

Krishna Shah, PhD

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ACADEMIC & RESEARCH POSITIONS

Assistant Professor , <i>Department of Mechanical Engineering</i> , University of Alabama, Tuscaloosa	Aug 2021- Present
Postdoctoral Scholar , <i>Texas Materials Institute</i> , University of Texas at Austin Supervising Faculty: Prof. Venkat Subramanian	Sep 2019-Aug 2021
Postdoctoral Scholar , <i>Department of Mechanical Engineering</i> , University of California, Merced Supervising & Collaborating Faculty: Prof. Yanbao Ma and Prof. James Palko	Sep 2017-July 2019
Visiting Researcher , <i>Energy Storage & Distributed Resources Division</i> , Lawrence Berkeley National Lab, Supervisor: Dr. Ravi Prasher	June 2016-Jan 2017

EDUCATION

Ph.D. Mechanical Engineering Microscale Thermophysics Laboratory, Department of Mechanical & Aerospace Engineering University of Texas at Arlington, United States Supervising Professor: Prof. Ankur Jain <i>Dissertation: "Modeling and measurements of thermal transport in Li-ion based energy conversion and storage devices"</i>	2017
Bachelor of Engineering Mechatronics Department of Mechatronics Engineering Sardar Patel University, India	2011

SELECT RESEARCH EXPERIENCE

Model development to study fundament issues in batteries

- Developed two-dimensional models to study lithium metal anodes for next generation batteries.
- This includes developing moving boundary models to study morphological evolution in lithium metal anode.
- Developed robust simulation tool to simulate the moving boundary models to predict morphology.
- Helped develop electrochemical, thermal, and capacity fade models for other next generation as well as commercial Li-ion batteries.
- Mentoring two graduate students in studying next generation foil anode and capacity fade in Li-ion batteries.
- Multiple manuscripts currently in preparation/review.

Battery testing and modeling for applied problems

- Conducted advanced battery testing experiments to study battery degradation under testing conditions relevant for consumer electronics.
- Helped develop predictive models to study capacity fade under experimentally relevant conditions.
- Developed coupled simulation framework for simultaneous simulation of battery and flight dynamics for electric aircraft.
- Battery pack sizing and design for all-electric and hybrid electric aircraft based on coupled simulation study.
- Collaboration with leading industry partners.

Analytical and numerical thermal modeling of Li-ion cells

- Developed analytical and numerical models to compute temperature field inside a Li-ion cell
- This work included steady state and transient thermal modeling as well as thermal modeling for battery cycling.
- This work was done at UT Arlington and resulted in 3 articles published in high impact journals.

Thermal analysis of thermal runaway in Li-ion cells

- Developed semi-analytical and numerical models to capture the thermal runaway phenomenon in Li-ion cells.
- These modeling tools were used to do detailed thermal analysis on thermal runaway prevention strategies and improving safety of Li-ion cells.

- This work was partly performed at UT Arlington and at UC Merced and led to four journal articles.
- Co-advising a graduate student at UT Arlington in conducting pack level thermal runaway propagation study.

Experimental and numerical study on Li-ion cell thermal management

- Different cooling conditions experimentally evaluated for Li-ion cell thermal management. An innovative approach of internal cooling of a Li-ion cell was experimentally investigated at UT Arlington.
- The experimental and modeling work on battery thermal management at UT Arlington led to the publication of 3 journal articles.
- Numerical study on minichannel based battery thermal management was performed at UC Merced. This led to one journal article.

Material level thermal characterization of Li-ion cell using in-situ techniques

- Assisted in conducting in-situ thermal property measurement on Li-ion pouch cell at Lawrence Berkeley National Lab.
- This work included fabrication of Li-ion pouch cell, sputter deposition of thermal sensor, building experimental setup for measurement, and preparing LabVIEW code for data acquisition.
- This research work is being continued by researchers at Lawrence Berkeley National Lab.

TECHNICAL SKILLS

- Modeling of heat transfer, battery dynamics, and coupled multi-physics problems for applications including modeling of Li-ion battery, lithium metal battery, alloy anode-based next generation batteries, thermal modeling of Li-ion and lithium sulfur batteries, conjugate heat transfer problems, etc.
- Battery electrode synthesis and fabrication, and commercial battery testing.
- Formulation of numerical techniques for battery and thermal/fluid simulations, including the use of commercial finite-element/volume solvers such as ANSYS, CFX, Fluent, and COMSOL.
- Computational skills using tools such as MATLAB, Mathematica, Maple, C and C++.
- Designing and building experimental setups for thermal and fluid measurements, including automated, high speed data acquisition using tools such as LabVIEW.
- Using optical methods, such as schlieren technique for flow visualization and measurement.
- Sputter deposition process for microfabrication.

