

Nathan Nakamura

EDUCATION

Carnegie Mellon University

Ph.D. in Mechanical Engineering (2015-2020)

Advisor: Prof. B. Reeja Jayan

University of California, Santa Barbara

B.S. in Mechanical Engineering (2011-2015)

AWARDS AND HONORS

- National Research Council (NRC) Postdoctoral Research Fellowship
 - National Defense Science and Engineering Graduate (NDSEG) Fellowship
 - Materials Research Society (MRS) Fall 2018 Graduate Student Award - Silver
 - Carnegie Mellon Mechanical Engineering Milton Shaw PhD Research Award
 - Carnegie Mellon Mechanical Engineering Nam Pyo and Young Suh Fellowship
 - UC Santa Barbara Honors Program Scholar
 - Undergraduate Research and Creative Activities Grant (URCA) Recipient, UC Santa Barbara
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PUBLICATIONS

1. **N. Nakamura**, P. Szypryt, J. W. Fowler, Z. H. Levine, D. S. Swetz, “Nanoscale x-ray tomography of integrated circuits using a hybrid electron/x-ray microscope: results and prospects”, *2023 IEEE Physical Assurance and Inspection of Electronics (PAINE)*, 2023, 1-7.
2. Z. H. Levine, B. A. Alpert, A. L. Dagel, J. W. Fowler, E. S Jimenez, **N. Nakamura**, D. S. Swetz, P. Szypryt, K. R. Thompson, J. N. Ullom. “A Tabletop Tomography Instrument for Nanometer-Scale Imaging: Reconstructions”, *Microsystems & Nanoengineering*, 2023, 9, 47.
3. Paul Szypryt, **Nathan Nakamura**, Daniel T Becker, Douglas A Bennett, Amber L Dagel, W Bertrand Doriese, Joseph W Fowler, Johnathon D Gard, J Zachariah Harris, Gene C Hilton, Jozsef Imrek, Edward S Jimenez, Kurt W Larson, Zachary H Levine, John AB Mates, Daniel McArthur, Luis Miaja-Avila, Kelsey M Morgan, Galen C O’Neil, Nathan J Ortiz, Christine G Pappas, Daniel R Schmidt, Kyle R Thompson, Joel N Ullom, Leila Vale, Michael R Vissers, Christopher Walker, Joel C Weber, Abigail L Wessels, Jason W Wheeler, Daniel S Swetz, A tabletop x-ray tomography instrument for nanometer-scale imaging: demonstration of the 1,000-element transition-edge sensor subarray”, *IEEE Transactions on Applied Superconductivity*, 2023, 33, 1-5.
4. P. Szypryt, D. A. Bennet, W. J. Boone, A. L. Dagel, G. Dalton, W. B. Doriese, M. Durkin, J. W. Fowler, E. J. Garboczi, J. D. Gard, G. C. Hilton, J. Imrek, E. S. Jimenez, V. Y. Kotsubo, K. Larson, Z. H. Levine, J. A. B. Mates, D. McArthur, K. M. Morgan, **N. Nakamura**, G. C. O’Neil, N. J. Ortiz, C. G. Pappas, C. D. Reintsema, D. R. Schmidt, D. S. Swetz, K. R. Thompson, J. N. Ullom, C. Walker, J. C. Weber, A. L. Wessels, J. W. Wheeler, “Design of a 3000-Pixel Transition-Edge Sensor X-ray Spectrometer for Microcircuit Tomography”, *IEEE Transactions on Applied Superconductivity*, 2021, 31, 1-5.
5. **N. Nakamura**, L. Su, H. Wang, N. Bernstein, S. K. Jha, E. Culbertson, H. Wang, S. J. L. Billinge, C. S. Hellberg, B. Reeja-Jayan, “Linking far-from-equilibrium defect structures in ceramics to electromagnetic driving forces”, *Journal of Materials Chemistry A*, 2021, 9, 8425-8434.
6. L. Su, P. Choi, **N. Nakamura**, H. Charalambous, S. Litster, J. Illavsky, B. Reeja-Jayan, “Multiscale operando X-ray investigations provide insights into electro-chemo-mechanical behavior of lithium intercalation cathodes”, *Applied Energy*, 2021, 299, 117315.
7. L. Su, J. Weaver, M. Groenenboom, **N. Nakamura**, J. A. Dura, E. Russ, P. Anand, S. K. Jha, J. S. Okasinski, B. Reeja-Jayan, “Tailoring electrode-electrolyte interfaces in lithium-ion batteries using molecularly engineered functional polymers”, *ACS Applied Materials & Interfaces*, 2021, 13, 9919-9931

