, April 23, 2019.
- 124.** “Reactive-Atom Scattering Dynamics and Liquid-Vacuum Interfacial Structure,” *XXVIII<sup>th</sup> International Symposium on Molecular Beams*, Edinburgh, UK, June 23-28, 2019.
- 125.** “Air-Carbon Boundary Layer Chemistry for Hypersonic Ablation,” *NASA/Ames Research Center, Technical Interchange Meeting*, Mountain View, CA, September 3, 2019.
- 126.** “Reactive-Atom Scattering Dynamics and Liquid-Vacuum Interfacial Structure,” *International Conference on Molecular Energy Transfer in Complex Systems 2019*, Hefei, China, September 22-27, 2019.
- 127.** “Reactive-Atom Scattering Dynamics and Liquid-Vacuum Interfacial Structure,” Department of Chemistry and Biochemistry, Texas Tech University, Lubbock, TX, November 8, 2019.
- 128.** “Studies of Gas-Surface Collisions Applied to Space Technology,” Smead Department of Aerospace Engineering Sciences, University of Colorado, Boulder, CO, January 23, 2020.
- 129.** “Air-Carbon Boundary Layer Chemistry for Hypersonic Ablation,” NASA Ames Research Center, Mountain View, CA, September 24, 2020. (presented virtually)
- 130.** “Surviving Atomic Oxygen in Low Earth Orbit,” *Remote Sensing, Earth & Space Sciences Seminar*, Smead Department of Aerospace Engineering Sciences, University of Colorado, Boulder, CO, December 19, 2020. (presented virtually)
- 131.** “Molecular Beam Studies of Extreme Aerospace Environments,” *Colorado Space Business Roundtable*, December 3, 2020. (presented virtually)
- 132.** “Molecular Beam Studies of O-Atom Reactions on Carbon at High Temperatures,” *American Chemical Society Spring 2021 National Meeting*, April 14, 2021. (presented virtually)
- 134.** “Molecular Beam Studies of Carbon Ablation,” Centre for Hypersonics, School of Mechanical and Mining Engineering, The University of Queensland, Brisbane, Australia, April 29, 2021. (presented virtually)

- 135.** “Molecular Beam Studies of Carbon Oxidation and Nitridation at High Temperatures,” *AFOSR Molecular Dynamics and Theoretical Chemistry Program Review*, Washington, DC, May 27, 2021. (presented virtually)
- 136.** “On the Utility of Coated POSS-Polyimides for VLEO Vehicles,” *1st International Symposium on VLEO Missions and Technologies*, University of Manchester, UK, June 28-29, 2021. (presented virtually)
- 137.** “On the Utility of Coated POSS-Polyimides for VLEO Vehicles,” *Applied Space Environments Conference 2021*, 1-5 November 2021. (presented virtually)
- 138.** “Molecular Beam Studies of Gas-Phase and Gas-Surface Interactions in Extreme Aerospace Environments,” *JOINT ARMY-NAVY-NASA-AIR FORCE (JANNAF) Interagency Propulsion Committee: 39<sup>th</sup> Exhaust Plume and Signatures (EPSS) Subcommittee Meeting*, Newport News, Virginia, June 6-10, 2022. (Special seminar for an Interagency Collaboration Forum)
- 139.** “Understanding Hypersonic Ablation with Molecular Beam Experiments: Gas-Surface Scattering Dynamics and a Table-Top Shock Tunnel,” *Sandia National Laboratories – Technical Interchange Meeting – Gas-Surface Interactions and Ablation Relevant to Hypersonics*, Albuquerque, NM, June 15, 2022.
- 140.** “On the Utility of Coated POSS-Polyimides for VLEO Vehicles,” Space Materials Workshop, organized by Office for Space Technology & Industry, Singapore (OSTIn) and Nanyang Technological University, Singapore, July 21, 2022. (presented virtually)
- 141.** “Minton-Sandia LDRD Projects,” *Sandia Research Day*, University of Colorado Boulder, Boulder, Colorado, August 29, 2022.
- 142.** “Neutral Environment: Atomic Oxygen and Drag Effects in LEO and VLEO,” *15<sup>th</sup> International Symposium on Materials in a Space Environment (ISMSE-15): Special tutorial session on space environmental effects on materials*, Leiden, The Netherlands, September 18, 2022.
- 143.** “Molecular Beam Studies of Extreme Aerospace Environments,” FSM Seminar, Smead Department of Aerospace Engineering Sciences, University of Colorado Boulder, October 19, 2022.
- 144.** “Molecular Beam Studies of Gas-Surface Interactions Applied to Space Technology,” *Physical Chemistry Seminar*, Department of Chemistry, Texas A&M University, College Station, TX, November 1, 2022. (Invited by graduate students)
- 145.** “Molecular Beam Studies on Gas-Surface Interactions in Extreme Aerospace Environments,” *AFOSR Gas-Surface Interaction Workshop*, Arlington, VA, January 19-20, 2023.

## CONTRIBUTED TALKS

1. “Direct Observation of ClO from Chlorine Nitrate Photolysis,” *XXth Informal Conference on Photochemistry*, Atlanta, GA, April 1992.
2. “Molecular Beam Scattering from Kapton and Correlation with the EOIM-3 Carousel Experiment,” *Third LDEF Post-Retrieval Symposium*, Williamsburg, VA, November 1993.
3. “Hyperthermal Atom Beam Etching: F + Si,” *Second SEMATECH Workshop on Neutral Beam Etching*, Orlando, FL, November 1993.