TEACHING EXPERIENCE

Assistant Professor, *Department of Mechanical Engineering*, University of Alabama, Tuscaloosa August 2021-Present

- ME 309 Heat Transfer (Fall 2021)
- ME 489 Mechanical Engineering Design I (co-advisor) (Fall 2021)
- ME 411/511 Computational Heat Transfer and Fluid Flow (Spring 2022)
- ME 490 Mechanical Engineering Design II (main advisor) (Spring 2022)
- ME 497 Mechanical Engineering Project (research based - advisor) (Spring 2022)

Lecturer, *Department of Mechanical Engineering*, University of California, Merced June 2019-Aug 2019

- ENGR 135 Heat Transfer (Summer 2019)

Graduate Teaching Assistant, *Department of Mechanical and Aerospace Engineering*, University of Texas at Arlington Jan 2014-May 2017

- MAE 3310 Thermodynamics (Spring 2015, Spring 2016, Spring 2017)
- ME 5316 Thermal Conduction (Fall 2015)
- AE 5331 Analytical Methods in Engineering (Fall 2014)

Students Mentored:

Divya Chalise	Current Ph.D. student at University of California, Berkeley.
Iretomiwa Esho	Current Ph.D. student at California Institute of Technology.
Cody McKee	Currently at Bell Helicopter, Fort Worth, TX.
Ahmad Elhars	Current Ph.D. student at University of California, Merced.

Zhoujian An	Completed Ph.D. from Beijing Jiaotong University.
Jesse Sanchez	Current undergraduate student at Cal Poly, San Luis Obispo.
Merari Cisneros	B.S. Bioengineering, University of California, Merced.
Jonathan Aguilar	B.S. Mechanical Engineering, University of California, Merced.
Daniel Hunt	B.S. Mechanical Engineering, University of California, Merced.
Maitri Uppaluri	Current Ph.D. student at University of Texas at Austin.
Kirutiga Srikanda	Current Ph.D. student at University of Texas at Austin.
Taejin Jang	Current Ph.D. student at University of Texas at Austin.
Owen Schreiber	Current B.S. student at University of Alabama.
Kara Alexander	Current B.S. student at University of Alabama.
Abbie Eidson	Current B.S. student at University of Alabama.
Anna Eidson	Current B.S. student at University of Alabama.
Justin Ahrens	Current B.S. student at University of Alabama.

SERVICE

Reviewing Manuscripts:

Reviewed 25+ manuscripts for journals such as Applied Thermal Engineering, Journal of Energy Storage, ASME Journal of Electrochemical Energy Conversion and Storage as well as conferences such as ASME InterPACK and ASME IMECE.

Outreach:

- **Outreach volunteer:** Showcased research work at College of Engineering summer camp for middle school students.
- **Lab volunteer:** Represented our research group at the department open house event for freshman year students.

AWARDS & RECONGNITIONS

I-Engage Fellowship

Awarded to Ph.D. students for mentoring and designing research course curriculum for undergraduate student researchers, University of Texas at Arlington

2015

Rajeshwar and Krishnan Endowed Fellowship in Energy and Sustainability

A highly competitive fellowship awarded annually for excellence in research, University of Texas at Arlington

2016

Dissertation Fellowship

A highly competitive fellowship awarded to exceptional Ph.D. candidates in School of Engineering, University of Texas at Arlington

2017

Rising Star in Mechanical Engineering

Among 30 participants selected nationwide to attend the prestigious Rising Star in ME workshop with a special focus on promoting diversity and inclusiveness in ME at University of California, Berkeley

2020

The Industrial Electrochemistry & Electrochemical Engineering (IE&EE) Division Early Career Travel Grant

Awarded travel grant to give a talk on “Challenges in Moving to Multiscale Battery Models: Where Electrochemistry Meets and Demands More from Math” at the Electrochemical Society (ECS) meeting PRiME 2020

2020

Texas Materials Institute Annual Newsletter

Featured in the Student and Postdoc Spotlight in the Texas Materials Institute Annual Newsletter, University of Texas at Austin

