# Cangyu Qu

Last updated 5/18/2025


## Postdoctoral Researcher

Dept. of Mechanical Engineering and Applied Mechanics, University of Pennsylvania, Philadelphia, PA
Contact: qucangyu@seas.upenn.edu; 267-226-4762
Links: ORCID | Google Scholar | Website


---

**Research Interests & Expertise**

- **Mechanics:** nanomechanics, experimental mechanics, solid-solid interfaces
- **Tribology:** nanotribology, friction, adhesion, fracture, mechanochemistry/tribochemistry
- **Nanomaterials:** graphene, 2D materials, layered materials

## Education

**Ph.D. Tsinghua University, Beijing, China** 2013.09 – 2019.07

- Mechanics
- Thesis: "*Fundamental Characteristics of Graphite Mesa Superlubric System*"
- Advisor: Prof. Quanshui Zheng

**B.S. Tsinghua University, Beijing, China** 2009.09 – 2013.07

- Engineering Mechanics

## Research Experience

**Postdoc**, University of Pennsylvania, US 2021.08 – present

- Advisor: Prof. Robert Carpick
- Research Projects:
  - NSF project: *Ultra-low power computing: A disruptive approach through a new integrated nanomechanics framework*. 4-PI collaboration. Conducted atomic force microscopy to assess candidate materials for nanoscale electrical contacts and investigated the degradation mechanisms.
  - NSF project: *Mechanics of the Formation and Function of 2D Materials Pleats – An Integrated, Multidisciplinary Study*. US-Ireland R&D Partnership. Conducted atomic force microscopy study on the mechanisms of fracture initiation in graphene edge steps.
  - Industrial collaborative project on chemical mechanical polishing. Carried out nanoscale wear tests.

**Research Associate**, Institute of Superlubricity Technology, Shenzhen, China 2019.08 – 2021.06

- Led a team of four to build lab-made equipment for manipulating large-scale superlubric contacts, understanding the role of defects in superlubric materials, and fabricating superlubric materials and contacts.
- Results led to 2 publications.

**Visiting PhD Student**, University of Pennsylvania, US 2018.04 – 2018.10

- Advisor: Prof. Robert Carpick
- Studied the scaling laws of superlubricity and nanoscale frictional ageing.
- Results led to 1 publication (first-authored).

**Visiting Undergraduate Student**, Harvard University, US 2012.08 – 2013.02

- Advisor: Prof. Katia Bertoldi
- Conducted experiments and simulations on the multi-mode folding of a porous soft structure.
- Results led to 1 publication (co-authored).

## Skills

- **Experimental**: atomic force microscopy (AFM), SEM/TEM, spectroscopic characterization (EDS, XPS, EBSD), microfabrication (thin-film deposition, annealing), micro/nano-manipulation, 2D materials
- **Analysis & Software**: contact mechanics, fracture mechanics, MATLAB, Python, COMSOL
- **Communication**: scientific writing and reviewing, classroom/lab teaching, research mentorship

## Teaching Experience

**TA**, *Statics & Strength of Materials (MEAM 2100)* Fall 2024

- Dept. of Mechanical Engineering and Applied Mechanics, University of Pennsylvania
- Undergraduate (sophomore) course (~80 students)
- Held weekly recitations (active learning) and office hours. Received highly positive student feedback for helping students grasp concepts, think critically and solve challenging problems.

**Co-instructor**, *Nanotribology (MEAM/MSE 5370)* Spring 2024, Spring 2022

- Dept. of Mechanical Engineering and Applied Mechanics, University of Pennsylvania
- Upper-level undergraduate/graduate course (~20 students)
- Delivered 4 lectures on contact mechanics, nanofriction, and superlubricity. Designed and conducted 3 lab sessions.

**TA**, *Tribology (MEAM/MSE 5040)* Spring 2023

- Dept. of Mechanical Engineering and Applied Mechanics, University of Pennsylvania
- Upper-level undergraduate/graduate course (~30 students)
- Assignment grading. Final presentation grading.

