

Nikhil Bajaj, Ph.D.

Education

- 2011 – 2017 ■ **Ph.D. in Mechanical Engineering, Purdue University, West Lafayette, Indiana** in Dynamics and Control.
Dissertation title: *Microresonator-based Sensors with Intentional Nonlinearities*. Supervisors: Dr. George T.-C. Chiu and Dr. Jeffrey F. Rhoads
- 2008 – 2011 ■ **M.S.M.E. Mechanical Engineering, Purdue University, West Lafayette, Indiana** in Design and Heat Transfer.
Thesis title: *Topological Design Optimization of Nested Channels for Squeeze Flow of Thermal Interface Materials*. Supervisors: Dr. Ganesh Subbarayan and Dr. Suresh V. Garimella
- 2004 – 2008 ■ **B.S.M.E. Mechanical Engineering, Purdue University, West Lafayette, Indiana.**

Experience

- Fall 2017 – Present ■ **Postdoctoral Researcher.** School of Mechanical Engineering, Purdue University, supervised by Dr. Jeffrey F. Rhoads. Research areas: My current research focuses on the development of novel, intelligent CO₂ sensors for building occupancy monitoring, as well as development of sensors based on similar platforms (OFETs, resonant MEMS) for VOC and public health applications. My prior postdoctoral research focused on the study of nonlinear oscillations, systems of coupled oscillators with applications for MEMS-based pattern recognition, and time-delayed nonlinear feedback in MEMS resonators, including both theoretical work and experimental prototypes. I am currently serving as a mentor to multiple graduate and undergraduate students related to this research.
- **Engineering Consultant.** General Vibration Corporation: I consulted on mechanical engineering and controls development projects in multi-actuator haptics technologies using coordinated control in order to create otherwise unrealizable haptic effects.
- Fall 2013 – Summer 2017 ■ **Research Assistant.** School of Mechanical Engineering, Purdue University, supervised by Dr. George T.-C. Chiu and Dr. Jeffrey F. Rhoads: I designed nonlinear resonant sensors for the detection of trace vapors using novel analog circuits to create nonlinear responses in quartz microresonators, and studied the associated theory (nonlinear oscillations including time delay). In addition, I developed an inkjet-based functionalization system for the sensors, and an inkjet-based method of sensitivity characterization for mass sensors. The sensors were targeted at security and safety applications (funding from Department of Homeland Security and NSF) and I demonstrated successful detection of vapor phase trinitrotoluene (TNT). Over this time period I served as a mentor to five undergraduate students on various projects related to this research and to biosensing and inkjet-based additive manufacturing projects.

Experience (continued)

- Spring 2013 – Present ■ **Engineering Consultant.** AIMPAD, LLC.: I developed force-sensitive keyboards for PC gaming applications, and performed circuit design, mechanical design, and embedded programming (signal processing and USB interface). The project created multiple generations of prototypes and generated IP in the form of patents. More recently (2017-2018) a gaming keyboard manufacturer has licensed the patents and is developing products based on the technology.
- Fall 2013 ■ **Teaching Assistant.** School of Mechanical Engineering, Purdue University, supervised by Dr. Peter H. Meckl, for the course ME 586: Microprocessors in Electromechanical Systems: I wrote new laboratory experiment documentation and designed and fabricated small circuit boards to aid in the course laboratory exercises, revised existing laboratory material to address course changes, and graded homework assignments, in addition to giving some lectures as needed by the course instructor. I was awarded the Estus H. and Vashti L. Magoon Outstanding Teaching Award by the College of Engineering.
- Fall 2011 – Spring 2013 ■ **Research Assistant.** School of Mechanical Engineering, Purdue University, supervised by Dr. George T.-C. Chiu, I worked on a project funded by a printer manufacturer to develop a method for classifying print media, involving mechatronic system design and machine learning. The final implementation resulted in publications, a patent application, and implementation in a mass-produced printer system.
- Summer 2010 ■ **Graduate Summer Intern.** Alcatel-Lucent Bell Laboratories, Murray Hill, New Jersey: I designed and built a wind tunnel for the testing novel 3D heat sink designs in realistic product scenarios, and worked on numerical simulation of 3D heat sink performance in Fluent/ICEPAK.
- Fall 2008 – Spring 2011 ■ **Research Assistant.** School of Mechanical Engineering, Purdue University, supervised by Dr. Ganesh Subbarayan and Dr. Suresh V. Garimella: I developed techniques for enhancing heat transfer in thermal interfaces through numerical simulation, design sensitivity analysis, and optimization for heatspreader design (CPU and power electronics applications). In addition, I developed a novel method for experimental characterization of thermal interface materials and validation of thermal interface designs.