4. "Dissociation Dynamics of ClONO<sub>2</sub> and Relative Cl and ClO Product Yields following Photoexcitation at 308 nm," *Faraday Discussion: 100, ATMOSPHERIC CHEMISTRY*, University of East Anglia, Norwich, England, April 19-21, 1995.
5. "Scattering Dynamics of Hyperthermal Atoms and Molecules from Surfaces," *42nd National Symposium of the American Vacuum Society*, Minneapolis, MN, October 16-20, 1995.
6. "The Laser Detonation Neutral Beam Source: Assessment of Performance via Mass Spectrometry," *Methodologies for Ground Simulation of the Space Environment*, Southampton, UK, July 17-19, 1996.
7. "Protocol for Atomic Oxygen Testing of Materials in Ground-Based Facilities," *Methodologies for Ground Simulation of the Space Environment*, Southampton, UK, July 17-19, 1996.
8. "Inelastic Scattering During Etching of Silicon with Hyperthermal Fluorine Atoms," *212th American Chemical Society National Meeting*, Orlando, FL, August 25-29, 1996.
9. "Reactive Scattering of Oxygen Atoms on a Liquid Hydrocarbon Surface," *214th American Chemical Society National Meeting*, Las Vegas, NV, September 7-11, 1997.
10. "Reactive Scattering of Ground-State and Electronically Excited Oxygen Atoms on a Liquid Hydrocarbon Surface," *Faraday Discussion 108, Dynamics of Electronically Excited States in Gaseous, Cluster, and Condensed Media*, University of Sussex, Brighton, UK, December 15-17, 1997.
11. "Mechanisms of Polymer Erosion in Low Earth Orbit: Implications for Ground-based Testing," *44th International SAMPE Symposium and Exhibition*, Long Beach, CA, May 25, 1999.
12. "Reactive Scattering Dynamics of Fast Oxygen Atoms with Hydrocarbon Surfaces: Initial and Steady-State Reactions," *46th International Symposium of the American Vacuum Society*, Seattle, WA, October 25-29, 1999.
13. "Atomic-Oxygen-Assisted Materials Degradation in LEO: Collision-Enhanced Erosion, Another Synergistic Effect," *8th International Symposium on Materials in a Space Environment and 5th International Conference on Protection of Materials and Structures from the LEO Space Environment*, Arcachon, France, June 5-9, 2000.
14. "Hyperthermal Reactions of Oxygen Atoms with Saturated Hydrocarbons," *223rd American Chemical Society National Meeting*, Orlando, FL, April 7-11, 2002.
15. "Hyperthermal Reactions of Oxygen Atoms with Saturated Hydrocarbons," *6th International Conference on Protection of Materials and Structures from the Space Environment*, Toronto, Canada, May 1-3, 2002.
16. "Hyperthermal Reactions of Oxygen Atoms with Saturated Hydrocarbons," *AFOSR MURI Contractors Meeting*, Chicago, IL, June 17-18, 2002.
17. "Model Atomic Oxygen Reactions: Detailed Experimental and Theoretical Studies of the Reactions of Ground-State O(<sup>3</sup>P) with H<sub>2</sub>, CH<sub>4</sub>, CH<sub>3</sub>CH<sub>3</sub>, and CH<sub>3</sub>CH<sub>2</sub>CH<sub>3</sub> at Hyperthermal Collision Energies," *9th International Symposium on Materials in a Space Environment*, Noordwijk, The Netherlands, June 16-20, 2003.
18. "Hyperthermal O(<sup>3</sup>P) Interactions: Beam-Source Characterization, Model Reactions with Small Alkanes, and Erosion Resistance of a POSS Polymer," *AFOSR MURI Contractors Meeting*, Pittsburgh, PA, August 19-20, 2003.

19. "Studies of the Erosion of Kapton H, FEP Teflon, and Hybrid Inorganic/Organic Polymers in an Atomic Oxygen Environment," *7<sup>th</sup> International Conference on the Protection of Materials from the Space Environment*, Toronto, Canada, May 10-13, 2004.
20. "Atomic Beam-Surface Scattering Studies of the Individual and Combined Effects of VUV Radiation and Hyperthermal O or Ar Atoms on FEP Teflon Surfaces," *International Chemical Conference of Pacific Basin Societies (Pacifichem) 2005*, Honolulu, HI, Dec. 19, 2005.
21. "Beam-Surface Scattering Studies of the Individual and Combined Interactions of VUV Radiation and Hyperthermal O, O<sub>2</sub>, or Ar with Fluorocarbon Surfaces," *10<sup>th</sup> International Symposium on Materials in a Space Environment*, Collioure, France, June 19-23, 2006.
22. "Space Survivability of Main-Chain and Side-Chain POSS-Kapton Polyimides," *9<sup>th</sup> International Conference on the Protection of Materials in a Space Environment*, Toronto, Canada, May 20-23, 2008.
23. "Investigation of the Reaction, O(<sup>3</sup>P) + DCCD → DCCO + D, at Hyperthermal Collision Energies," *238<sup>th</sup> American Chemical Society National Meeting*, Washington, DC, August 16-20, 2009.
24. "Protecting Polymers with Atomic Layer Deposition Coatings," *11<sup>th</sup> International Symposium on Materials in a Space Environment*, Aix-En-Provence, France, September 15-18, 2009.
25. "The Remarkable Lack of Synergistic Effects in the Erosion of FEP Teflon and PMMA," *11<sup>th</sup> International Symposium on Materials in a Space Environment*, Aix-En-Provence, France, September 15-18, 2009.
26. "Protecting Polymers with Atomic Layer Deposition Coatings," *International Chemical Congress of Pacific Basin Chemical Societies (Pacifichem)*, Honolulu, HI, December 15-20, 2010.
27. "Atomic Oxygen Effects on POSS Polyimides," *10<sup>th</sup> International Conference on the Protection of Materials from the Space Environment*, Okinawa, Japan, June 12-17, 2011.
28. "Oxidation and Erosion of Diamond by Hyperthermal Atomic Oxygen," *10<sup>th</sup> International Conference on the Protection of Materials from the Space Environment*, Okinawa, Japan, June 12-17, 2011.
29. "On the Mechanisms of Hyperthermal O(<sup>3</sup>P) Reactions with Hydrocarbon Surfaces," *10<sup>th</sup> International Conference on the Protection of Materials from the Space Environment*, Okinawa, Japan, June 12-17, 2011.
30. "Atomic Oxygen Effects on POSS Polyimides," *242<sup>nd</sup> American Chemical Society National Meeting and Exposition*, Denver, CO, August 28 – September 1, 2011.
31. "Stepwise Photocatalytic Dissociation of Methanol and Water on a TiO<sub>2</sub>(110) Surface," *243<sup>rd</sup> American Chemical Society National Meeting*, San Diego, CA, March 25-29, 2012.
32. "Oxidation and Erosion of Carbon by Hyperthermal Atomic Oxygen," *12<sup>th</sup> International Symposium on Materials in a Space Environment*, Noordwijk, The Netherlands, September 24-28, 2012.
33. "Scattering Dynamics of Hyperthermal Oxygen Atoms on a Series of Ionic Liquid Surfaces: [C<sub>4</sub>mim][BF<sub>4</sub>], [C<sub>8</sub>mim][BF<sub>4</sub>], and [C<sub>12</sub>mim][BF<sub>4</sub>]," *248<sup>th</sup> American Chemical Society National Meeting & Exposition*, San Francisco, CA, August 10-14, 2014.