*Mentorship*

- Mentored 3 summer research undergraduates at University of Pennsylvania (2023-2024).
- Mentored 5 PhD students and 2 undergraduates at Tsinghua University (2018-2024). Resulted in 9 co-authored publications.

*Teaching Training*

- *Learning Community for Inclusive & Equitable Teaching* (2024), University of Pennsylvania
- *Structured Active In-class Learning TA Training* (2024), University of Pennsylvania
- Mini-course on *Inclusive & Equitable Teaching* (2024), University of Pennsylvania
- *Summer Research: Mentor Training* (2023), University of Pennsylvania

## Academic Service

- **Co-chair**, Tribochemistry Joint Session, Society of Tribologists and Lubrication Engineers (STLE) Annual Meeting & Exhibition, 2024 – 2025
- **Vice Paper Solicitation Chair**, Nanotribology Session, Society of Tribologists and Lubrication Engineers (STLE) Annual Meeting & Exhibition, 2024 – 2025
- **Guest Editor**, *Lubricants*, special issues 2024 & 2023
- **Independent reviewer** for *Physical Review Letters*, *ACS Nano*, *Small*, *Nanoscale*, *Applied Physics Letters*, *Carbon*, *Langmuir*, *Lubricants*, etc.
- **Co-reviewer** for *Nature Materials*, *Nature Communications, Physical Review Letters, Science Advances, ACS Nano, Nano Letters, Tribology Letters,* etc.

## Honors & Awards

- **Distinguished Doctoral Dissertation Award**, Chinese Society of Theoretical and Applied Mechanics, 2020
  - Awarded to 5 Ph. D. theses nationwide across all mechanics-related disciplines.
- **Tsien Excellence in Engineering Program**, Tsinghua University, 2009-2013
  - Selected as one of 29 students in the mechanics track of Tsinghua's elite undergraduate program (Tsinghua School Program) from over 3,000 incoming freshmen.

## Publications

*In progress:*

- (To be submitted, invited Perspective by ***Nature Chemistry***) **Qu, C.**[#], Nautiyal, P.[#], Zholdassov, Y.[#], (#: equal contribution) Martini, A., Braunschweig, A., Carpick, R. Meaning, Value, and Limitations of the Activation Volume in Mechanochemical Kinetics and Selectivity.
- (To be submitted) **Qu, C.** and Carpick, R. Mechanochemically-driven Formation of Tribopolymer in Metallic Nanoscale Contacts Studied by Atomic Force Microscopy.

*Published, as first or corresponding author* (*):

1. **Qu, C.**, Fang, L., Carpick, R.* (2025). Contact Mechanics Correction of Activation Volume in Mechanochemistry. ***Physical Review B***, 111(19), 195405.
2. Yang, D., **Qu, C.***, Gongyang, Y., Zheng, Q.* (2023). Manipulation and Characterization of Submillimeter Shearing Contacts in Graphite by the Micro-Dome Technique. ***ACS Applied Materials & Interfaces***, 15(37), 44563.
3. **Qu, C.***, Shi, D., Chen, L., Wu, Z., Wang, J., Shi, S., Gao, E., Xu, Z., & Zheng, Q.* (2022). Anisotropic Fracture of Graphene Revealed by Surface Steps on Graphite. ***Physical Review Letters***, 129(2), 026101.
4. **Qu, C.**, Wang, K., Wang, J., Gongyang, Y., Carpick, R., Urbakh, M., Zheng, Q.* (2020). Origin of Friction in Superlubric Graphite Contacts. ***Physical Review Letters***, 125(12), 126102.
5. Wang, K., **Qu, C.***, Wang, J., Quan, B., Zheng, Q.* (2020). Characterization of a Microscale Superlubric Graphite Interface. ***Physical Review Letters***, 125(2), 026101. (Editors' suggestion)
6. **Qu, C.**, Xiang, X., Ma, M., Zheng, Q.* (2020). Controlled Movements in Superlubric MEMS. ***Journal of Harbin Institute of Technology (New Series)***, 27(3), 45.
7. Zhao, S., Shi, S., Xia, K., Wang, T., Chai, M., Zhang, Y., **Qu, C.***, Zheng, Q*. (2020). Scratching of Graphene-Coated Cu Substrates Leads to Hardened Cu Interfaces with Enhanced Lubricity. ***ACS Applied Nano Materials***, 3(2), 1992.
8. **Qu, C.**, Shi, S., Ma, M., Zheng, Q.* (2019). Rotational Instability in Superlubric Joints. ***Physical Review Letters***, 122(24), 246101. (Highlighted by *Nature Materials*)
9. **Qu, C.**, Cao, W., Liu, B., Wang, A., Xie, F., Ma, M., Shan, W., Urbakh, M., Zheng, Q.* (2019). Direct Measurement of Adhesions of Liquid on Graphite. ***The Journal of Physical Chemistry C***, 123(18), 11671.
10. **Qu, C.**, Liu, B., Ma, M., Zheng, Q.* (2018). Design and Optimization of the Diamagnetic Lateral Force Calibration Method. ***Review of Scientific Instruments***, 89(11), 113704.

