

Harmandeep S. Khare, Ph.D.

Department of Mechanical Engineering
School of Engineering and Applied Science
Gonzaga University

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1. EDUCATION

Doctor of Philosophy in Mechanical Engineering, 2014

University of Delaware, Newark DE

Dissertation title: The coupled effects of environmental composition, temperature and contact size-scale on the tribology of molybdenum disulfide

Bachelor of Engineering (Honors) in Mechanical Engineering, 2008

Panjab University, Chandigarh (India)

2. PROFESSIONAL APPOINTMENTS

Assistant Professor, August 2018 - present

Department of Mechanical Engineering, Gonzaga University

Manager of Research Projects, March 2016 – August 2018

Nanotribology Laboratory of Prof. Robert W. Carpick

Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania

Postdoctoral Associate, June 2014 – February 2016

Nanotribology Laboratory of Prof. Robert W. Carpick

Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania

3. AWARDS AND HONORS

Marshall B. Peterson Award, American Society of Mechanical Engineers (ASME), 2016

Poster Award, Gordon Research Seminar on Tribology, 2016

Early Career Researcher Award, Society of Tribologists & Lubrication Engineers (STLE), 2015

Poster Award, Gordon Research Seminar on Tribology, 2014

Professional Development Award, University of Delaware, 2014, 2012

Graduate Scholarship, National Association for Surface Finishing, 2014

Student Scholarship, Society of Tribologists & Lubrication Engineers, Philadelphia Section, 2013

Young Tribologist Award, Society of Tribologists & Lubrication Engineers, 2013

Graduate Achievement Award, University of Delaware Department of Mechanical Engineering, 2013

University Graduate Fellow, University of Delaware, 2012

Best Poster Award, Society of Tribologists & Lubrication Engineers, Annual Meeting, 2012

Poster Award, ASME-STLE International Joint Tribology Conference, 2011

4. FEATURED ARTICLES AND COVERAGE

- *Nanotribological Printing* selected as one of two featured technologies for the University of Pennsylvania 2017-18 Y-Prize competition (<https://youtu.be/Q9VMqQv8rCk>)
- Featured article in *Nanowerk* (nanowerk.com/spotlight/spotid=51476.php)

5. SELECTED PROFESSIONAL ACTIVITIES

- Associate Editor, Tribology Transactions, 2020-present
- Merit Panel Reviewer for the National Science Foundation (NSF-MRI)
- Proposal Reviewer for Department of Energy
- Guest Editor, MDPI Lubricants (Multiscale Tribology of Solid Lubricants), 2021-present
- Topic Editor, Frontiers in Mechanical Engineering: Tribology (Ionic Liquids in Lubrication), 2021
- Chair, Nanotribology Technical Committee of the STLE Annual Meeting, 2019
- Technical Editor, STLE Tribology and Lubrication Technology, 2018
- Conference Chair, Gordon Research Seminar on Tribology, 2018
- Invited peer Reviewer (50+ papers reviewed by invitation), for journals including Nature Communications, Scientific Reports, ACS Applied Materials and Interfaces, ACS Nano Letters, Journal of Materials Research, Journal of Composite Materials, ASM International, Wear, Tribology Letters, ASME Journal of Tribology, Tribology Transactions, Wear of Materials (conference), etc.

6. RESEARCH INTERESTS

- Tribology (friction, wear and lubrication), surface science and multi-scale interfacial mechanics
- Scanning Probe Microscopy: nanotribology, colloidal probe microscopy and novel methods in scanning probe nanolithography and nanomanufacturing
- Experimental multi-scale tribology of liquid and solid lubricant materials, including lubricant additives and their interactions, multifunctional polymer, ceramic and metal-matrix nanocomposites and nanostructured surface coatings
- Surface analytical techniques, surface metrology, metallography and powder metallurgy
- Ultraprecision machine design and fabrication of instruments for experimental tribometry

7. PATENTS

1. Systems and Methods for Nano-Tribological Manufacturing of Nanostructures, US Patent 10,768,202
2. Nano-additives enabled advanced lubricants, US Patent 10,647,938

8. PEER-REVIEWED PUBLICATIONS

Peer-reviewed articles (Google Scholar Citations: 762; h-index: 10)