34. "Oxidation of Carbon at High Temperatures Representative of a Re-Entry Environment," *13<sup>th</sup> International Symposium on Materials in a Space Environment*, Pau, France, June 22-26, 2015.
35. "Oxidation of Carbon at High Temperatures and Pyrolysis of PICA," *7<sup>th</sup> Ablation Workshop*, University of Tennessee Space Institute, Tullahoma, TN, October 21-22, 2015.
36. "Dynamics of Hyperthermal Atomic-Oxygen Interactions with Hot Carbon Surfaces – from 600 K to 2200 K," *8<sup>th</sup> European Workshop on Thermal Protection Systems and Hot Structures*, European Space Agency – European Space Research and Technology Centre (ESA-ESTEC), Noordwijk, The Netherlands, April 19-22, 2016.
37. "Pyrolysis of PICA: Molar (and Mass) Yields as a Function of Heating Rate," *8<sup>th</sup> Ablation Workshop*, University of Arizona, Tucson, AZ, October 5-6, 2016.
38. "Probing the Structure of an Ionic Liquid Interface by Reactive Atom Scattering," *255<sup>th</sup> American Chemical Society National Meeting and Exposition*, New Orleans, LA, March 18-22, 2018.
39. "Molecular Beam Studies of Carbon and Silicon Carbide Ablation by Atomic Oxygen," *10<sup>th</sup> Ablation Workshop*, University of Vermont, Burlington, VT, September 17-18, 2018.
40. "Gas-Surface Model in DSMC for Molecules Passing Through a Funnel-Type Gas Concentrator." *2019 AIAA Scitech Forum*, San Diego, CA, January 7-11, 2019.
41. "Molecular Beam Studies of Carbon and Silicon Carbide Ablation by Atomic Oxygen," *2<sup>nd</sup> Applied Space Environments Conference*, Los Angeles, CA, May 12-17, 2019.
42. "Molecular Beam Studies of Carbon Ablation by O and N atoms," *11<sup>th</sup> Ablation Workshop*, University of Minnesota, Minneapolis, Minnesota, September 16-17, 2019.
43. "Molecular Beam Studies of Extreme Aerospace Environments," *Sandia National Laboratories Technical Exchange Meeting: Predictive Agile Reentry Tools*, April 5, 2021. (presented virtually)
44. "Table-Top Shock Tunnel (TTST) for Studies of Shock Layer Chemistry and Rapid and Low-Cost Testing of Materials for Hypersonics." *HiSST: 2<sup>nd</sup> International Conference on High-Speed Vehicle Science Technology*, Bruges, Belgium, September 11-15, 2022.
45. "Molecular Beam Studies of Carbon and Silicon Carbide Ablation by Atomic Oxygen and Nitrogen," *HiSST: 2<sup>nd</sup> International Conference on High-Speed Vehicle Science Technology*, Bruges, Belgium, September 11-15, 2022.
46. "Investigation of Kapton Erosion by Atomic Oxygen in a Table-Top Shock Tunnel (TTST)," *15<sup>th</sup> International Symposium on Materials in a Space Environment (ISMSE-15)*, Leiden, The Netherlands, September 19-23, 2022.
47. "Table-Top Shock Tunnel (TTST) for Investigations of Hypersonic Ablation," *12<sup>th</sup> Ablation Workshop*, Lexington, KY, November 9-10, 2022.
48. "High Temperature Ablation of Vitreous Carbon in a Table-Top Shock Tunnel (TTST)," *AIAA SciTech Forum and Exposition*, National Harbor, MD, January 23-27, 2023, 2023.



**TEACHING/SERVICE HIGHLIGHTS**

- Ongoing* Referee for NSF, DoE, Air Force Office of Scientific Research, Petroleum Research Fund, Caltech President's Fund, Army Research Office, Defense Threat Reduction Agency, *J. Chem. Phys.*, *J. Phys. Chem.*, *Phys. Chem. Chem. Phys.*, *J. Am. Chem. Soc.*, *ACS Appl. Mat. Interfaces*, *AIAA Journal*, *J. Spacecraft and Rockets*, *High Perform. Polym.*, *Appl. Phys. Lett.*, *Chem. Phys. Lett.*, *Thin Solid Films*, *Rev. Sci. Instrum.*, *Polymer*, *Surface and Coatings Technology*, *Appl. Surf. Sci.*, *Acta Astronautica*, *Polym. Degrad. Stability*, promotion cases at other universities and government labs, theses at other universities, ICPMSE proceedings.
- 2010-present Associate Editor, *The Journal of Spacecraft and Rockets*.
- 2022-2023 Chair, Workshop on Materials in Space
- 2022 Assoc. Editor who handled special issue of *J. Spacecr. Rockets* based on Applied Aerospace Environments Conference in November of 2021.
- Ph.D. Dissertation Committee for AES Student (Thesis Defense)
- Prelim Committee for AES Student
- Ph.D. Dissertation Committee for AES Student (Comprehensive exam)
- Ph.D. Dissertation Committee for AES Student (Thesis Defense)
- Primary Unit Evaluation Committee – Overall (Fall semester)
- Member Undergraduate Curriculum Committee, AES Department (Spring and Fall Semesters)
- Faculty Representative to the Boulder Faculty Assembly (Spring Semester)
- 2021 Faculty Representative to the Boulder Faculty Assembly
- Member Undergraduate Curriculum Committee, AES Department
- Served on Primary Unit Evaluation Committee for promotion of faculty member to Full Professor, AES Department, Fall.
- Presented guest lecture in ASEN 5519, Introduction to Hypersonics, “Molecular Beam Studies Applied to Hypersonics,” December 7.
- Served on AES Student's Ph.D. Dissertation Committee – Comprehensive Exam in December, 2021.
- Served on Primary Unit Evaluation Committee for reappointment of research faculty member, AES Department, Summer.
- Served on Primary Unit Evaluation Committee for Post-Tenure Review of AES faculty member, AES Department, April.

Presented guest lecture in ASEN 1022, Materials Science for Aerospace Engineers, “Ablative Thermal Protection System (TPS): What happens when the heat is on?” March 24.

Presented guest lecture to Prof. Iain Boyd’s Group Meeting, “Molecular Beam Studies of Extreme Aerospace Environments: Gas-Surface Interactions,” March 17.

Served on AES Student’s Ph.D. Dissertation Committee – Comprehensive Exam in February, 2021.

