

# Harmandeep S. Khare, Ph.D.

Mechanical Engineering & Applied Mechanics  
School of Engineering and Applied Sciences  
University of Pennsylvania

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## 1. EDUCATION

**Doctor of Philosophy in Mechanical Engineering**, 2014

University of Delaware, Newark DE

**Bachelor of Engineering (Honors) in Mechanical Engineering**, 2008

Panjab University, Chandigarh (India)

## 2. PROFESSIONAL RESEARCH EXPERIENCE

**Manager of Research Projects**, March 2016 - present

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

*Awarded biennially for early career achievement and promise for pursuit of research in tribology*

**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

**Best Research Presentation**, U. Delaware Mechanical Engineering Graduate Research Symposium, 2010

## 4. SELECTED PROFESSIONAL ACTIVITIES

- Chair, Nanotribology Technical Committee of the STLE Annual Meeting, 2019
- Technical Editor, STLE Tribology and Lubrication Technology, 2018
- Co-Chair, Gordon Research Seminar on Tribology, 2018
- Invited Reviewer on 39 peer-reviewed manuscripts in 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)

## 5. RESEARCH INTERESTS

- Tribology (friction, wear, adhesion, reliability), surface science and multi-scale mechanics of materials;
- Scanning Probe Microscopy: nanotribology, colloidal probe microscopy and novel methods in scanning probe nanolithography;
- 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;
- Precision machine design, instrumentation and control.

## 6. PATENTS AND DISCLOSURES

1. Systems and Methods for Nano-Tribological Manufacturing of Nanostructures, International Patent WO/2017/044331, 2017
2. Nano-additives enabled advanced lubricants, International Patent WO/2016/179224, 2016

## 7. PEER-REVIEWED PUBLICATIONS

Total citations=250, h-index=6 (source: Google Scholar)

### ***Manuscripts in preparation (in final stage before submission):***

1. Tribofilm growth kinetics generated from nanoparticle anti-wear additives: An *in-situ* study  
**H.S. Khare**, R.W. Carpick, *et al.*
2. Nanotribological printing: An additive method for nanoscale lithography  
**H.S. Khare**, R.W. Carpick, *et al.*
3. Additive synergies between ZDDP and ZrO<sub>2</sub> nanoparticle additives in low viscosity lubricants  
**H.S. Khare**, R.W. Carpick, *et al.*

### ***Published peer-review articles:***

1. 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]
2. Quantitative characterization of solid lubricant transfer film quality  
J. Ye, **H.S. Khare**, D.L. Burris, *Wear*, **316** (1), 133-143, 2014
3. 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
4. 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
5. 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
6. 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
7. A quantitative method for measuring nanocomposite dispersion  
**H.S. Khare**, D.L. Burris, *Polymer*, **51** (3), 719-729, 2010  
*'Top 25 Hottest Article' in Polymer (January-March, 2010)*

### ***Featured Articles***

1. Methods in characterization of nanoscale friction in solid lubricants  
**H.S. Khare**, D.L. Burris, *Tribology and Lubrication Technology*, September 2012
2. Characterization of nanoscale surface films in solid lubricants  
**H.S. Khare**, D.L. Burris, *Tribology and Lubrication Technology*, May 2012

### **8. GRANT WRITING EXPERIENCE**

- Helped conceptualize and lead author on an NSF Grant Opportunities for Academic Liaison with Industry (GOALI) proposal (with ExxonMobil Research & Engineering), titled '*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**).
- 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**).
- 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**).
- 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**).
- Conceptualized and authored two proposals to support summer undergraduate researchers through the Penn Undergraduate Research Mentoring Program (PURM), 2015, 2016 (**awarded, \$5,000 each**).
- Assisted in conceptual development and writing of a grant proposal submitted to the Department of Energy's Vehicle Technologies Office Incubator Program, titled '*Friction Reduction in Rolling Bearings through High Performance Greases – A Nanotechnology Approach*', 2015 (**not awarded**).
- Helped conceptualize, co-authored 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**).
- Helped conceptualize and led the writing of a seed funding grant at the Department of Mechanical Engineering (University of Delaware) titled '*Metal-Matrix Nanocomposites as Next Generation Tribomaterials*', 2014 (**awarded, \$30,000**).
- Contributing co-author of project report titled '*Linking Tribofilm Nanomechanics to the Origins of Low Friction and Wear*', submitted to the Air Force Office of Scientific Research (AFOSR), 2013.

