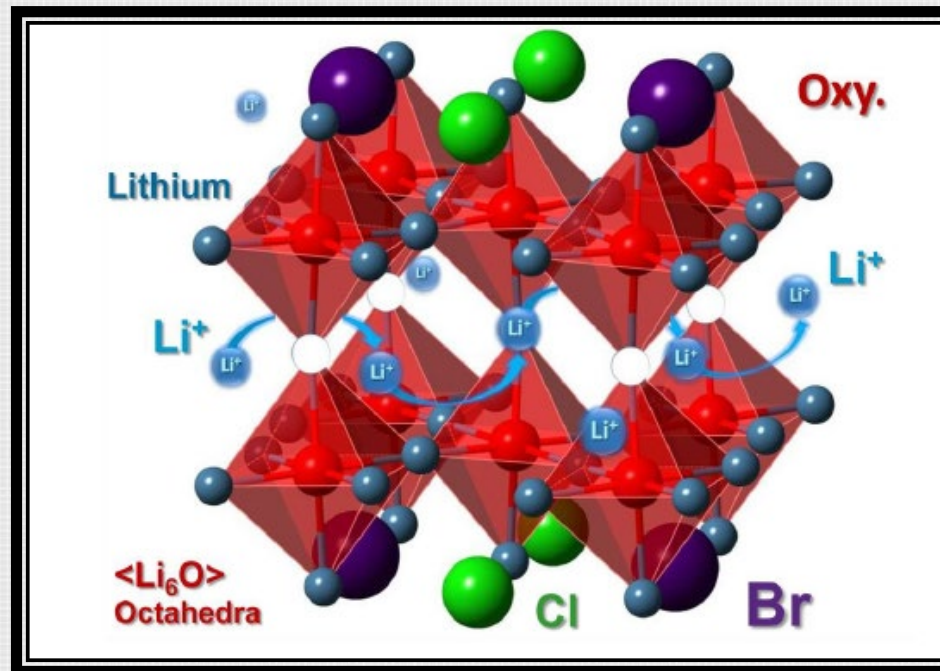


Battery Research at UNLV



Why UNLV?

- For more than a decade, UNLV researchers have conducted a world-class effort in various aspects of battery research. This program has been funded by federal and state agencies, as well as many industrial partners.
- UNLV's outstanding achievements in renewable energy research, its success in forging public/private partnerships, and its excellent academic programs, place the university at the forefront of the field.
- Our researchers have addressed questions about battery materials, energy storage, fuel cells, and integration of batteries in the grid.
- We would like to introduce you to some of our researchers. Please feel free to contact us if we can help with future collaboration.



Why Nevada?

- Nevada is located centrally in the southwest and is close to many renewable energy resources including solar, wind, and geothermal energies.
- Nevada is the home of the *Tesla Gigafactory*, which has the potential for producing batteries at a massive scale to significantly reduce the cost of batteries for cars and energy storage.
- Institutions of higher learning in Nevada are dedicated to advancing various aspects of renewable energy in the region and beyond.



Faculty Involved in Battery Research

Dr. Yahia Baghzouz

*Professor, Department of Electrical and Computer Engineering
Associate Director, Center for Energy Research*

Dr. Yi-Tung Chen

*Chair & Professor, Department of Mechanical Engineering
Co-Director, Center for Energy Research*