1. AFM at the Macroscale: Methods to Fabricate and Calibrate Probes for Milli-Newton Force Measurements
N.T. Garabedian, **H.S. Khare**, R.W. Carpick, D.L. Burris, *Tribology Letters*, **67** (1), 21, 2019
2. Nanoscale Generation of Robust Solid Films from Liquid Dispersed Nanoparticles via *In-situ* Atomic Force Microscopy: Growth Kinetics and Nanomechanical Properties
H.S. Khare, I. Lahouij, A. Jackson, G. Feng, Z. Chen, G.D. Cooper, R.W. Carpick, *ACS Applied Materials & Interfaces*, **10** (46), 40335-40347, 2018
3. Nanotribological Printing: A Nanoscale Additive Manufacturing Method
H.S. Khare, N.N. Gosvami, I. Lahouij, Z.B. Milne, J.B. McClimon, R.W. Carpick, *Nano Letters*, **18** (11) 6756-6763, 2018
4. Interrelated effects of temperature and environment on wear and tribochemistry of an ultralow wear PTFE composite
H.S. Khare*, A.C. Moore*, D.R. Haidar, L. Gong, J. Ye, J.F. Rabolt, D.L. Burris, *Journal of Physical Chemistry C*, **119** (29), 16518-16527, 2015 [*equal contribution]

5. Quantitative characterization of solid lubricant transfer film quality
J. Ye, **H.S. Khare**, D.L. Burris, *Wear*, **316** (1), 133-143, 2014
6. Surface and subsurface contributions of oxidation and moisture to room temperature friction of molybdenum disulfide
H.S. Khare, D.L. Burris, *Tribology Letters*, **53** (1), 329-336, 2014
7. The effects of environmental water and oxygen on the temperature-dependent friction of sputtered molybdenum disulfide
H.S. Khare, D.L. Burris, *Tribology Letters*, **52** (3), 485-493, 2013
8. The extended wedge method: Atomic force microscope friction calibration for improved tolerance to instrument misalignments, tip offset, and blunt probes
H.S. Khare, D.L. Burris, *Rev. of Sci. Instruments*, **84** (5), 055108, 2013
9. Transfer film evolution and its role in promoting ultra-low wear of a PTFE nanocomposite
J. Ye, **H.S. Khare** and D.L. Burris, *Wear*, **297** (1), 1095-1102, 2013
10. A quantitative method for measuring nanocomposite dispersion
H.S. Khare, D.L. Burris, *Polymer*, **51** (3), 719-729, 2010

Articles in Professional Trade Magazines

1. Relating macroscale wear to mechanical properties of transfer films in UHMWPE-PEEK tribological composites
B.J. Miller, **H.S. Khare**, *Tribology and Lubrication Technology*, April 2022
2. Methods in characterization of nanoscale friction in solid lubricants
H.S. Khare, D.L. Burris, *Tribology and Lubrication Technology*, September 2012
3. Characterization of nanoscale surface films in solid lubricants
H.S. Khare, D.L. Burris, *Tribology and Lubrication Technology*, May 2012

9. AWARDED GRANTS AND SUPPORT

1. Gonzaga University SEAS Innovation Award, 2020 (**awarded \$9,114; role: PI**)
2. NSF-MRI: *Acquisition of an Atomic Force Microscope for Fundamental Research in Engineering, Biochemistry and Biology at Gonzaga University*, 2019 (**awarded, \$268,988; role: PI**)
3. Gonzaga University Research Council Award: *An AFM Investigation of Nanoscale Friction in 2D Materials*, 2019 (**awarded \$1,750; role: PI**)
4. NSF-GOALI: *Enabling Ultra-Low Viscosity Lubricants Through Fundamental Understanding of Additive Interactions and Tribofilm Growth Mechanisms: An In-Situ Study*, 2017 (**awarded, \$383,819; role: Senior Personnel**).