Research Publications

Journal Articles

- 1 **Bajaj, N.**, Laster, J. S., Boudouris, B. W., Chiu, G. T.-C., & Rhoads, J. F. (Expected 2019). A vapor phase trinitrotoluene threshold detector enabled by nonlinear feedback. *In Review, Submitted.*
- 2 Habermehl, S. T., **Bajaj, N.**, Shah, S. Y., Quinn, D. D., Weinstein, D., & Rhoads, J. F. (Expected 2019). Synchronization in a network of coupled MEMS-Colpitts oscillators. *In Review, Submitted.*
- 3 Murrell, N., Bradley, R., **Bajaj, N.**, Whitney, J., & Chiu, G. T.-C. (Expected 2019). A method for sensor reduction in a supervised machine learning classification system. *Accepted, IEEE/ASME Transactions on Mechatronics.*
- 4 Pyles, C. S., **Bajaj, N.**, Weinstein, D., Quinn, D. D., & Rhoads, J. F. (Expected 2019). The dynamics of large systems of globally coupled, mistuned electromechanical resonators. *In Review, Submitted.*
- 5 Shah, S. Y., **Bajaj, N.**, Pyles, C., Weinstein, D., Rhoads, J. F., & Quinn, D. D. (Expected 2019). The dynamics of MEMS-Colpitts oscillators. *In Review, Submitted.*

- 6 **Bajaj, N.**, Chiu, G. T.-C., & Rhoads, J. F. (2018). Megahertz-frequency, tunable piecewise-linear electromechanical resonator realized via nonlinear feedback. *Journal of Sound and Vibration*, *425*, 257–274.
- 7 Murray, A. K., Novotny, W., **Bajaj, N.**, Gunduz, I., Son, S., Chiu, G. T.-C., & Rhoads, J. F. (2018). Piezoelectric inkjet-printed metallic igniters. *Journal of Imaging Science and Technology*, *62*(4), 40406-1–40406-6.
- 8 **Bajaj, N.**, Rhoads, J. F., & Chiu, G. T.-C. (2017). Characterizing the spatially-dependent sensitivity of resonant mass sensors using inkjet deposition. *ASME Journal of Dynamic Systems, Measurement, and Control*, *139*(11), 114505–114505-6.
- 9 Geesey, B. A., Wetherton, B. A., **Bajaj, N.**, & Rhoads, J. F. (2017). Shaping the frequency response of electromechanical resonators using a signal interference control topology. *ASME Journal of Dynamic Systems, Measurement, and Control*, *139*(3), 031011–031011-9.
- 10 Wadas, M. J., Tweardy, M., **Bajaj, N.**, Murray, A. K., Chiu, G. T. C., Nauman, E. A., & Rhoads, J. F. (2017). Detection of traumatic brain injury protein biomarkers with resonant microsystems. *IEEE Sensors Letters*, *1*(6), 1–4.
- 11 **Bajaj, N.**, Sabater, A. B., Hickey, J. N., Chiu, G. T.-C., & Rhoads, J. F. (2016). Design and implementation of a tunable, Duffing-like electronic resonator via nonlinear feedback. *Journal of Microelectromechanical Systems*, *25*(1), 2–10.
- 12 Sung, S. H., **Bajaj, N.**, Rhoads, J. F., Chiu, G. T.-C., & Boudouris, B. W. (2016). Radical polymers improve the metal-semiconductor interface in organic field-effect transistors. *Organic Electronics*, *37*, 148–154.
- 13 **Bajaj, N.**, Subbarayan, G., & Garimella, S. V. (2012). Topological design of channels for squeeze flow optimization of thermal interface materials. *International Journal of Heat and Mass Transfer*, *55*(13), 3560–3575.