8. **N. Nakamura**, L. Su, J. Bai, S. Ghose, B. Reeja-Jayan, “*In-situ* synchrotron pair distribution function analysis to monitor synthetic pathways under electromagnetic excitation”, *Journal of Materials Chemistry A*, 2020, 8, 15909-15918.
9. L. Su, S. K. Jha, X. L. Pha, J. Xu, **N. Nakamura**, H. Wang, J. S. Okasinski, B. Reeja-Jayan, “Engineering lithium-ion battery cathodes for high-voltage applications using electromagnetic excitation”, *Journal of Materials Science*, 2020, 55, 12177-12190.
10. S. K. Jha, **N. Nakamura**, S. Zhang, L. Su, P. M. Smith, X. L. Phuah, H. Wang, H. Wang, J. S. Okasinski, A. J. H. McGaughey, B. Reeja-Jayan, “Defect-mediated anisotropic lattice expansion in ceramics as evidence for nonthermal coupling between electromagnetic fields and matter”, *Advanced Engineering Materials*, 2019, 21, 1900762.
11. **N. Nakamura**, B. Reeja-Jayan, “Synchrotron x-ray characterization of materials synthesized under microwave irradiation”, *Journal of Materials Research*, 2019, 34, 194-205.
12. P. M. Smith, L. Su, W. Gong, **N. Nakamura**, B. Reeja-Jayan, S. Shen, “Thermal conductivity of poly (3,4-ethylenedioxythiophene) films engineered by oxidative chemical vapor deposition (oCVD)”, *RSC Advances*, 2018, 8, 19348-19352.
13. A. Lassnig, **N. Nakamura**, T. Jorg, B. Reeja-Jayan, M. J. Cordill, “Molecularly grafted, structurally integrated multifunctional polymer thin films with improved adhesion”, *Surface and Coatings Technology*, 2018, 349, 963-968.
14. **N. Nakamura**, M. W. Terban, S. J. L. Billinge, B. Reeja-Jayan, “Unlocking the structure of mixed amorphous-crystalline ceramic oxide films synthesized under low temperature electromagnetic excitation”, *Journal of Materials Chemistry A*, 2017, 5, 18434-18441.
15. **N. Nakamura**, J. Seepaul, J. B. Kadane, B. Reeja-Jayan, “Design for low-temperature microwave-assisted crystallization of ceramic thin films”, *Applied Stochastic Models in Business and Industry*, 2017, 33, 314-321.
16. M. L. Castillo, A. Ugur, H. Sojoudi, **N. Nakamura**, Z. Liu, F. Lin, R. E. Brandt, T. Buonassisia, B. Reeja-Jayan, K. K. Gleason, “Organic passivation of silicon through multifunctional polymeric interfaces”, *Solar Energy Materials & Solar Cells*, 2017, 160, 470-475.