*Published, as co-author:*

11. Capaldi, L.N., Yuan, L., **Qu, C.**, Sánchez, D.A., Carpick, R.W.* and Tertuliano, O.A.*, (2025). High-Throughput Formation of 3D van der Waals Auto-Kirigami. ***Nano Letters***, 25(10), 3964.
12. Peng, D., Wang, Y., Li, H., Wu, Z., Yang, X., Huang, X., Xiang, X., Nie, J., **Qu, C.**, Cao, W., Wu,

M., Ouyang, W., Liu, Z., Ma, M., Ding, F., Liu, Y., Xu, Z.*, Zheng, Q.* (2025). Structural superlubric slidevices. ***Device***. (Published online)

13. Wang, K., He, Y., Cao, W., Wang, J., **Qu, C.**, Chai, M., Liu, Y., Zheng, Q., Ma, M.* Structural superlubricity with a contaminant-rich interface. ***Journal of the Mechanics and Physics of Solids***, 169, 105063 (2022).
14. Jia, X., Shao, Q., Xu, Y., Li, R., Huang, K., Guo, Y., **Qu, C.**, Gao, E.* (2021). Elasticity-Based-Exfoliability Measure for High-Throughput Computational Exfoliation of Two-Dimensional Materials. ***npj Computational Materials***, 7 (1), 211.
15. He, Y., Li, H., **Qu, C.**, Cao, W.*, & Ma, M.* (2021). Recent understanding of solid-liquid friction in ionic liquids. ***Green Chemical Engineering***, 2(2), 145–157.
16. He, Y., Shi, D., **Qu, C.**, Xu, Z., Chen, L., Wang, Y., Yu, Z., & Ma, M.* (2021). Diffusion Induced Different Distributions of Sulfur Clusters on Suspended and Supported Graphene. ***The Journal of Physical Chemistry C***, 125(21).
17. Peng, D., Wu, Z., Shi, D., **Qu, C.**, Jiang, H., Song, Y., Ma, M., Aeppli, G., Urbakh, M., Zheng, Q.* (2020). Load-induced dynamical transitions at graphene interfaces. ***Proceedings of the National Academy of Sciences***. 117(23) 12618.
18. Song, Y., **Qu, C.**, Ma, M.* & Zheng, Q. (2020). Structural Superlubricity Based on Crystalline Materials. ***Small***. 16(15), 1903018.
19. Liu, B., Wang, J., Zhao, S., **Qu, C.**, Liu, Y., Ma, L., Zhang, Z., Liu, K., Zheng, Q., Ma, M.* (2020). Negative friction coefficient in microscale graphite/mica layered heterojunctions. ***Science Advances***, 6(16), eaaz6787.
20. Gongyang, Y., Ouyang*, W., **Qu, C.**, Urbakh, M., Quan, B., Ma, M.*, & Zheng, Q. (2020). Temperature and velocity dependent friction of a microscale graphite-DLC heterostructure. ***Friction***, 8(2), 462–470.
21. Wang, K., **Qu, C.**, Wang, J., Ouyang, W., Ma, M.*, Zheng, Q.* (2019). Strain Engineering Modulates Graphene Interlayer Friction by Moiré Patterns Evolution. ***ACS Applied Materials & Interfaces***, 11, 36169.
22. Wang, J., Cao, W., Song, Y., **Qu, C.**, Zheng, Q., Ma, M.* (2019). Generalized Scaling Law of Structural Superlubricity. ***Nano Letters.*** 19, 7735.
23. Gongyang, Y., **Qu, C.**, Zhang, S., Ma, M.*, & Zheng, Q.* (2018). Eliminating delamination of graphite sliding on diamond-like carbon. ***Carbon***, 132, 444.
24. Liu, B., Wang, J., Peng, X., **Qu, C.**, Ma, M.*, & Zheng, Q. (2018). Direct fabrication of graphite-mica heterojunction and in situ control of their relative orientation. ***Materials & Design***, 160, 371–376.
25. Shan, S., Kang, S. H., Wang, P., **Qu, C.**, Shian, S., Chen, E. R., Bertoldi, K.* (2014). Harnessing multiple folding mechanisms in soft periodic structures for tunable control of elastic waves. ***Advanced Functional Materials***, 24(31), 4935.