2021

PUBLICATIONS

1. **Shah, K.**, Drake, S.J., Wetz, D.A., Ostanek, J.K., Miller, S.P., Heinzl, J.M., Jain, A., ‘Modeling of Steady-State Convective Cooling of Cylindrical Li-ion Cells’, *Journal of Power Sources*, **258**, pp. 374-381, 2014
2. **Shah, K.**, Drake, S.J., Wetz, D.A., Ostanek, J.K., Miller, S.P., Heinzl, J.M., Jain, A., ‘Experimentally validated transient model for cylindrical Li-ion Cells’, *Journal of Power Sources*, **271**, pp. 262-268, 2014
3. **Shah, K.**, Jain, A., ‘An iterative, analytical method for solving conjugate heat transfer problems,’ *International Journal of Heat Mass Transfer*, **90**, pp. 1232-1240, 2015
4. Sarkar, D., **Shah, K.**, Haji-Sheikh, A., Jain, A., ‘Analytical modeling of temperature distribution in an anisotropic cylinder with circumferentially-varying convective heat transfer’, *International Journal of Heat and Mass Transfer*, **79**, pp. 1027–1033, 2014
5. **Shah, K.**, Jain, A., ‘Modeling of Steady-State and Transient Thermal Performance of a Li-ion Cell with an Axial Fluidic Channel for Cooling’, *International Journal of Energy Research*, **39**, pp. 573-584, 2015
6. **Shah, K.**, McKee, C., Chalise, D., Jain, A., ‘Experimental and numerical investigation of core cooling of Li-ion cells using heat pipes,’ *Energy*, **113**, pp. 852-860, 2016
7. **Shah, K.**^{*}, Vishwakarma, V.^{*}, Jain, A., ‘Measurement of multiscale thermal transport phenomena in Li-ion cells: A review,’ *ASME. J. Electrochem. Energy Conv. Storage.*, **13**, 2016 (*Equal contributor)
8. **Shah, K.**, Chalise, D., Jain, A., ‘Experimental and theoretical analysis of a method to predict thermal runaway in Li-ion cells,’ *Journal of Power Sources*, **330**, pp. 167-174, 2016
9. Ostanek, J., **Shah, K.**, Jain, A., ‘Measurement sensitivity analysis of transient hot source sensors,’ *ASME Journal of Thermal Science & Engineering Appl.*, **9**, 2017
10. Chalise, D., **Shah, K.**, Halama, T., Komsiyyska, L., & Jain, A., ‘An experimentally validated method for temperature prediction during cyclic operation of a Li-ion cell,’ *International Journal of Heat and Mass Transfer*, **112**, pp. 89-96, 2017
11. **Shah, K.**, Balsara, N., Banerjee, S., Chintapalli, M., Cocco, A.P., Chiu, W.K.S., Lahiri, I., Martha, S., Mistry, A., Mukherjee, P., Ramadesigan, V., Sharma, C., Subramanian, V., Mitra, S., Jain, A., ‘State-of-the-art and Future Research Needs for Multiscale Analysis of Li-ion Cells’ *ASME. J. Electrochem. Energy Conv. Storage*, **14**(2), 020801, 2017
12. Chalise, D., **Shah, K.**, Prasher, R., Jain, A., ‘Conjugate heat transfer analysis of thermal management of a Li-ion battery pack,’ *Journal of Electrochemical Energy Conversion and Storage*, **15**(1), 011008, 2018
13. Esho, I.^{*}, **Shah, K.**^{*}, Jain, A., ‘Measurements and modeling to determine the critical temperature for preventing thermal runaway in Li-ion cells,’ *Applied Thermal Engineering*, **145**, pp.287-294, 2018 (*Equal contributor)
14. **Shah, K.**, Jain, A., ‘Prediction of thermal runaway and thermal management requirements in cylindrical Li-ion cells in realistic scenarios,’ *International Journal of Energy Research*, **43**, pp. 1827-1838, 2019
15. **Shah, K.**^{*}, An, Z.^{*}, Jia, L., Ma, Y., ‘A Parametric Study for Optimization of Minichannel Based Battery Thermal Management System,’ *Applied Thermal Engineering*, **154**, pp.593-601, 2019 (*Equal contributor)
16. **Shah, K.**^{*}, An, Z.^{*}, Jia, L., Ma, Y., ‘Modeling and Analysis of Thermal Runaway in Li-ion Cell,’ *Applied Thermal Engineering*, **160**, 2019 (*Equal contributor)
17. Yu, Q., **Shah, K.**, Wang, D., Ma, Y., ‘Model Based Study of Crop Evapotranspiration Under Canopy Shading,’ *Agronomy*, **9**(6), pp.334, 2019
18. **Shah, K.**, Subramaniam, A., Mishra, L., Jang, T., Bazant, M. Z., Braatz, R. D., & Subramanian, V. R., ‘**Editors’ Choice**—Perspective—Challenges in Moving to Multiscale Battery Models: Where Electrochemistry Meets and Demands More from Math,’ *Journal of The Electrochemical Society*, **167**(13), 133501, 2020
19. Mishra, D., **Shah, K.**, Jain, A., ‘Investigation of the impact of flow of vented gas on propagation of thermal runaway in a Li-ion battery pack,’ *Journal of Electrochemical Society*, **168**(6), 060555, 2021
20. Mishra, L., Subramaniam, A., Jang, T., **Shah, K.**, Uppaluri, M., Roberts, S. A., Subramanian, V. R., ‘Perspective – Mass conservation in models for electrodeposition/stripping in lithium metal batteries,’ *Journal of Electrochemical Society*, **168**(9), 092502, 2021