Member of Ad Hoc Search Committee, leading to offers to two candidates for Assistant Professor. AES Department, CU Boulder, Jan.-Feb., 2021.

2020 Served on Primary Unit Evaluation Committee for reappointment of teaching faculty member, AES Department, December.

Presented guest lecture to Hypersonics class (ASEN 5519), AES Department, December 1.

2000-2020 Coordinator for occasional Departmental Seminars (since 2000). [provided funding for most speakers that I hosted]

2019 Chair of *Conference on Dynamics of Molecular Collisions XXVII*.

Member of ACS National Award Selection Committee.

Served on MSU Chem&Biochem Theoretical Chemistry Faculty Search Committee.

2005-2019 Senior Editor, *The Journal of Physical Chemistry A/B/C*.

2014-19 Faculty Mentor for assistant professor, Washington State University.  
STEM Mentor for Park High School and MSU STEM Partnership.

2018 Member of Program Committee for the *14<sup>th</sup> International Symposium on Materials in a Space Environment*, to be held in Biarritz, France, October 1-5, 2018.

2017-18 Served on MSU Chem&Biochem Inorganic Faculty Search Committee.

2017 Organizer of *9<sup>th</sup> Ablation Workshop*, August 30-31, MSU Campus.

Vice-Chair of *Conference on Dynamics of Molecular Collisions XXVI*.

Member of ACS National Award Selection Committee.

Delivered two-hour lecture to students in reaction dynamics class at the University of Perugia, Italy, March 10, “Hyperthermal Atomic-Oxygen Reactions in Low Earth Orbit: from Scattering Dynamics to Material Erosion.”

2016 Editor of special issue of *The Journal of Spacecraft and Rockets*, “Space Environmental Effects on Materials.”

2015-16 Served on MSU Chem&Biochem Inorganic Faculty Search Committee.

- 2015 Candidate for Chair of the American Physical Society Division of Chemical Physics.  
Member of Program Committee for the *13<sup>th</sup> International Symposium on Materials in a Space Environment*, held in Pau, France, June 22-26, 2015.
- Served on an ACS National Award Selection Committee.
- Chair of Earle K. Plyler Prize for Molecular Spectroscopy & Dynamics Selection Committee.
- 2014 Vice-Chair of Earle K. Plyler Prize for Molecular Spectroscopy & Dynamics Selection Committee.
- Member of Organizing Committee for the *11<sup>th</sup> International Conference on the Protection of Materials in a Space Environment*, held in Lijiang, Yunnan, China, May 5-9, 2014.
- 2012 Member of Program Committee for the *12<sup>th</sup> International Symposium on Materials in a Space Environment*, held in Noordwijk, The Netherlands, September 24-28, 2012.
- Chair of Department of Chemistry and Biochemistry Promotion and Tenure Committee.
- 2011 Member of Program Committee for the *10<sup>th</sup> International Conference on the Protection of Materials in a Space Environment*, held in Okinawa, Japan, June 13-17, 2011.
- Served on Department of Chemistry and Biochemistry Promotion and Tenure Committee.
- 2010 Served on Department of Chemistry and Biochemistry Promotion and Tenure Committee.
- Served on Department of Chemistry and Biochemistry Undergraduate Program Committee.
- Guest Editor for a special issue of *ACS Applied Materials and Interfaces* on “Materials in a Space Environment.”
- 2009 Guest in Winan Elementary School in Livingston, Montana, where I conducted scientific demonstrations and led hands-on activities for a 5<sup>th</sup> grade class; November 2009.
- Member of Organizing Committee for the *11<sup>th</sup> International Symposium on Materials in a Space Environment*, Aix-En-Provence, France, September 15-18, 2009.
- Served on Department of Chemistry and Biochemistry Promotion and Tenure Committee.
- Served on Department of Chemistry and Biochemistry Undergraduate Program Committee.
- Head Project Judge for FIRST Lego League Tournament in Bozeman, MT; January 2009.
- 2008 Featured on the evening news on the local CBS affiliate station for experiments on the Materials International Space Station - 6 (MISSE-6), which was launched on the Space Shuttle on March 11, 2008. The air date of the broadcast was March 6.
- Member of Organizing Committee for the *9<sup>th</sup> International Conference on the Protection of Materials in a Space Environment*, held in Toronto, Canada, May 20-23, 2008. Also, contributed \$4k to support the meeting.

- Head Project Judge for FIRST Lego League Tournament in Bozeman, MT; January 2008.
- 2007 Co-Organizer of symposium ("*International Symposium on Free Radicals*") held at Big Sky, Montana, August 12-17, 2007.
- Served on Department of Chemistry and Biochemistry Undergraduate Program Committee.
- Project Judge for FIRST Lego League Tournament in Bozeman, MT; March 2007.
- 2006 Organizer of symposium ("*Chemical Dynamics in Extreme Environments*") held at the ACS National Meeting, San Francisco, September 10-14, 2006.
- Served on Department of Chemistry and Biochemistry Undergraduate Program Committee.
- 2005 Co-Organizer of symposium ("*In Situ Studies of Gas-Solid Surface Reactions*") held at the Materials Research Society National Meeting in San Francisco, CA, Mar. 28 - Apr. 1, 2005.
- Served on Department of Chemistry and Biochemistry Undergraduate Program Committee.
- 2004 Member of the Organizing Committee for the 7<sup>th</sup> *International Conference on the Protection of Materials and Structures from the Space Environment*, Toronto, Canada, May 10-13, 2004.
- Served on Department of Chemistry and Biochemistry Undergraduate Program Committee.
- Member of curriculum reform committee, Dept. of Chemistry and Biochemistry, MSU.
- 2003 Member of DoE On-Site Review Team for the Chemical Physics Research Program at Brookhaven National Laboratory.
- Served on Department of Chemistry and Biochemistry Undergraduate Program Committee.
- 2002 Member of the Program Committee for the 6<sup>th</sup> *International Conference on the Protection of Materials and Structures from the Space Environment*, Toronto, Canada, May 1-3, 2002.
- Served on Department of Chemistry and Biochemistry Undergraduate Program Committee.
- 2000 Member of Evaluation Committee for ASTM Standard Practice on materials testing in an atomic oxygen environment. (ASTM E2089)
- 1999 Instructor for workshop on chemistry in "Peaks and Potentials," a summer camp at Montana State University for 6<sup>th</sup> through 8<sup>th</sup> grade children.
- Member of Evaluation Committee for ASTM Standard Practice on materials testing in an atomic oxygen environment. (ASTM E2089)
- Served on Department of Chemistry and Biochemistry Undergraduate Program Committee.
- Obtained funding for and purchased new optical spectroscopy instrument for the physical chemistry laboratory. (Spring Semester)
- 1998 Served on Department of Chemistry and Biochemistry Undergraduate Program Committee.