Contributions to other grant applications (not in a PI/Senior Personnel role)

5. Helped conceptualize and author a Phase II Department of Defense Small Business Technology Transfer (STTR) grant, titled 'Fuel Efficient Nano-Fluid Gear Oil', 2017 (**awarded, \$340,000**)
6. Conceptualized and authored an NSF Research Experience for Undergraduates (REU) Supplement to the grant 'Temperature dependence of atomic scale friction', CMMI-1401164, 2017 (**awarded, \$5,000**).
7. Conceptualized and authored a proposal for an undergraduate summer research project at the University of Pennsylvania Singh Center REU program, 2016 (**awarded, \$5,500, plus instrument user fees**).
8. Conceptualized and authored two proposals to support summer undergraduate researchers through the Penn Undergraduate Research Mentoring Program (PURM), 2015, 2016 (**awarded, \$5,000 each**).

9. Helped conceptualize, author and collected preliminary data for a grant proposal titled '*A Direct Experimental Link Between Atomic-Scale and Macroscale Friction*', NSF CMMI #1434435, 2014 (awarded, \$297,946).

10. PRESENTATIONS

Presenting author on 19 contributed talks and 9 poster presentations (see #18 for list of contributed talks).

Invited Talks

1. Scratching the Surface (Mathematically Speaking), *MATH360: Math Seminar*, Gonzaga University, 2022
2. Enabling Novel Nanomanufacturing Methods and Advanced Lubricant Additives Using *In-Situ* AFM *Singh Nanovation Conference at the University of Pennsylvania*, Philadelphia PA, 2017
3. Revealing Growth and Wear Protection Mechanisms of Engine Oil Additive Tribofilms through *in-situ* Atomic Force Microscopy
Microscopy Symposium of the Philadelphia Society of Microscopy, Philadelphia PA, 2017
4. Fundamental studies of molybdenum disulfide tribology
STLE Philadelphia Section Meeting, Orelan, PA 2014
5. Scanning Probe Microscopy (SPM) applications in tribology
Bruker Nano Surface Metrology Workshop, UD Center for Composite Materials, Newark DE, 2012
6. Applications of 3D optical microscopy in tribology research
Bruker Nano Surface Metrology Workshop, UD Center for Composite Materials, Newark DE, 2012

11. TEACHING EXPERIENCE

Department of Mechanical Engineering, Gonzaga University

- Instructor of Record
ENSC486, Tribology & Surface Science: Spring 2020, 2021, 2022
MENG456, Design for Manufacturing: Fall 2020
MENG301, Manufacturing Processes (and Lab): Fall 2018, 2020; Spring 2019, 2020, 2021, 2022
ENSC491/2, Senior Design: AY 19/20, 21/22
MENG221, Materials Engineering: Fall 2019, 2021

Department of Mechanical Engineering & Applied Mechanics, University of Pennsylvania

- Guest Lecturer, Fall 2017, 2016, 2015
MEAM 504: Tribology, lectures on Solid Lubrication and Boundary Lubrication
- Teaching Assistant and Recitation Instructor, Fall 2016, 2015
MEAM 354: Mechanics of Solids

Department of Mechanical Engineering, University of Delaware

- Teaching Assistant and Laboratory Instructor, Fall 2013
MEEG 311: Vibrations and Control
- Teaching Assistant and Laboratory Instructor, Spring 2009
MEEG 346: Thermal Laboratory
- Teaching Assistant and Laboratory Instructor, Fall 2008
MEEG 331: Fluid Mechanics I

12. TRAINING IN PEDAGOGY

1. **Equity Minded Teaching Co-Lab**, 2021-22
Center for Teaching and Advising, Gonzaga University
2. **Ignatian Mission Formation Program**, 2021-22
Office of Mission & Ministry, Gonzaga University

3. **The Cataldo Project**, May 2019
Center for Teaching and Advising, Gonzaga University
4. **Course Design Institute**, February 2019
Center for Teaching and Advising, Gonzaga University
5. **Fundamentals of Classroom Teaching**, October – November 2015
University of Pennsylvania’s Center for Teaching and Learning and School of Eng. & Applied Science
6. **Creating Assessments and Evaluation Plans**, September – December 2015
Center for the Integration of Research, Teaching and Learning
7. **Course in College Teaching**, January – May 2015
University of Pennsylvania’s Center for Teaching and Learning
8. **An Introduction to Evidence-Based Undergraduate STEM Teaching**, October – November 2014
Center for the Integration of Research, Teaching and Learning
9. **Pedagogy and Orientation for the American Classroom**, July – August 2008
International Teaching Assistant Training Program, University of Delaware