TECHNICAL SKILLS

- **Programming Languages:**
 - Python
 - MATLAB
- **Software:**
 - PENELOPE (Penetration and ENERgy LOss of Positrons and Electrons) Monte Carlo simulations
 - GEANT4 monte carlo models for simulation of particle interactions with matter
 - MASS (Microcalorimeter Analysis Software System)
 - Diffpy-CMI x-ray pair distribution function analysis software
 - Artemis/Athena – x-ray absorption spectroscopy data analysis and processing
 - Solidworks CAD design software
- **Laboratory Experience:**
 - Cryogenic sensor design, assembly, and testing, including superconducting transition-edge sensor (TES) development, readout, and operation
 - Implementation and use of TES arrays in measurement applications, including x-ray tomography and materials analysis
 - Vacuum system operation, including adiabatic demagnetization refrigerator (ADR) and dilution refrigerator (DR) cryostats, and ultra-high vacuum (UHV) chambers for electron and x-ray microscopy
 - Design of analysis pipelines for x-ray data analysis, including for TES pulse processing for spectroscopic analysis and large *in-situ* x-ray scattering and absorption datasets
 - Instrument development
 - development and operation of x-ray tomographic instrument based on the use of a focused electron beam and a TES spectrometer

- development of microwave reactor enabling solution-based nanoparticle synthesis and implementation at synchrotron beamline facilities for *in-situ* x-ray characterization
 - Materials synthesis
 - solution-based synthesis of ceramic oxide nanomaterials
 - low-temperature thin film deposition
 - magnetron thin film sputtering
- **Materials Characterization:**
 - x-ray characterization techniques, including x-ray diffraction, energy dispersive x-ray diffraction, x-ray absorption spectroscopy, and pair distribution function analysis
 - Raman spectroscopy
 - Scanning electron microscopy
 - Cyclic voltammetry
- **Funding:**
 - Assisted with successful proposal writing for DoD and NSF funding, helping lead to Air Force Office of Scientific Research (AFOSR) Young Investigator Award, Army Research Office (ARO) Young Investigator Award, and NSF CAREER Award
 - Proposal writing for experimental time at DOE National User Facilities, including the Advanced Photon Source (APS), National Synchrotron Light Source II (NSLS-II), and Cornell High Energy Synchrotron Source (CHESS)

RESEARCH EXPERIENCE

National Institute of Standards and Technology, Quantum Sensors Group (*August 2022-Present*)

PREP Physicist

- *Ultrafast X-Ray Spectroscopy*
 - Development and upgrade of an ultrafast (~ps) x-ray spectroscopy setup using a transition-edge sensor (TES) spectrometer
- *3000 Pixel Transition-Edge Sensor (TES) Spectrometer Development*
 - Assisted with the development of a 3000 pixel TES microcalorimeter spectrometer, the largest such instrument ever built. Device currently is at 1000 pixels, with improvements ongoing.
 - Assembled and tested TES μ Snout devices, included detector characterization and x-ray pulse data analysis
- *Monte Carlo Modeling of Thermal Kinetic Inductance Detectors*
 - GEANT4 modeling of natural radiation background as detected by thermal kinetic inductance detectors in a cryostat
 - Compared GEANT4 simulation results with experimental data to develop understanding of the background signal one can expect when utilizing cryogenic equipment, such as for quantum computing testbeds

National Institute of Standards and Technology, Quantum Sensors Group (*August 2020-August 2022*)

National Research Council (NRC) Postdoctoral Fellow

- *TOMographic Circuit Analysis Tool (TOMCAT) Development and Implementation*
 - Assisted with the development of an x-ray microscope for nm-scale integrated circuit characterization based on a focused electron beam and 240-pixel TES spectrometer
 - Performed system diagnostics to characterize the electron beam size and shape, expected photon count rates, and ideal scan areas for tomography
 - Carried out day-to-day setup and operation of the TES spectrometer, ADR cryostat, and electron gun to enable tomographic imaging measurements of integrated circuit samples
 - Developed data analysis pipeline incorporating TES data processing, energy dispersive x-ray spectrometry (EDS) collection and processing, and sample positioning information to feed into tomographic reconstruction algorithms
 - Assembled and tested μ snout design TES spectrometers for the development of a 3000 pixel TES spectrometer
- *Monte Carlo Modeling of Electron and Photon Transport*

- PENELOPE modeling of various x-ray source geometries and materials to guide sample design decisions for the TOMCAT x-ray tomography instrument
- Performed predictive modeling using results from PENELOPE to explore how electron beam size, shape, and current coupled with x-ray target material and geometry affect expected tomographic imaging speed and resolution