- 1995-8 Occasional guest in elementary school classrooms, where I conducted scientific demonstrations and led children in performing hands-on science experiments.
- 1997-8 Compiled and wrote new lab manual for the physical chemistry laboratory.
- 1997 Received donation of Nd:YAG laser from the University of Zürich, Switzerland.
- Obtained funding for and set up new computers and interfaces for the physical chemistry laboratory. (Fall Semester)
- Obtained funding for and purchased a new UV/VIS spectrophotometer for the physical chemistry laboratory (Fall Semester).
- Member of Center for Biofilm Engineering (MSU) Education Committee.
- Served on Department of Chemistry and Biochemistry Undergraduate Program Committee.
- 1996 Received donation of video contact angle apparatus from Advanced Surface Technologies, Billerica, MA.
- Developed new experiment on IR spectroscopy of HCl for the physical chemistry laboratory. (Spring Semester)
- Developed new experiment on enzyme kinetics for the physical chemistry laboratory. (Fall Semester)
- 1995 Developed a new experiment on Matrix-Assisted Laser Desorption Ionization (MALDI) mass spectrometry for the physical chemistry laboratory. (Fall Semester)

## RESEARCH FUNDING AND TASK MANAGEMENT

### NASA/JPL

*Molecular Beam Studies of Antarctic Stratospheric Chemistry* (co-investigator with M. Okumura)

\$88k January 1991 – December 1992

### Ballistic Missile Defense Organization

*Atomic Oxygen Ground-Based Studies/Testing* (task manager)

\$150k November 1992 – November 1993

### Ballistic Missile Defense Organization

*Mechanistic Studies of Atomic Oxygen Interactions* (task manager)

\$110k March 1993 – March 1994

### NASA/JPL

*Semiconductor Etching by Hyperthermal Neutral Beams* (task manager)

\$15k May 1993 – May 1994

U. S. Air Force Phillips Laboratory

*Synergistic Effects in the Reaction of Hyperthermal O-Atoms with a Surface* (task manager)

\$41k            June 1993 – November 1993

NASA/JPL

*Semiconductor Etching by Hyperthermal Neutral Beams* (co-investigator with K. P. Giapis)

\$25k            September 1993 – September 1994

NASA

*Molecular Beam Studies of Stratospheric Photochemistry* (co-investigator with M. Okumura)

\$200k           March 1994 – March 1997

Ballistic Missile Defense Organization

*Mechanistic Studies of Atomic Oxygen Interactions* (task manager)

\$250k           April 1994 - April 1995

NASA/JPL

*Mars Global Surveyor Fast CO<sub>2</sub> Energy Accommodation Measurement* (task manager)

\$45k            February 1995 – July 1995

Montana State University

*Startup Award* (principal investigator)

\$70k            July 1995 indefinite

NSF/MONTS

*Novel Surface Modifications with Hyperthermal Neutral Beams* (principal investigator)

\$17k            March 1995 – August 1996

Montana Space Grant Consortium

*Development and Characterization of a Novel O-Atom Source for Materials Processing* (principal investigator)

\$61k            March 1996 – February 1997

Air Force Office of Scientific Research (DoD EPSCoR)

*Interactions of Hyperthermal Oxygen Atoms with Polymer Surfaces* (principal investigator)

\$343k           June 1996 – May 1999

NASA Upper Atmosphere Research Program

*Molecular Beam Studies of Stratospheric Photochemistry* (co-investigator with M. Okumura)

\$70k            March 1997 – March 1998

NASA/Ionwerks

*Development and Characterization of a Novel O-Atom Source for Materials Processing*  
(principal investigator)

\$75k            May 1997 – November 1998

Boeing

*Atomic Oxygen Testing on Boeing Concentrators and Materials* (principal investigator)

\$5k            November 1997 – December 1997

Air Force Office of Scientific Research (DoD EPSCoR)

*Dynamics of Etching at the Gas-Surface Interface* (principal investigator)

\$564k           April 1999 – March 2002

Air Force Office of Scientific Research (DoD EPSCoR)  
*Reaction Dynamics Relevant to Spacecraft in Low Earth Orbit* (principal investigator)  
 \$650k April 2001 – March 2004

Chemat Technology, Inc.  
*Atomic Oxygen Testing of Chemat Samples* (principal investigator)  
 \$8k February 2001 – August 2001

Air Force Office of Scientific Research  
*ICPMSE Meeting Organization* (principal investigator)  
 \$5k April 2002 – October 2002

Boeing  
*MISSE Samples Investigation* (principal investigator)  
 \$3k April 2003 – October 2003

Air Force Office of Scientific Research, Multidisciplinary University Research Initiative (MURI)  
*Center for Materials Chemistry in the Space Environment* (co-investigator)  
 \$5M for seven investigators May 2001 – April 2006 (\$750k for T. Minton)

Air Force Office of Scientific Research (DoD EPSCoR)  
*Space Vehicle Interactions with the Low-Earth Orbital Environment* (principal investigator)  
 \$400k July 2004 – June 2007

DARPA/Air Force Research Laboratory, Edwards, AFB  
*Atomic-Oxygen Studies of Space Survivable POSS Polyimides* (principal investigator)  
 \$100k November 2004 – October 2005

Department of Defense Appropriation/Missile Defense Agency  
*Laboratory Studies of Rocket Plume Chemistry* (principal investigator)  
 \$900k October 2005 – September 2007

Soreq NRC, Israel  
*Atomic-Oxygen Exposure of Optical Materials* (principal investigator)  
 \$7k November 2004 – December 2004

Spectral Sciences, Inc.  
*Crossed-Beams Studies of Rocket Fuel Components* (principal investigator)  
 \$57.5k December 2004 – October 2006

Missile Defense Agency  
*STTR Phase I: Full-spectrum Integrated Reaction Evaluation and Synthesis (FIRES)* (co-investigator)  
 \$100k September 2005 – March 2007 (\$35k for T. Minton; \$65k for Spectral Sciences, Inc.)