13. UNDERGRADUATE RESEARCH MENTORING

Department of Mechanical Engineering, Gonzaga University

19+ undergraduate students mentored since Fall 2018, on projects ranging from ultraprecision design of instruments for experimental tribometry, fabrication and testing of polymer nanocomposites and atomic force microscopy based measurements

Department of Mechanical Engineering & Applied Mechanics, University of Pennsylvania

- Benjamin Riedel, Kai Wang, James Buser, Sabino Padilla, Darryl Beronque, Omar Rizkallah, BSME ’18, *Capstone Design: Multi-Setting Tribometer Design & Fabrication*
- Samantha Lunt, BSME ’20, *Interaction of ZDDP anti-wear additives with ZrO₂ nanoparticle additives*
- Eugenia Bejar, BSME ’18, *Design and fabrication of a variable temperature microtribometer*
- Daniel Anderson, BSMSE ’19 (UPenn-Georgia Tech REU), *Mechanisms of ZDDP tribofilm growth*
- Noah Glachman, BSMSE ’18, *Interaction of nanoparticle additives with lubricant co-additives*
- Julia Lin, BSME ’18, *Design and control instrumentation of an AFM-modeled microtribometer*

Department of Mechanical Engineering, University of Delaware

- David Anlian, BSME ’14, *Effects of environment and temperature on wear of PTFE nanocomposites*
- Jaghab Hishmeh, BSME ’15, *Tribology of metal-matrix composites; design of kinematic fixtures*
- Steven Rosenkrantz, BSME ’14, *Metal-matrix nanocomposites for automotive components*
- Jeffrey Lugo, BSME ’11, *Design of an environmental chamber for controlled microtribometry*

14. OUTREACH ACTIVITIES

1. **Philadelphia Alliance for Minority Participation (AMP) Research Symposium and Mentoring Conference**, October 2017, Philadelphia PA
Volunteer judge for the student poster competition, in the engineering category.
2. **Tribology STEM Camp**, May 2017, 2016, 2015
STLE Annual Meeting and Exhibition
Led high school sophomores and juniors through hands on experiments on a custom-built, macroscale replica of an atomic force microscope, illustrating optical lever detection and its use in measurement of nanoscale friction and topography.

3. **Philly Materials Day**, February 2017, 2016
University of Pennsylvania and Drexel University, Philadelphia PA
Co-organized hands-on demos and short experiments for children aged 5-years and above which introduce them to thinking about everyday objects and phenomena through a materials science and tribology lens.
4. **National Society of Black Engineers (NSBE) STEM Conference**, September 2014
University of Pennsylvania, Philadelphia PA
Co-developed and led tribology demonstrations, and hands-on activities and experiments for middle and high-school students replicating DaVinci's tribology experiments for verifying the laws of friction.
5. **Academic Job Search Panel Discussion**, December 2012
Mechanical Engineering Graduate Association, University of Delaware, Newark DE
Organized and hosted an informal panel discussion for Mechanical Engineering undergraduate and graduate students on navigating the path to successful careers in academia.
6. **Undergraduate Research and Applying to Graduate School**, April 2012
Mechanical Engineering Graduate Association, University of Delaware, Newark DE
Organized an informal panel discussion for engineering majors exploring strategies for getting involved and utilizing campus resources for undergraduate research and looking ahead to graduate school.

15. PROFESSIONAL SERVICE

- Spokane Intercollegiate Research Conference, Planning Committee Member, 2019
- Gordon Research Seminar on Tribology, Discussion Leader, 2016
- STLE Tribology Frontiers Conference, Session Chair, 2016
- STLE Early Career Committee, since 2016
- STLE Annual Meeting Nanotribology Technical Committee
 - Paper Solicitation Chair, Nanotribology Sessions, 2017
 - Paper Solicitation Co-chair, Nanoparticle Additives and Interactions special session, 2017
 - Paper Solicitation Chair, Nanotribology-Materials Tribology Joint Session, 2016
 - Technical Session and Vice Paper Solicitation Chair, 2013-16
- STLE Annual Meeting Materials Tribology Technical Committee
 - Vice-Paper Solicitation Chair, 2014-15
 - Technical Session Chair, 2012-14