Carnegie Mellon University, Mechanical Engineering Department (*August 2015-May 2020*)

National Defense Science and Engineering Graduate (NDSEG) Fellow

- *Electromagnetic field effects in ceramic oxide phase transitions*
 - Investigated electromagnetic field effects on atomic structure, phase transitions, and phase stability using synchrotron x-ray diffraction, pair distribution function analysis, and x-ray absorption spectroscopy
 - Designed and implemented materials synthesis reactor capable of *in-situ* synchrotron x-ray characterization during electromagnetic field-assisted nanoparticle synthesis
 - Developed Python scripts for automated data processing, curve-fitting, and analysis of large, *in-situ* x-ray scattering datasets
 - Utilized statistical regression models to analyze the relationship between synthesis inputs and resultant thin film characteristics
 - Developed novel microwave cyclic voltammetry experiments enabling *in-situ* measurements of local electric field intensities at substrate-solution interfaces during electromagnetic field-assisted synthesis
 - Developed optical laser thermorefectance experimental setup to measure local temperature during electromagnetic field-assisted reactions
- *Polymer surface engineering effects on Li ion battery cathode performance*
 - *In-operando* energy dispersive x-ray diffraction studies of polymer surface engineering effects on cathode atomic structure and Li-ion battery cycling stability
 - Application of synchrotron characterization, including energy dispersive x-ray diffraction, small angle scattering, and wide-angle scattering, during *in-operando* experiments
- *Linking synchrotron experimental studies with machine learning and atomistic modeling*
 - Collaborated with interdisciplinary team to link experimental x-ray scattering data, atomistic simulations, and machine learning/artificial intelligence (AI) to develop an AI research assistant capable of guiding the x-ray scattering data analysis process

Carnegie Mellon University, Department of Statistics (*Summer 2019*)

Statistical Learning Workshop

- Applied various statistical and machine learning techniques to prediction of social movement success
- Discussed integration of data science into effective communication and mentorship in collaborative environments

Argonne National Laboratory and Oak Ridge National Laboratory (*Summer 2017*)

19th National School on Neutron and X-ray Scattering

- Reviewed fundamentals of a wide variety of synchrotron x-ray and neutron characterization techniques
- Gained hands-on experience at the Advanced Photon Source, Spallation Neutron Source, and High Flux Isotope Reactor collecting and analyzing x-ray/neutron scattering and absorption data
- Specific techniques used included x-ray and neutron pair distribution function analysis, x-ray radiography, and x-ray small angle scattering

University of California, Santa Barbara, Department of Materials Science (*2014-2015*)

Undergraduate Research Intern

- Assessed mechanical properties of bio-inspired polymer and polymer-nanoparticle composite materials
- Designed and fabricated tensile test components enabling stress/strain analysis of mussel byssal threads

Toyon Research Corporation, Goleta CA (*Summer 2013*)

Homeland Security Department Intern

- Designed and implemented mechanical systems for projects related to airborne biological hazard detection

LEADERSHIP EXPERIENCE

Carnegie Mellon University, Mechanical Engineering Department (*August 2015-May 2020*)

Graduate Mentor

- Oversaw and supported undergraduate research projects related to ceramic oxide synthesis and characterization
- Provided mentorship and feedback related to scientific results, scientific writing, and future graduate school/career plans

University of California, Santa Barbara, Mechanical Engineering Department (2014-2015)

Team Leader of Soft Robotics Senior Capstone Group

- Led senior design team to design, manufacture, and program various soft robotic actuators
 - Initiated outreach efforts utilizing soft robotic systems as demos in k-12th grade bio-inspired materials outreach
 - Presented results and ideas to 60 local Santa Barbara k-12th grade teachers for integrating STEM research into standard curriculum
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COMMUNITY SERVICE AND OUTREACH

Carnegie Mellon University, STEM Demo Day (May 2018)

Team Leader, Chladni Plate – Fun with Frequencies

- Designed interactive demo linking piano notes to resonant frequencies and vibrational patterns in sand
- Presented to Pittsburgh middle school students from underserved communities