Soreq NRC, Israel  
*Atomic-Oxygen Exposure of Materials* (principal investigator)  
 \$10k April 2006 – June 2006

DARPA/Air Force Research Laboratory, Edwards, AFB  
*Atomic-Oxygen Studies of Space Survivable POSS Polyimides* (principal investigator)  
 \$42k January 2007 – August 2007

DARPA/Air Force Research Laboratory, Edwards, AFB  
*Atomic-Oxygen Studies of Space Survivable POSS Polyimides* (principal investigator)  
 \$21k                      June 2007 – August 2007

Department of Defense Appropriation/Missile Defense Agency  
*Ground-Based Studies of Rocket Plume Chemistry* (principal investigator)  
 \$2,170k                    September 2007 – October 2011

Air Force Office of Scientific Research/Alameda Applied Sciences Corp.  
*STTR Phase I: Protective Conformal Coatings for Spacecraft Polymers and Paints* (co-investigator)  
 \$40k                        September 2007 – May 2008

Air Force Office of Scientific Research/ALD Nanosolutions  
*STTR Phase I: Protective Conformal Coatings for Spacecraft Polymers and Paints* (co-investigator)  
 \$30k                        September 2007 – May 2008

NASA Astrobiology Institute  
*Astrobiology and Geocatalysis Research Center* (co-investigator)  
 \$6M for 10 investigators                      November 2007 – October 2012 (\$580k for T. Minton)

Boeing  
*Quartz Crystal Microbalances for MISSE-7B* (principal investigator)  
 \$20k                        June 2008 – December 2008

Air Force Office of Scientific Research/ALD Nanosolutions  
*STTR Phase II: Protective Conformal Coatings for Spacecraft Polymers and Paints* (co-investigator)  
 \$170k                      January 2009 – June 2011

Metatech Corporation  
*Atomic Oxygen Exposure of Kapton H Polyimide and FEP Teflon* (principal investigator)  
 \$30k                        June 2009 – Dec. 2009

National Science Foundation/Centers for Chemical Innovation  
*Center for Energetic Nonequilibrium Chemistry at Interfaces* (co-investigator)  
 \$1.5M for 6 investigators                      October 2009 – September 2012 (\$235k for T. Minton)

Metatech Corporation  
*Atomic Oxygen Exposure of Russian Teflon and Japanese Kapton* (principal investigator)  
 \$30k                        July 2010 – Dec. 2010

Air Force Office of Scientific Research, Multidisciplinary University Research Initiative (MURI)  
*Fundamental Processes in High-Temperature Gas-Surface Interactions* (co-investigator)  
 \$7.5M for 10 investigators                      October 1, 2010 – September 30, 2015 (\$750k for T. Minton)

Lockheed Martin Aeronautics  
*Laser Ablation Beam Source* (principal investigator)  
 \$76,095                    August 2010 – December 2010

Air Force Research Lab (Edwards, AFB)  
*Analysis of MISSE-6 Samples* (principal investigator)  
 \$10k                        June 2010 – June 2011



Kobe University, Japan

*Fabrication of Pulsed Molecular Beam Valves* (principal investigator)

\$24k            October 2010 – November 2011

Air Force Research Lab (Kirtland, AFB)

*Hyperthermal Atomic-Oxygen Interactions with Surfaces: Sensor Applications in LEO* (princ. investigator)

\$50k            October 2010 – September 2012

Eltron Research Corporation

*Testing and Evaluation of POSS Polymers in an Atomic Oxygen Environment* (principal investigator)

\$8k             February – March 2011

Metatech Corporation

*Atomic Oxygen Exposure of Spacecraft Materials* (principal investigator)

\$33k            August 2011 – December 2011

Lockheed Martin Aeronautics Co.

*Hyperthermal Chemistry for Power Generation* (principal investigator)

\$346k          March 6, 2012 – August 2, 2013 (fixed term contract; \$240k for T. Minton)

Montana State University – Vice President for Research

*Retention Award*

\$150k          July 1, 2012 – June 30, 2016

National Science Foundation

*Ionic Liquid Surface Structure: Informing Applications through Dynamical Measurements* (principal investigator)

\$423k          September 1, 2013 – August 31, 2016

NASA/Ames

*Decomposition Kinetics of Phenolic/Carbon Composite* (principal investigator)

\$50k            July 12, 2013 – March 31, 2014

Air Force Research Lab

*Reactive Scattering Experiments on Ionic Liquid Hypergols* (principal investigator)

\$25k            July 30, 2013 – January 31, 2014

NASA/Ames

*Decomposition Mechanisms of Phenolic and Carbon/Phenolic Composite* (principal investigator)

\$75k            August 1, 2014 – July 31, 2016

NASA/JPL

*Scattering from Concentrator Surfaces* (principal investigator)

\$70k            January 1, 2015 – March 31, 2015

NASA/Space Technology Research Grants Program – Early Stage Innovations

*Uncovering the Chemical Processes during Atmospheric Entry of a Carbon/Phenolic Ablator:*

*Laboratory Studies by Mass Spectrometric and Molecular Beam Techniques* (principal investigator)

\$545,066      January 16, 2015 – June 30, 2018

NASA/JPL

*Scattering from Concentrators* (principal investigator)

\$60k April 1, 2015 – September 30, 2015

European Space Research and Technology Centre (ESTEC)

*Technical Assessment and Delivery of Pulsed Molecular Beam Valve* (principal investigator)

\$46k September 1, 2015 – August 15, 2016

NASA/JPL

*Concentrator Testing* (principal investigator)

\$60k October 1, 2015 – September 30, 2016

NASA/JPL

*Concentrator Testing II* (principal investigator)

\$68k September 1, 2016 – March 31, 2017

NASA/JPL

*Concentration of Gases for Mass Spectrometric Detection* (principal investigator)

\$59,719 May 25, 2017 – September 30, 2017

Centre National d'Études Spatiales (CNES), France

*Validation and Calibration of AO Sensors (Resistack and ORMADD)* (principal investigator)

\$43k June 10, 2017 – September 30, 2017

NASA/JPL

*Concentrator Testing III* (principal investigator)

\$122,278 November 13, 2017 – September 24, 2018

Skeyeon, Inc.

