

Cangyu Qu

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Postdoctoral Researcher,

Dept. of Mechanical Engineering and Applied Mechanics, University of Pennsylvania, Philadelphia, PA.

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Research Interests & Expertise:

- Nanotribology, solid-solid contacts and interfaces, friction, adhesion, fracture;
- Experimental mechanics, nanomechanics, mechanochemistry;
- Nanomaterials, 2D materials and layered materials.

Education

Ph.D. Tsinghua University, Beijing, China 2013.08 – 2019.07

- Mechanics
- Thesis: “*Fundamental Characteristics of Graphite Mesa Superlubric System*”
- Advisor: Prof. Quanshui Zheng
- Awarded the *Distinguished Doctoral Dissertation Award* from the Chinese Society of Theoretical and Applied Mechanics (CSTAM) in 2020 (one of five awardees nationwide)

B.S. Tsinghua University, Beijing, China 2009.08 – 2013.07

- Engineering Mechanics
- Received the Tsinghua Xuetao Talent Program Scholarship (Tsien Excellence in Engineering Program)

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 – 2021.07

- 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.

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.

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.

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).
- Gave 4 lectures on adhesive contact mechanics, nanofriction, 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.
- Mentored 5 PhD students and 2 undergraduates at Tsinghua University. Resulted in 9 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*, *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.

Publications

In progress:

- (Under review in *Physical Review Letters*) **Qu, C.**, Fang, L., Carpick, R.* Contact Mechanics Correction of Activation Volume in Mechanochemistry.
- (To be submitted) **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. 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.
2. **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.
3. **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.
4. 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)
5. **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.
6. 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.
7. **Qu, C.**, Shi, S., Ma, M., Zheng, Q.* (2019). [Rotational Instability in Superlubric Joints](#). *Physical Review Letters*, 122(24), 246101. ([Highlighted by Nature Materials](#))
8. **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.
9. **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:

10. 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).
11. 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.
12. 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.
13. 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).
14. 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.
15. Song, Y., **Qu, C.**, Ma, M. & Zheng, Q. (2020). [Structural Superlubricity Based on Crystalline](#)

- [Materials](#). *Small*. 16(15), 1903018.
16. 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.
 17. 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.
 18. 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.
 19. Wang, J., Cao, W., Song, Y., **Qu, C.**, Zheng, Q., Ma, M. (2019). [Generalized Scaling Law of Structural Superlubricity](#). *Nano Letters*. 19, 7735.
 20. Gongyang, Y., **Qu, C.**, Zhang, S., Ma, M., & Zheng, Q. (2018). [Eliminating delamination of graphite sliding on diamond-like carbon](#). *Carbon*, 132, 444.
 21. 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.
 22. 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. *Gordon Research Conference on Tribology*, 2024, Lewiston, ME.
Contact Mechanics Correction of Activation Volume in Mechanochemistry (poster & oral – promoted from the Gordon Research Seminar to the Gordon Research Conference).
2. *Society for Tribologists and Lubrication Engineers (STLE) Annual Meeting*, 2024, Minneapolis, MN.
Contact Mechanics Correction of Activation Volume in Mechanochemistry (oral).
3. *Society for Tribologists and Lubrication Engineers (STLE) Annual Meeting*, 2023, Long Beach, CA.
Durability of Materials for Nanoelectromechanical Switches Studied by Scanning Probe Microscopy (oral).
4. *Society for Experimental Mechanics (SEM) Annual Conference*, 2022, Pittsburgh, PA.
Durability of Materials for Nanoelectromechanical Switches Studied by Scanning Probe Microscopy (oral).
5. *Gordon Research Conference on Tribology*, 2022, Lewiston, ME.
Durability of Materials for Nanoelectromechanical Switches Studied by Scanning Probe Microscopy (poster).
6. *Vienna Virtual Materials Tribology Workshop (ViViMat)*, 2021, virtual.
Friction Origin and Characterization of a Superlubric Graphite Contact (oral).
7. *25th International Congress of Theoretical and Applied Mechanics (ICTAM)*, 2021, virtual.
Rotational Instability of Superlubric Joints & Its Implication on Superlubric Devices (oral).
8. *2nd International Workshop on Superlubricity at Nano and Mesoscales*, 2019, Shenzhen, China.
Rotational Instability in Superlubric Joints (poster).
9. *Gordon Research Conference on Tribology*, 2018, Lewiston, ME, US.
Scaling and Edge Effects of Microscale Superlubricity (poster).
10. *Workshop on Atomic Force Microscopy for Advanced Functional Materials*, 2018, Nanjing, China.
Adhesions of Liquids on Graphite (oral).