Carnegie Mellon University, Leonard Gelfand Center for Service Learning and Outreach (2015-2018)

Course Instructor, Energy from Everyday Things

- Designed and taught course instructing 1st-6th grade students about renewable energy
- Led interactive demonstrations allowing students to build their own photovoltaic cell using fruit juice

Carnegie Mellon University, Summer Engineering Experience for Girls Camp (July 2016)

Course Instructor

- Taught short class and led activities to demonstrate opportunities available in STEM, with a focus on clean energy and photovoltaics

University of California, Santa Barbara, Soft Robotics STEM Outreach (Oct. 2014-June 2015)

Team Leader

- Presented and led activities on materials applications in soft robotics and the basics of mechanical design
- Developed exercises that allowed students to design their own mechanical systems to complete challenges using cardboard, string, and straws
- Performed this event multiple times throughout the year both by traveling to local elementary schools and by hosting students on UC Santa Barbara's campus, resulting in an award for "Best STEM Integration" at UC Santa Barbara's Mechanical Engineering Design Fair

University of California, Santa Barbara, Materials Science Lab Teachers Workshop (March 2015)

Lecturer

- Presented and discussed materials science outreach and how STEM concepts could be incorporated into classrooms on an everyday basis with over 100 local elementary school, middle school, and high school teachers

Isla Vista Community Parks Department, ASME Community Waterwheel Project (March 2015-June 2015)

Volunteer

- Worked with a team of mechanical engineers to design and build a waterwheel for a local park in the Santa Barbara community
 - Final waterwheel design effectively aerated a park stream, helping keep the water clean and providing an inhabitable area for local wildlife
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PRESENTATIONS

Oral Presentations

1. **N. Nakamura** *et. al.*, "Nanoscale X-ray Tomography of Integrated Circuits using a Hybrid Electron/X-ray Microscope", *IEEE International Conference on Physical Assurance and Inspection of Electronics*, 2023, Huntsville, AL, Oct. 24-27.

2. **N. Nakamura** *et. al.*, “Nanoscale X-ray Tomography of Integrated Circuits using Transition-Edge Sensors”, 20th *International Workshop on Low Temperature Detectors*, 2023, Daejeon, South Korea, July 23-28.
3. **N. Nakamura** *et. al.*, “Table-top Time-Resolved X-ray Spectroscopy using a Laser Plasma X-ray Source and Transition-Edge Sensors”, 76th *International Symposium on Molecular Spectroscopy*, 2023, Champaign, IL, June 19-23.
4. **N. Nakamura** *et. al.*, “A Tabletop X-Ray Tomography Instrument for Spectral Imaging utilizing a Transition Edge Sensor Spectrometer”, *International Conference on Methods and Applications of Radioanalytical Chemistry*, 2022, Kailua-Kona, HI, April 3-8.
5. **N. Nakamura** *et. al.*, “TOMographic Circuit Analysis Tool (TOMCAT) – An instrument for 3D x-ray imaging of nanoscale integrated circuits using a TES spectrometer”, 19th *International Workshop on Low Temperature Detectors*, 2021, Boulder, CO, July 19-29.
6. **N. Nakamura**, L. Su, C. S. Hellberg, B. Reeya Jayan, “X-ray Synchrotron Investigation of ZrO₂ Phase Formation under Electromagnetic Excitation”, *Materials Research Society (MRS) Fall Meeting 2019*, Boston, USA, Dec. 1-6.
7. **N. Nakamura**, E. Culbertson, H. Wang, H. Wang, C. S. Hellberg, S. J. L. Billinge, B. Reeya Jayan, “The Role of Defects in Microwave-Assisted Synthesis of Cubic ZrO₂”, *Electric Field Enhanced Processing of Advanced Materials II: Complexities and Opportunities 2019*, Tomar, Portugal, March 10-15.
8. **N. Nakamura**, E. Culbertson, S. J. L. Billinge, B. Reeya Jayan, “Low-Temperature Phase Transitions in Ceramic Oxides via Electromagnetic Field Exposure”, *Materials Research Society (MRS) Fall Meeting 2018*, Boston, USA, Nov. 25-30.
9. **N. Nakamura**, E. Culbertson, S. J. L. Billinge, B. Reeya Jayan, “Electromagnetic Field Effects on Atomic Structure in Ceramic Oxide Thin Films”, *Materials Science and Technology (MS&T) Meeting 2018*, Columbus, USA, Oct. 14-18.
10. **N. Nakamura**, E. Culbertson, H. Wang, H. Wang, S. J. L. Billinge, B. Reeya Jayan, “Electromagnetic Field Effects on Atomic Structure and Phase Transitions in Ceramic Oxide Thin Films”, *Gordon Research Conference (GRC) – Solid State Studies in Ceramics 2018*, South Hadley, USA, Aug. 12-17.
11. **N. Nakamura**, M.W. Terban, S. J. L. Billinge, B. Reeya-Jayan, “Evolution of Distinct Phase Composition in Ceramic Thin Films Grown under Electromagnetic Excitation”, *Materials Science and Technology (MS&T) Meeting 2017*, Pittsburgh, USA, Oct. 8-12.
12. **N. Nakamura**, J. Seepaul, J. Kadane, B. Reeya-Jayan, “Low-Temperature Crystallization of Ceramic Nanoscale Films Using Microwave Radiation – Statistically Driven Experimental Design”, *Materials Research Society (MRS) Fall Meeting 2016*, Boston, USA, Nov. 28 – Dec. 2.