*Atomic-Oxygen Testing of Materials* (principal investigator)

\$33k May 2, 2018 – December 31, 2018

National Science Foundation

*Transport and Reactivity at the Ionic Liquid-Gas Interface*

\$466,320 September 1, 2016 – August 31, 2019

Dalian Maritime University, China

*Atomic-Oxygen Testing of Materials* (principal investigator)

\$30k August 1, 2018 – December 31, 2019

Soreq NRC, Israel

*Atomic-Oxygen Exposures of ELOP Materials* (principal investigator)

\$10,667 April 1, 2019 – December 31, 2019

Air Force/SBIR (Phase I) with Spectral Energies

*High-Energy Atomic Oxygen Source for Low Earth Orbit Equivalent-Exposure Tests* (principal investigator)

\$45k August 19, 2019 – December 31, 2019

Air Force Office of Scientific Research

*Nonequilibrium Gas-Surface Interactions at High Temperature* (co-investigator)

\$1.9M for 5 investigators March 15, 2017 – March 14, 2020 (\$435k for T. Minton)

NASA/Ames

*Ablation Reactions of Heat Shield Silicones* (principal investigator)

\$318,264 April 2, 2018 – June 30, 2021

NASA/JPL

*Molecular Beam Studies for Hypervelocity Gas Sampling* (principal investigator)

\$280k October 1, 2018 – September 30, 2020

Air Force Office of Scientific Research / Defense University Research Instrumentation Program

*Table-Top Shock Tunnel for Studying Thermochemical Nonequilibrium Processes in Hypersonic Flows*  
(principal investigator)

\$472,908 April 1, 2019 – March 31, 2021

Sandia National Laboratories

*Pyrolysis of Sandia Phenolic Ablators* (principal investigator)

\$60k October 1, 2019 – September 30, 2020

Israeli Ministry of Defense

*Effects of Oxidizing Environments on Carbon-Based Materials - 1* (principal investigator)

\$400k January 1, 2017 – July 31, 2020

NASA/SpaceTech–REDDI–2018

*Air-Carbon Boundary Layer Chemistry for Hypersonic Ablation* (PI)

\$500k for three investigators January 15, 2019 – September 30, 2023 (\$250k for T. Minton)

NASA/Heliophysics Technology and Instrument Development for Science

*Laboratory Investigation of Satellite Gas-Surface Interactions for Accurate Construction of Atmospheric Models* (Co-PI)

\$406,043 April 1, 2019 – February 12, 2023 (\$285,277 for T. Minton)

Air Force Research Lab

*Construction of a Table-Top Shock Tunnel* (PI)

\$180k September 1, 2020 – September 30, 2022

Sandia National Laboratories

*Pyrolysis of Sandia Phenolic Ablators* (principal investigator)

\$40k February 1, 2021 – September 30, 2021

Sandia National Laboratories

*Ablative Material Chemistry using the Table-Top Shock Tunnel* (principal investigator)

\$50k February 1, 2021 – September 30, 2021

NASA/Ames Research Center

*New Investigation of PICA Pyrolysis* (PI)

\$150k January 1, 2020 – December 22, 2022

NASA/Space Technology Mission Directorate

*Advanced Computational Center for Entry System Simulation* (Co-PI)

\$15,000k June 15, 2021 – June 14, 2026 (\$886,466 for T. Minton)

Spectral Energies/AFOSR SBIR, Phase II  
*High-Energy Atomic Oxygen Source for Low Earth Orbit Equivalent-Exposure Tests* (institutional PI)  
 \$750k April 1, 2021 – March 31, 2023 (\$150k for T. Minton)

NASA/Science Mission Directorate, Astrophysics  
*Atomic Oxygen Resistant Coating for Polymethyl Methacrylate Lenses* (institutional-PI)  
 \$376,452 February 1, 2022 – January 31, 2024 (\$119,427 for T. Minton)

Sandia National Laboratories  
*Pyrolysis of Sandia Phenolic Ablators - II* (PI)  
 \$40k October 1, 2021 – September 30, 2022

Sandia National Laboratories  
*Ablative Material Chemistry using the Table-Top Shock Tunnel – II* (principal investigator)  
 \$50k October 1, 2021 – September 30, 2022

Sandia National Laboratories  
*Molecular Beam Studies of Carbon Oxidation at High Temperatures* (PI)  
 \$172k October 1, 2021 – September 30, 2023

NASA/Ames Research Center  
*Recombination Reactions on Heat Flux Sensors* (PI)  
 \$40k May 10, 2022 – May 9, 2023

Israeli Ministry of Defense  
*Effects of Oxidizing Environments on Carbon-Based Materials - 2* (PI)  
 \$200k February 17, 2022 – January 22, 2024

Office of Naval Research – MURI  
*Development of Validated Hypersonic Plasma Kinetics Models Including Atomic Excitation* (Co-PI)  
 \$7.5M September 2, 2022 – September 1, 2027 (\$1.5M for T. Minton)

NASA Innovative Advanced Concepts (NIAC) Phase I  
*In-situ Neutral-Optics Velocity Analyzer for Thermospheric Exploration* (Co-PI)  
 \$174,132 April 1, 2022 – December 28, 2022 (\$72k for T. Minton)

Air Force Research Laboratory – Space Vehicles Directorate  
*Multi-Domain Awareness, Decision, and Exploitation – Hypersonics* (task PI)  
 \$122k September 9, 2022 – September 30, 2023

National Science Foundation – Division of Materials Research  
*Conference: Workshop on Materials for Space* (PI)  
 \$127,944 November 15, 2022 – October 31, 2023

Sandia National Laboratories  
*CU Boulder – Sandia TPS Grand Challenge* (PI)  
 \$405k October 1, 2022 – September 30, 2025

Australian Research Council – University of Queensland  
*Advancing the Science of Giant Planet Atmospheric Entry* (institutional PI)  
 \$13,189 January 18, 2023 – December 31, 2024

**Pending**

Air Force Office of Scientific Research – High-Speed Aerodynamics Program  
*"Experimental/Computational Study of Gas-phase and Gas-surface Interactions for High Speed Rarefied Flow"* (institutional PI)  
 \$466,247 April 1, 2023 – March 31, 2025

NASA Innovative Advanced Concepts (NIAC) Phase II  
*In-situ Neutral-Optics Velocity Analyzer for Thermospheric Exploration* (Co-PI)  
 \$575,059 June 1, 2023 – May 31, 2025 (\$305,716 for T. Minton)

Various Industry, Government, and University Sponsors  
*Rate-Based Service Activities – Atomic-Oxygen Testing of Materials* (PI)  
 >\$50k expected in 2023

**PERSONNEL in MINTON GROUP (includes significant visits)****Editorial Assistant/Lab Manager**

Nicole Wolf (May 2005 – May 2021)