16. UNIVERSITY SERVICE

- Senator representing SEAS, Gonzaga University Faculty Senate, 2021-present
- Council for Diversity, Equity & Inclusion, Gonzaga University, 2020 – present
- Member of the *Black Student Union (BSU) Task Force*, 2021-present
- Member of the *Health Partnership Faculty Research Task Force*, 2021-present
- Representing the Mechanical Engineering department on the IT Computer Refresh Policy committee, 2022-present
- Representing the Mechanical Engineering department on the SEAS Freshman Year Seminar (ENSC 191/192) committee, 2021-present
- Representing the Mechanical Engineering department on the Renouard Distinguished Lecture Series committee, 2021-present

- Representing the Mechanical Engineering department on the SEAS ‘Lab use/work for hire’ committee, 2021-present
- Faculty Search Committee, Gonzaga University Mechanical Engineering, 2019, 2022
- SEAS Associate Dean Search Committee, 2020-21
- Academic Council Curriculum Committee, 2019-21
- University of Delaware Mechanical Engineering Graduate Association (MEGA): Founding Member and Vice President, 2011-12
- Panjab University Society of Automotive Engineers (SAE) Student Chapter: Founding Member and President, 2007-08

17. MEMBERSHIP IN PROFESSIONAL ORGANIZATIONS

American Society of Mechanical Engineers (ASME)
 American Society for Engineering Education (ASEE)
 Society of Tribologists and Lubrication Engineers (STLE)

18. COMPLETE LIST OF PRESENTATIONS

Contributed Conference Talks (as presenting or corresponding author)

1. Effects of Metal-Oxide Fillers on Dry Sliding Wear of Novel PTFE Nanocomposites
 Q. Pham, B.J. Miller, **H.S. Khare**, *STLE Annual Meeting*, Orlando FL, 2022
2. *In-situ* Atomic Force Microscopy Study of Additive Tribofilm Formation: The Effect of Shear Rate and Asperity-Scale Surface Interactions on ZDDP Tribofilm Growth
H.S. Khare, N.N. Gosvami, D.C. Anderson, A. Jackson, R.W. Carpick, *ASTM Symposium of Tribometry and Tribochemistry*, Boston MA, 2017
3. Contribution of Shear Rate and Asperity-Scale Surface Interactions on the Growth of ZDDP Tribofilms: An *In-situ* Atomic Force Microscopy Study
H.S. Khare, D.C. Anderson, A. Jackson, R.W. Carpick, *STLE Annual Meeting*, Atlanta GA, 2017
4. *In-situ* AFM measurements of nanoparticle anti-wear additives: growth mechanisms and interactions with co-additives
H.S. Khare, I. Lahouij, N. Glachman, A. Jackson, Z. Chen, G.D. Cooper, R.W. Carpick, *Tribology Frontiers Conference*, Chicago IL, 2016
5. Revealing Mechanisms of Growth and Wear Protection of Nanoparticle Additive Tribofilms Through *In-Situ* Atomic Force Microscopy
H.S. Khare, I. Lahouij, A. Jackson, Z. Chen, G.D. Cooper, R.W. Carpick, *Gordon Research Seminar on Tribology*, Lewiston ME, 2016
6. *In-situ* AFM measurements of the interaction between conventional lubricant additives with a novel anti-wear nanomaterial
H.S. Khare, I. Lahouij, A. Jackson, Z. Chen, G.D. Cooper, R.W. Carpick, *STLE Annual Meeting*, Las Vegas NV, 2016
7. Nano-Tribological Printing: A novel additive manufacturing method for nanostructures
H.S. Khare, N.N. Gosvami, I. Lahouij, G.D. Cooper, R.W. Carpick, *MRS Meeting*, Boston MA, 2015
8. *In-situ* growth of anti-wear tribofilms at a nano-scale lubricated contact from a novel nanomaterial
H.S. Khare, N.N. Gosvami, I. Lahouij, A. Jackson, W. Xu, Z. Chen, G.D. Cooper, R.W. Carpick, *STLE Annual Meeting*, Dallas TX, 2015
9. The effects of high temperature on the wear and transfer of alumina-PTFE nanocomposites
H.S. Khare, J. Ye, D.L. Burris, *STLE Annual Meeting*, Lake Buena Vista FL, 2014

