# Summer 2024 Joint Colloquium
# Materials Department & Materials Research Laboratory

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11:00 am | ESB 1001

## Nanomechanics of phase transforming nanopillars: deformation mechanism, size effect and scaling law

Functional materials that undergo solid-solid phase transformations are widely exploited in various applications such as biomedical devices, microelectronics, caloric cooling, and energy harvesting. As nanotechnologies are widely used in manufacturing of small scale devices, the analysis of mechanical behaviors and microstructure become very important. In this presentation, I will briefly discuss the continuum mechanics theories used to predict the microstructure formation in these materials, which is crucial to the transformability and fatigue properties under stress-induced phase transformations. To verify the theories, I will demonstrate how to carry out nanomechanical experiments for phase-changing materials, including the focused ion beam techniques for miniaturized sample preparation as well as the ex/in situ nanomechanical tensile and compression tests on transforming alloys and ceramics. I will show that our experimental results validate the underlying mechanics theories, reveal the size effect and scaling law, which eventually provide valuable insights for designing low-fatigue alloys and multiferroic ceramics.

**Main references for this talk:**


- *Z. Zhu, M. Karami, C. Zhang, X. Chen, Twinning, Slip and Size Effect of Phase-Transforming Ferroelectric Nanopillars, J. Mech. Phys. Solids, Preprint 2024.*
- *M. Karami, Z. Zhu, K. H. Chan, P. Hua, N. Tamura, X. Chen, Non-dissipative martensitic phase transformation after multi-million superelastic cycles, Phys. Rev. Lett. 132, 066101 (2024).*
- *M. Karami, Z. Zhu, Z. Zeng, N. Tamura, Y. Yang and X. Chen, Two-tier compatibility of Superelastic Bi-crystal Micropillar at Grain Boundary, Nano Letters 20, 11(2020) 8332.*
- *M. Karami, K. Chu, Z. Zhu, Z. Wang, Q. P. Sun, M. Huang, X. Chen, Orientation-dependent superelasticity and fatigue of CuAlMn alloy under in situ micromechanical tensile characterization, J. Mech. Phys. Solids, 160, (2022) 104787.*
- *X. Ni, J. Greer, K. Bhattacharya, R. D. James and X. Chen, Exceptional resilience of small- scale AuCuZn under cyclic stress-induced phase transformation. Nano Letters 16 (12) (2016): 7621-7625.*
- *X. Chen, Y. Song, N. Tamura, R. D. James, Determination of the stretch tensor for structural transformation, J. Mech. Phys. Solids, 93(2016): 34-43.*
- *Y. Song, X. Chen, V. Dabade, TW. Shield and R. D. James, Enhanced reversibility and un- usual microstructure of a phase-transforming material, Nature, 502(2013), 85.*

- *X. Chen, V. Srivastava, V. Dabade and R. D. James, Study of Cofactor Conditions: conditions of supercompatibility between phases, J. Mech. Phys. Solids, 61(2013), 2566.*

Biography: Dr. Chen is an Associate Professor at Mechanical and Aerospace Engineering at Hong Kong University of Science and Technology. She received her Ph.D. in Solid Mechanics, supervised by Prof. Richard D. James, at the University of Minnesota. She worked at Lawrence Berkeley National Lab as the ALS Fellow, then worked at the Department of Mechanical and Civil Engineering, Caltech on nanomechanics of shape memory alloys with Kaushik Bhattacharya and Julia Greer. Dr. Chen received the Early Career Award from RGC, Hong Kong in 2017. She was awarded the Simon Fellowship by Isaac Newton Institute, Cambridge, UK in 2019. Her research interests are the continuum mechanics, nanomechanics, advanced structural characterization and machine learning algorithms for phase-transforming materials. She developed in situ nanomechanics experiments and theoretical approaches for phase transforming polycrystals with much enhanced fatigue resistance. These materials have emerging applications in medical devices, microelectronics and energy conversion devices.

Hosted by Ananya Renuka Balakrishna