21. Mishra, D., **Shah, K.**, Jain, A., ‘Investigation of the Impact of Radiative Shielding by Internal Partitions Walls on Propagation of Thermal Runaway in a Matrix of Cylindrical Li-Ion Cells,’ *Journal of The Electrochemical Society*, **168(12)**, 120507, 2021

Currently in-review/preparation

22. Uppaluri, M., **Shah, K.**, Vishwanathan, V. V., Subramanian, V. R., ‘The Importance of a Moving Boundary Approach for Modeling the SEI Layer Growth to Predict Capacity Fade,’ *Journal of Electrochemical Society: Focus Issue on Electrochemical Energy Storage in Honor of Professor John B. Goodenough: A Centenarian Milestone (invited)* (in review)
23. **Shah, K.**, Kolluri, S., Wang, M., Mesbahi, M., Subramanian, V. R., ‘Coupled Simulation of Electric Flight Dynamics and Physics Based Battery Model for Electric Aircraft Battery Pack Sizing Analysis,’ *Journal of Electrochemical Society* (in preparation)
24. Jang, T., Mishra, L., **Shah, K.**, Uppaluri, M., Roberts, S. A., Subramanian, V. R., ‘A simple (perhaps not so simple) two-dimensional model for deposition/stripping in lithium metal batteries,’ *Journal of Electrochemical Society* (in preparation)
25. Balan, K. S., **Shah, K.**, Yu, J., Heligman, B. T., Manthiram, A., Hwang, G. S., Subramanian, V. R., ‘Multiscale Modeling of Nanostructured Foil Anode for Next Generation Batteries,’ *Journal of Electrochemical Society* (in preparation)
26. Alhares, A., **Shah, K.**, Aguilar, J., Cisneros, M., Ma, Y., ‘Formation of Grouped Vortices Due to Flow over Streamwise Oscillating Cylinder: A New Vortex Shedding Mode,’ *Journal of Fluid Mechanics* (in preparation)

Conference Publications/Presentations

1. An, Z., **Shah, K.**, Ma, Y., Jia, L., ‘A Comprehensive Parametric Study of Minichannel Based Liquid Cooling of Li-Ion Battery Pack,’ *ASME 2018 IMECE*, November 9-15, 2018
2. Alhares, A., **Shah, K.**, Ma, Y., ‘Shift in Vortex Shedding Mode for Flow over Streamwise Oscillating Cylinder Under Constant Conditions,’ *ASTFE TFEC 2020*, April 5-8, 2020
3. Kolluri, S., Subramanian, A., Mittal, P., Preger, Y., **Shah, K.**, Subramanian, V. R., ‘Parameter Estimation of Lithium-Ion Battery Models Using a Novel Tanks-in-Series Approach,’ *Electrochemical Society Meeting - PRiME 2020*, October 4-9, 2020
4. Parke, C., **Shah, K.**, Subramanian, A., Schwartz, D., Subramanian, V. R., ‘A Coupled Electrochemical-Thermal Model for Lithium Sulfur Batteries,’ *Electrochemical Society Meeting - PRiME 2020*, October 4-9, 2020
5. **Shah, K.**, Subramanian, A., Mishra, L., Jang, T., Bazant, M. Z., Braatz, R. D., Subramanian, V. R., ‘Challenges in Moving to Multiscale Battery Models: Where Electrochemistry Meets and Demands More from Math,’ *Electrochemical Society Meeting - PRiME 2020*, October 4-9, 2020
6. Balan, K.S.P., **Shah, K.**, Yu, J., Heligman, B.T., Manthiram, A., Subramanian, V.R., Hwang, G.S. and Muthuraman, K., ‘Multiscale Modelling of Nanostructured Foil Anode for Next Generation Batteries,’ 239th *Electrochemical Society Meeting 2021*, May 30-June 3, 2021
7. Uppaluri, M., **Shah, K.**, Vishwanathan, V. V., Subramanian, V. R., ‘A New Modeling Approach to Simulate the SEI Layer Growth in Lithium-Ion Batteries to Predict Capacity Fade,’ 239th *Electrochemical Society Meeting 2021*, May 30-June 3, 2021
8. Jang, T., Mishra, L., **Shah, K.**, Mittal, P., Subramanian, A., Gururajan, M.P., Roberts, S.A. and Subramanian, V.R., ‘Robust 2D Simulation of Morphological Evolution in Lithium-Metal Batteries,’ 239th *Electrochemical Society Meeting 2021*, May 30-June 3, 2021