10. Coupled effects of environmental composition and temperature on the friction of MoS₂
H.S. Khare, D.L. Burris, *STLE Annual Meeting*, Lake Buena Vista FL, 2014
11. Nanotribological and nanomechanical properties of tribofilms in MoS₂ solid lubricants
H.S. Khare, D.L. Burris, *STLE Annual Meeting*, Detroit MI, 2013
12. *In-situ* calibration of lateral force in AFM-nanotribology
H.S. Khare, D.L. Burris, *International Joint Tribology Conference*, Denver CO, 2012
13. Isolating the effects of water, oxygen and temperature on MoS₂ tribology
H.S. Khare, D.L. Burris, *International Joint Tribology Conference*, Denver CO, 2012
14. Characterization of nanoscale surface films in molybdenum disulfide
H.S. Khare, D.L. Burris, *STLE Annual Meeting*, St. Louis MO, 2012
15. Characterization of nanoscale surface films in solid lubricants
H.S. Khare, D.L. Burris, *International Joint Tribology Conference*, Los Angeles CA, 2011
16. A quantitative metric for nanocomposite dispersion analysis
H.S. Khare, D.L. Burris, *STLE Annual Meeting*, Las Vegas NV, 2010

Poster Presentations

1. An *In-situ* Atomic Force Microscopy Study of ZrO₂ Nanoparticle and ZDDP Additive Tribofilm Growth and Wear Protection
H.S. Khare, N.N. Gosvami, I. Lahouij, S. Lunt, A. Jackson, Z. Chen, G.D. Cooper, R.W. Carpick, *ExxonMobil-UPenn Research Symposia*, Philadelphia PA, 2017
2. Revealing Mechanisms of Growth and Wear Protection of Nanoparticle Additive Tribofilms Through *In-Situ* Atomic Force Microscopy
H.S. Khare, I. Lahouij, A. Jackson, Z. Chen, G.D. Cooper, R.W. Carpick, *Gordon Research Conference and Seminar on Tribology*, Lewiston ME, 2016
3. Coupled effects of environmental composition and temperature on the friction of MoS₂
H.S. Khare, D.L. Burris, *Gordon Research Conference/Seminar on Tribology*, Waltham MA, 2014
4. Evaluation of competing mechanisms in the thermal and environmental dependence of MoS₂ friction
H.S. Khare, D.L. Burris, *STLE Annual Meeting*, Detroit MI, 2013
5. *In-situ* AFM calibration for quantitative nanotribological studies
H.S. Khare, D.L. Burris, *International Joint Tribology Conference*, Denver CO, 2012
6. Isolating the effects of water, oxygen and temperature on MoS₂ tribology
H.S. Khare, D.L. Burris, *Gordon Research Conference on Tribology*, Waterville ME, 2012
7. Methods in characterization of nanoscale friction in solid lubricant tribofilms
H.S. Khare, D.L. Burris, *STLE Annual Meeting*, St. Louis MO, 2012
8. Characterization of nanoscale surface films in solid lubricants
H.S. Khare, D.L. Burris, *International Joint Tribology Conference*, Los Angeles CA, 2011
9. High temperature tribology of solid lubricants for space
H.S. Khare, E.D. Bonnevie, D.L. Burris, *UDRF Research Symposium*, Newark DE, 2010

Colloquia and Seminars

1. On the face of things: A multi-scale approach to understanding friction and self-lubrication
H.S. Khare, D.L. Burris, *University of Delaware Graduate Student Forum*, Newark, DE, 2012
2. Characterization of Nanoscale Surface Films in Solid Lubricants
H.S. Khare, D.L. Burris, *University of Delaware Graduate Student Forum*, Newark, DE, 2011
3. Tribology: Mechanics of materials in contact
H.S. Khare, D.L. Burris, *Dept. of Mechanical Engineering, University of Delaware*, Newark, DE, 2011