Poster Presentations

1. **N. Nakamura**, M. W. Terban, S. J. L. Billinge, B. Reeya Jayan, “Unlocking the structure of mixed amorphous-crystalline ceramic oxide thin films synthesized under electromagnetic excitation”, *The 75th Annual Pittsburgh Diffraction Conference*, October 2017
2. **N. Nakamura**, B. Reeya Jayan, “Unlocking the structure of mixed amorphous-crystalline ceramic oxide thin films synthesized under electromagnetic excitation”, *Air Force Office of Scientific Research (AFOSR) Student Research Day*, September 2017
3. **N. Nakamura**, M. W. Terban, S. J. L. Billinge, B. Reeya-Jayan, “Rapid, Low Temperature Synthesis of Amorphous-Crystalline Thin Films under Electromagnetic Excitation”, *Carnegie Mellon Mechanical Engineering Graduate Student Research Symposium*, March 2017.
4. **N. Nakamura**, M. W. Terban, S. J. L. Billinge, B. Reeya-Jayan, “Rapid, Low Temperature Synthesis of Amorphous-Crystalline Thin Films Under Electromagnetic Excitation”, *Carnegie Mellon Energy Week Poster and Multimedia Presentation*, March 2017.
5. **N. Nakamura**, M. W. Terban, S. J. L. Billinge, B. Reeya-Jayan, “Microwave-Assisted Synthesis of Crystalline TiO₂ Thin Films”, *Carnegie Mellon Bennet Conference*, March 2016.

6. **N. Nakamura**, M. Martineau, T. Barth, E. Park, G. Draper, “Soft Robotics for Materials Science Outreach”, *UC Santa Barbara Undergraduate Research Colloquium*, May 2015.
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TEACHING EXPERIENCE

Graduate Teaching Assistant, Carnegie Mellon University (*August-December 2018*)

Heat Transfer

- Assisted in teaching undergraduate course on heat transfer. This involved teaching recitation sessions and holding office hours

Graduate Teaching Assistant, Carnegie Mellon University (*January-May 2016*)

Mechanical Systems Experimentation

- Assisted in teaching undergraduate laboratory course on dynamic mechanical systems and controls
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PROFESSIONAL ACTIVITIES

- Vice President – Mechanical Engineering Graduate Student Organization (*2015-2017*)
- Tau Beta Pi Engineering Honors Society (*2014-Present*)
- Materials Research Society (*2015-Present*)