### **9. PRESENTATIONS**

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

#### ***Invited Talks***

1. Enabling Novel Nanomanufacturing Methods and Advanced Lubricant Additives Using *In-Situ* Atomic Force Microscopy  
*Singh Nanovation Conference at the University of Pennsylvania*, Philadelphia PA, 2017
2. 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
3. Fundamental studies of molybdenum disulfide tribology  
*STLE Philadelphia Section Meeting*, Oreland, PA 2014
4. Scanning Probe Microscopy (SPM) applications in tribology  
*Bruker Nano Surface Metrology Workshop, UD Center for Composite Materials*, Newark DE, 2012

5. Applications of 3D optical microscopy in tribology research  
*Bruker Nano Surface Metrology Workshop, UD Center for Composite Materials, Newark DE, 2012*

## 10. TEACHING EXPERIENCE

1. **Guest Lecturer**, Fall 2017, 2016, 2015  
MEAM 504: Tribology, lectures on Solid Lubrication and Boundary Lubrication  
*Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania*
2. **Teaching Assistant and Recitation Instructor**, Fall 2016, 2015  
MEAM 354: Mechanics of Solids  
*Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania*
3. **Teaching Assistant and Laboratory Instructor**, Fall 2013  
MEEG 311: Vibrations and Control  
*Department of Mechanical Engineering, University of Delaware*
4. **Teaching Assistant and Laboratory Instructor**, Spring 2009  
MEEG 346: Thermal Laboratory  
*Department of Mechanical Engineering, University of Delaware*
5. **Teaching Assistant and Laboratory Instructor**, Fall 2008  
MEEG 331: Fluid Mechanics I  
*Department of Mechanical Engineering, University of Delaware*

## 11. TRAINING IN PEDAGOGY

1. **Fundamentals of Classroom Teaching**, October – November 2015  
University of Pennsylvania's Center for Teaching and Learning and School of Eng. & Applied Science
2. **Creating Assessments and Evaluation Plans**, September – December 2015  
Center for the Integration of Research, Teaching and Learning
3. **Course in College Teaching**, January – May 2015  
University of Pennsylvania's Center for Teaching and Learning
4. **An Introduction to Evidence-Based Undergraduate STEM Teaching**, October – November 2014  
Center for the Integration of Research, Teaching and Learning
5. **Pedagogy and Orientation for the American Classroom**, July – August 2008  
International Teaching Assistant Training Program, University of Delaware

## 12. RESEARCH MENTORING

- Lu Fang, ME PhD '21, University of Pennsylvania, 2017  
*Mechanisms of Lubricant Additive Interactions using Atomic Force Microscopy*
- Samantha Lunt, BSME '20, University of Pennsylvania, 2017  
*Interaction of ZDDP anti-wear additives with ZrO<sub>2</sub> nanoparticle additives*
- Eugenia Bejar, BSME '18, University of Pennsylvania, 2016  
*Design and fabrication of a variable temperature microtribometer*
- Daniel Anderson, BSMSE '19, UPenn-Georgia Tech REU, 2016  
*Mechanisms of ZDDP tribofilm growth*
- Noah Glachman, BSMSE '18, University of Pennsylvania, 2016  
*Interaction of nanoparticle anti-wear additives with lubricant co-additives*
- Julia Lin, BSME '18, University of Pennsylvania, 2015  
*Design and control instrumentation of an AFM-modeled microtribometer*

- David Anlian, BSME '14, University of Delaware, 2014  
*Effects of environment and temperature on the tribology of PTFE nanocomposites*
- Jaghab Hishmeh, BSME '15, University of Delaware, 2013  
*Tribology of metal-matrix composites; design and validation of precision locating fixtures*
- Steven Rosenkrantz, BSME '14, University of Delaware, 2012  
*Fabrication and characterization of metal-matrix nanocomposites for automotive components*
- Jeffrey Lugo, BSME '11, University of Delaware, 2010  
*Design and fabrication of an environmental chamber for controlled microtribometry*

### 13. 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.

### 14. SYMPOSIUM PLANNING AND ORGANIZATION

- 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

## 15. ACADEMIC SERVICE

- 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

## 16. MEMBERSHIP IN PROFESSIONAL ORGANIZATIONS

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

## 17. COMPLETE LIST OF PRESENTATIONS

### *Contributed Conference Talks (as presenting author)*

1. *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
2. 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
3. *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
4. 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
5. *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
6. 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
7. *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
8. 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
9. Coupled effects of environmental composition and temperature on the friction of MoS<sub>2</sub>

- H.S. Khare**, D.L. Burris, *STLE Annual Meeting*, Lake Buena Vista FL, 2014
10. Nanotribological and nanomechanical properties of tribofilms in MoS<sub>2</sub> solid lubricants  
**H.S. Khare**, D.L. Burris, *STLE Annual Meeting*, Detroit MI, 2013
  11. *In-situ* calibration of lateral force in AFM-nanotribology  
**H.S. Khare**, D.L. Burris, *International Joint Tribology Conference*, Denver CO, 2012
  12. Isolating the effects of water, oxygen and temperature on MoS<sub>2</sub> tribology  
**H.S. Khare**, D.L. Burris, *International Joint Tribology Conference*, Denver CO, 2012
  13. Characterization of nanoscale surface films in molybdenum disulfide  
**H.S. Khare**, D.L. Burris, *STLE Annual Meeting*, St. Louis MO, 2012
  14. Characterization of nanoscale surface films in solid lubricants  
**H.S. Khare**, D.L. Burris, *International Joint Tribology Conference*, Los Angeles CA, 2011
  15. 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 ZrO<sub>2</sub> 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 MoS<sub>2</sub>  
**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 MoS<sub>2</sub> 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 MoS<sub>2</sub> 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