Conference Proceedings

- 1 Pyles, C. S., **Bajaj, N.**, Weinstein, D., Quinn, D. D., & Rhoads, J. F. (2018, August). The dynamics of large-scale arrays of globally coupled, mistuned micromechanical resonators (3rd place award in IDETC 2018 VIB). In *ASME 2018 IDETC/CIE: The 2018 ASME International Design Engineering Technical Conferences, 30th Conference on Mechanical Vibration and Noise*.
- 2 **Bajaj, N.**, Murrell, N. J., Whitney, J. G., Allebach, J. P., & Chiu, G. T.-C. (2016, July). Expert-prescribed weighting for support vector machine classification. In *2016 IEEE International Conference on Advanced Intelligent Mechatronics (AIM)* (pp. 913–918).
- 3 **Bajaj, N.**, Rhoads, J. F., & Chiu, G. T.-C. (2016, October). Characterization of resonant mass sensors using inkjet deposition. In *ASME 2016 Dynamic Systems and Control Conference (V002T26A005)*.
- 4 Singh, Y., **Bajaj, N.**, & Subbarayan, G. (2016, May). Simultaneous thermal/flow characterization of thermal interface materials. In *2016 15th IEEE Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems (ITherm)* (pp. 1360–1365).
- 5 **Bajaj, N.**, Boley, J., Fulton, A., & Chiu, G. T.-C. (2014, October). Syringe position control for back pressure modulated drop volume in functional inkjet printing. In *ASME Dynamic Systems and Control Conference (V001T12A004)*.
- 6 **Bajaj, N.**, Chiu, G. T.-C., & Allebach, J. P. (2014, September). Reduction of memory footprint and computation time for embedded support vector machine (svm) by kernel expansion and consolidation. In *2014 IEEE International Workshop on Machine Learning for Signal Processing (MLSP)* (pp. 1–6).

- 7 Fulton, A., Boley, J., **Bajaj, N.**, & Chiu, G. T.-C. (2014, January). Drop volume modulation via applied backpressure in inkjet systems. In *NIP & Digital Fabrication Conference, 2014: International Conference on Digital Printing Technologies* (pp. 20–25).
- 8 Kota, K., Sobers, D., Kolodner, P., **Bajaj, N.**, Cheng, J. H., Simon, E., & Salamon, T. (2012, May). Numerical and experimental studies of ultra low profile three-dimensional heat sinks (3DHS) made using a novel manufacturing approach. In *2012 13th IEEE Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems (ITherm)* (pp. 466–474).
- 9 **Bajaj, N.**, Subbarayan, G., & Garimella, S. V. (2010a, June). Squeeze flow characterization of particle-filled polymeric materials through image correlation. In *2010 12th IEEE Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems (ITherm)* (pp. 1–6).
- 10 **Bajaj, N.**, Subbarayan, G., & Garimella, S. V. (2010b, November). Topological design optimization of nested channels for squeeze flow of thermal interface materials. In *ASME 2010 International Mechanical Engineering Congress and Exposition* (pp. 427–436).

Conference Presentations and Posters

- 1 **Bajaj, N.**, Shah, S. Y., Pyles, C. S., Weinstein, D., Quinn, D. D., & Rhoads, J. F. (2018a, August). Technical Brief: The Dynamics of a MEMS-Colpitts Oscillator. *IDETC/CIE 2018: The 2018 ASME International Design Engineering Technical Conferences*.
- 2 Habermehl, S. T., **Bajaj, N.**, Shah, S. Y., Weinstein, D., Quinn, D. D., & Rhoads, J. F. (2018b, August). Technical Brief: Synchronization in a Network of Coupled MEMS-Colpitts Oscillators. *IDETC/CIE 2018: The 2018 ASME International Design Engineering Technical Conferences*.
- 3 **Bajaj, N.**, Chiu, G. T.-C., & Rhoads, J. F. (2017a, August). Poster: Electronic feedback-enabled microresonators with intentional nonlinearities. *TRF Napa Microsystems Workshop*.
- 4 **Bajaj, N.**, Chiu, G. T.-C., & Rhoads, J. F. (2017b, August). Technical Brief: MHz-frequency tunable piecewise-linear electromechanical resonator realized via nonlinear feedback. *IDETC/CIE 2017: The 2017 ASME International Design Engineering Technical Conferences*.
- 5 **Bajaj, N.**, Sabater, A. B., Hickey, J. N., Chiu, G. T.-C., & Rhoads, J. F. (2015, August). Technical Brief: A tunable, Duffing-like electromechanical resonator realized via nonlinear feedback for sensing applications. *IDETC/CIE 2015: The 2015 ASME International Design Engineering Technical Conferences*.