**Visiting Scientists**

Masahito Tagawa (Osaka University and Kobe University, Japan, 1994-5, 2001)  
 Weiqing Zhang (Dalian Institute of Chemical Physics, Dalian, China, Fall 2009)  
 Gilbert Nathanson (University of Wisconsin, Madison, July-October, 2010)  
 Steven Chambreau (Air Force Research Laboratory, Edwards, AFB, August-September, 2013)  
 Irina Gouzman (Soreq NRC, Israel, July 2021 – June 2022)

**Research Staff**

Donna J. Garton (January 1999-August 2000)  
 Nicole Wolf (October 2004-April 2005)  
 Jianming Zhang (July 2004-October 2011)  
 Jane Klassen (September 2009-September 2011)  
 Alexandra Jones (May 2017-March 2018)  
 Cal Treadway (January 2019-June 2020)  
Chenbiao Xu (University of Colorado, September 2020-present)  
Cornelia Heid (University of Colorado, November 2022-present)

**Technicians**

Alexander Ide (Montana State University, 1995-6)  
 Angela Frandsen (Montana State University, 1997-8)

**Post-docs**

Mark A. Hanning-Lee (JPL, National Research Council Post-Doctoral Fellow, 1992)  
 Hiroshi Kinoshita (Montana State University, July 2000-January 2002)  
 Brian Keller (Montana State University, September 2002-November 2003)  
 Hari P. Upadhyaya (Montana State University, November 2004-November 2006)  
 Evgueni Kadossov (Montana State University, January 2005-August 2005)  
 Edwin Lindholm (Montana State University, September 2007-August 2008)  
 Bohan Wu (Montana State University, November 2007-May 2010)  
 Li Che (Montana State University, September 2008-December 2010)  
 Sridhar Lahankar (Montana State University, November 2007-September 2011)

Christopher Fleming (Montana State University, November 2010-August 2011)  
 William Alexander (Montana State University, June 2010-July 2012)  
 Sridhar Lahankar (Montana State University, November 2012-March 2014)  
 Min Qian (Montana State University, August 2014-July 2016)  
 Savio Poovathingal (Montana State University, August 2016-August 2018)  
 Vanessa J. Murray (Montana State University, July 2018-September 2019)  
 Adriana Caracciolo (Montana State University, June 2019-August 2020)  
 Sara Marquez (Montana State University, July 2019-June 2020)  
 Chenbiao Xu (Montana State Univ., Nov. 2016-Aug. 2020)  
 Yanice Benitez (University of Colorado, December 2020-August 2022)  
 Adriana Caracciolo (University of Colorado, September 2021-August 2022)

### Visiting Post-docs

Bernd-Michael Haas (Caltech, Deutsche Forschungsgemeinschaft Fellow, visitor, 1994)  
 Thomas Schindler (Caltech, Deutsche Forschungsgemeinschaft Fellow, visitor, 1996)  
 Simon Purcell (Heriot-Watt University, UK, visitor, 2015, 2016)

### Graduate Students

Christine M. Nelson (shared with Caltech, NASA Fellow, 1990-1993, *Ph.D. 1993*)  
 Teresa A. Moore (shared with Caltech, NASA Fellow, 1991-1997, *Ph.D. 1997*)  
 Terry Thompson (Montana State University, Center for Biofilm Eng. grad. student, 1995-7, *M.S. 1997*)  
 James Seale (Montana State University, 1996-8, *M.S. 1998*)  
 Donna Garton (Montana State University, NASA Fellow, 1996-8, *M.S. 1998, Ph.D. 2004*)  
 Jianming Zhang (Montana State University, 1997-2001, *Ph.D. 2001*)  
 Chiang-Lin Fong (Montana State University, 1999-2000, *M.S. 2000*)  
 Yu Du (Montana State University, 2000-2001)  
 Deanna Buczala (Montana State University, 2001-2004, *M.S. 2004*)  
 Amy Brunsvold (Montana State University, 2002-2007, *Ph.D. 2007*)  
 Amelia Valasek (Montana State University, 2005)  
 Ken Mousseau (Montana State University, 2006)  
 Ramon Tusell (Montana State University, 2006)  
 Linda Barr (Montana State University, 2006-2007)  
 Matthew Hettick (Montana State University, 2010-2013)  
 Brooks Marshall (Montana State University, 2010-2016)  
 Vanessa Murray (Montana State University, 2012-2018, NDSEG Fellow, 2013-2016, *Ph.D. 2018*)  
 Brody Bessire (Montana State University, 2012-2018, *Ph.D. 2018*)  
 Philip Woodburn (Montana State University, 2012-2014)  
 Heilong Wang (Dalian Maritime University, 2012-2016, *Ph.D. 2019*)  
 Eric Smoll (Montana State University, 2013-2019, *Ph.D. 2019*)  
 David Chen (Montana State University, 2016-2021, *Ph.D. 2021*)  
 Isaac Armstrong (University of Colorado, 2020)  
 John Wright (University of Colorado, 2020)  
Brian Riggs (University of Colorado, 2021-present)  
 Erin Acuña (University of Colorado, 2021-January 2022)  
Celeste Guiles (University of Colorado, 2021-present)  
Samer Hammoodi (University of Colorado, 2023-present)

### Visiting Graduate Students

MacKenzie E. King (University of Wisconsin, visitor, 1993-1994)  
 Kathleen M. Fiehrer (University of Wisconsin, visitor, 1994)  
 Agnes Tempez (University of Houston, visitor, 1998)  
 Laurence Yeung (Caltech, visitor, 2007)

Justin Wiens (University of Wisconsin, visitor, 2010-2011)

**Undergraduate Students**

Octaviano Espinosa (Montana State University, 1999)  
Alexis Foreman (Montana State University, 1999-2000)  
Matthew Dorrington (Montana State University, 2001-2002)  
Jalice Manso (Montana State University, 2001-2002)  
Heather Green (Montana State University, 2002-2003)  
Russell Cooper (Montana State University, 2004-2006)  
David Stockdale (Montana State University, 2006)  
Casey Knight (Montana State University, 2007)  
Linhan Shen (Montana State University, 2007-2011)  
Ann Staudinger (Montana State University, 2009-2010)  
Sara Marquez (Montana State University, 2010-2011)  
Wei Wei (Montana State University, 2015)  
Fei San Lee (Montana State University, 2015)  
Matthew Hall (Montana State University, 2015-2016)  
Kendra Fischer (Montana State University, 2017-2018)  
Cameron King (University of Colorado, 2022-present)