## Conference Presentations

1. Anisotropy and Stress-Assisted Thermal Activation Kinetics of Graphene Fracture (poster). **Materials Research Society (MRS) Fall Meeting**, 2024, Boston, MA, US.
2. Contact Mechanics Correction of Activation Volume in Mechanochemistry (poster & oral – promoted from the Gordon Research Seminar to the Gordon Research Conference). **Gordon Research Conference on Tribology**, 2024, Lewiston, ME, US.

3. Contact Mechanics Correction of Activation Volume in Mechanochemistry (oral). **Society for Tribologists and Lubrication Engineers (STLE) Annual Meeting**, 2024, Minneapolis, MN.
4. Durability of Materials for Nanoelectromechanical Switches Studied by Scanning Probe Microscopy (oral). **Society for Tribologists and Lubrication Engineers (STLE) Annual Meeting**, 2023, Long Beach, CA.
5. Durability of Materials for Nanoelectromechanical Switches Studied by Scanning Probe Microscopy (oral). **Society for Experimental Mechanics (SEM) Annual Conference**, 2022, Pittsburgh, PA, US.
6. Durability of Materials for Nanoelectromechanical Switches Studied by Scanning Probe Microscopy (poster). **Gordon Research Conference on Tribology**, 2022, Lewiston, ME, US.
7. (invited) Friction Origin and Characterization of a Superlubric Graphite Contact (oral). **Vienna Virtual Materials Tribology Workshop**, 2021, virtual.
8. Rotational Instability of Superlubric Joints & Its Implication on Superlubric Devices (oral). **25th International Congress of Theoretical and Applied Mechanics (ICTAM)**, 2021, virtual.
9. Rotational Instability in Superlubric Joints (poster). **2nd International Workshop on Superlubricity at Nano and Mesoscales**, 2019, Shenzhen, China.
10. Scaling and Edge Effects of Microscale Superlubricity (poster). **Gordon Research Conference on Tribology**, 2018, Lewiston, ME, US.
11. Adhesions of Liquids on Graphite (oral). **Workshop on Atomic Force Microscopy for Advanced Functional Materials**, 2018, Nanjing, China.

## References

**Robert W. Carpick (**carpick@seas.upenn.edu**)**
John Henry Towne Professor, former Chair (ME)
Dept. of Mechanical Engineering and Applied Mechanics
Dept. of Materials Science and Engineering
University of Pennsylvania, PA, USA
Website

**Michael Urbakh (**urbakh@tauex.tau.ac.il**)**
Professor
School of Chemistry
Tel Aviv University, Tel Aviv, Israel
Website

**Ashlie Martini (**amartini@ucmerced.edu**)**
Professor, Chair (ME)
Department of Mechanical Engineering
University of California Merced, CA, USA
Website

**Quanshui Zheng (**zhengqs@tsinghua.edu.cn**)**
Professor, Member of the Chinese Academy of Sciences
Institute of Materials Research
Tsinghua Shenzhen International Graduate School, Shenzhen, China
Website