Other Articles

- 1 Florence, S., **Bajaj, N.**, & Chiu, G. (2018). Inspiring future generations in STEM fields through robotics competition: a college student mentoring approach. *ASME Dynamic Systems and Control Magazine*, 6(1), 13–17.

Patents (Provisional and Granted)

Provisional Patents and Applications

- 1 Rhoads, J. F., Chiu, G. T.-C., & **Bajaj, N.** (2017, December). *Provisional: US Patent Application 62597976.: Nonlinear mass sensors based on electronic feedback*.
- 2 Wadas, M. J., Twardy, M., **Bajaj, N.**, Murray, A. K., Chiu, G. T.-C., Nauman, E. A., & Rhoads, J. F. (2017, July). *Provisional: US Patent Application 62534374.: Method of detecting a substance*.
- 3 Murrell, N. J., Whitney, J. A. G., Bradley, R. T., **Bajaj, N.**, Chiu, G. T.-C., & Allebach, J. P. (2016, February). *US Patent Application, Pub. No.: US 2016/0044195 A1, Imaging device and method for sensing media type*.

Granted Patents

- 1 Rhoads, J. F., Chiu, G. T.-C., **Bajaj, N.**, & Sabater, A. B. (2018, March). *US Patent No. 9927287: Nonlinear mass sensors based on electronic feedback and methods of using the same.*
- 2 **Bajaj, N.** & Madsen, L. W. (2014a, May). *US Patent No. 8717202: Force sensitive input devices and methods.*
- 3 **Bajaj, N.** & Madsen, L. W. (2014b, December). *US Patent No. 8922399: Force sensitive input devices and methods.*

Other Experience

Proposal Writing

- 2017 **ARPA-E SENSOR Program** “Building-Integrated Microscale Sensors for CO₂-Level Monitoring”, *Grant Awarded, \$1,533,000*, written with PIs Jeffrey F. Rhoads, George T.-C. Chiu, James E. Braun, and Bryan W. Boudouris. Responsible for helping to generate ideas and improvements, literature review, and writing.

Awards and Achievements

- 2013 **Estus H. and Vashti L. Magoon Outstanding Teaching Award** Purdue University College of Engineering.
- 2008 **Helen And John Lozar Research Assistantship** Purdue University School of Mechanical Engineering

Selected Outreach Activities

- 2005 – Present **Member of Purdue FIRST Programs**
- Served as a mentor to high school and undergraduate students in the FIRST (For Inspiration and Recognition of Science and Technology) Robotics Competition at the team level, providing consulting and guidance on mechanical and control system design.
 - Conference co-organizer (2011 – 2016) for the Purdue FIRST/Indiana FIRST Forums, a 400+ attendee conference of high school students, teachers, and engineering mentors from throughout Indiana to exchange ideas on FIRST, encompassing engineering education and workshop training.
 - (2010-2014) Gave presentations on LabVIEW programming and PID control geared at high school students at the Purdue FIRST/Indiana FIRST Forums and (2013) at a Northwestern University FIRST workshop.
 - Served as a judge and judge advisor (2011 – present) for local First Lego League and First Tech Challenge competitions in the Greater Lafayette area and elsewhere in Indiana).
- 2012 – 2013 **OMEGA (Official Mechanical Engineering Graduate Association** (Purdue University) Served as Treasurer.

Affiliations and Service

- **Member of ASME and IEEE.**
- **Peer Reviewer** for Conferences: ASME Dynamic Systems and Controls Conference (DSCC), American Controls Conference (ACC), ASME/IEEE Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems (ITherm), IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), IEEE Conference on Decision and Control (CDC).

Other Experience (continued)

- ▣ **Peer Reviewer** for Archival Journals: IEEE/ASME Transactions on Mechatronics, IS&T Journal of Imaging Science and Technology, ASME Journal of Vibration and Acoustics, IEEE Sensors Letters, IEEE Journal of Microelectromechanical Systems.
- ▣ **US Citizen**