Dr. Kwang Kim

Distinguished Professor, Department of Mechanical Engineering

Dr. Jaeyun Moon

Associate Professor, Department of Mechanical Engineering

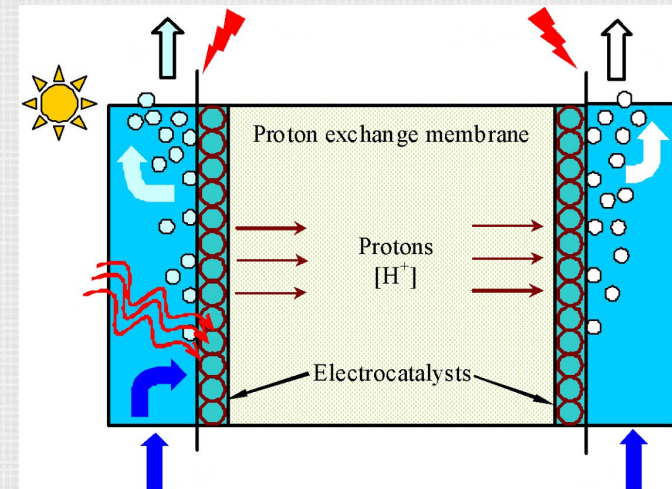
Dr. Hui Zhao

Professor, Department of Mechanical Engineering



Collaboration

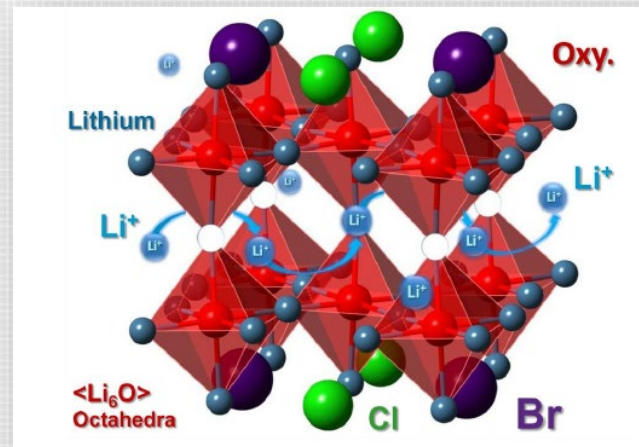
- UNLV researchers have been addressing various critical needs in battery research in conjunction with national laboratories, other universities and the battery industry.
- Past and present partners include:
 - K2 Energy Solutions, Inc.
 - Lawrence Berkeley National Laboratory
 - Los Alamos National Laboratory
 - Rechargeable Power Energy North America, LLC
 - Sandia National Laboratory
 - Tesla Motors
 - University of Texas, Austin



Battery Research Areas of Expertise

- Cell electrical characteristics
- Static and dynamic equivalent circuits
- Cell impedance
- Power electronic battery chargers
- Coupled mass, electron, and charge transport in lithium-ion flow batteries
- Nanostructured Si-based anode materials for Li-ion batteries
- Battery cell assessment
- Multi-physics model of batteries
- Modeling electrochemistry and lithium ion batteries
- Ionic-liquid-based energy storage technology
- Development of efficient and durable rechargeable batteries
- Hybrid battery materials for printable batteries
- Materials synthesis and coin cell assembly

Battery Research Highlights



Dr. Yahia Baghzouz

Professor, Department of Electrical and Computer Engineering
Associate Director, Center for Energy Research

Phone: (702) 895-0887

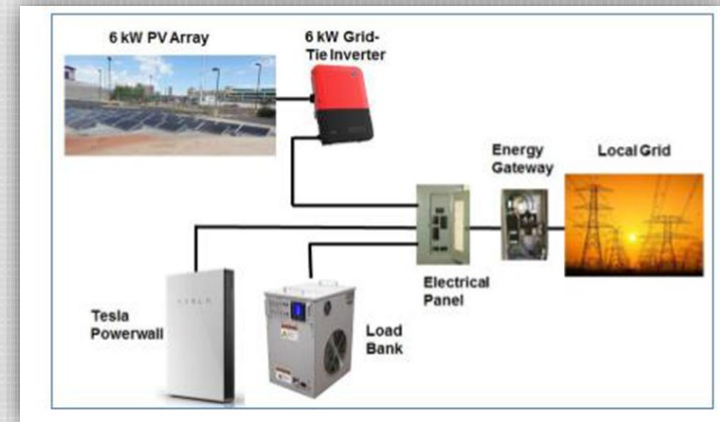
Email: yahia.baghzouz@unlv.edu

- **Research Areas**

- Cell electrical characteristics
- Static and dynamic equivalent circuits
- Cell impedance, lifecycle analysis
- Power electronics battery chargers
- Battery integration with the grid
- Battery residential/commercial applications

- **Test Equipment**

- Fully-automated 16-channel Maccor Model 4200 multifunction test system
- Solar - grid - battery integrated system with programmable charging and discharging



Dr. Yahia Baghzouz

Professor, Department of Electrical and Computer Engineering
Associate Director, Center for Energy Research



Related Publications

- B. Blackstone, Y. Baghzouz, "Value added Sequential Services for BTM Storage when Paired with PV Systems". 19th International Conference on Harmonics and Quality of Power, IEEE, 2020.
- C. Hicks and Y. Baghzouz, "Experimental Steady-State and Transient Analysis of a Behind-The-Meter Battery Storage for Residential Customers with PV Systems", IEEE International Conference on Clean Electric Power, Otranto, Italy, July 2-5, 2019. art. no. 8890193, pp. 438-443.
- Y. Baghzouz, "Economic Evaluation of Behind-The-Meter Battery Storage for Residential Customers with PV Systems in the Regional Market Environment", Hong Kong International Conference on Engineering and Applied Science (HKICEAS), Dec. 18-20, 2018.
- Arabali, A., Ghofrani, M., Etezadi-Amoli, M., Fadali, M.S., Baghzouz, Y., "Genetic-Algorithm-Based Optimization Approach for Energy Management," *IEEE Transactions on Power Delivery*, vol.28, no.1, pp. 162-170, Jan. 2013.
- Peng, W. and Baghzouz, Y., "Accurate Circuit Model for Steady-State and Dynamic Performance of Lead-Acid AGM Batteries", Utility Exhibition on Power and Energy Systems: Issues & Prospects for Asia (ICUE), Pattaya City, Thailand, Sept. 28-30, 2011.

Dr. Yi-Tung Chen

Chair & Professor, Department of Mechanical Engineering

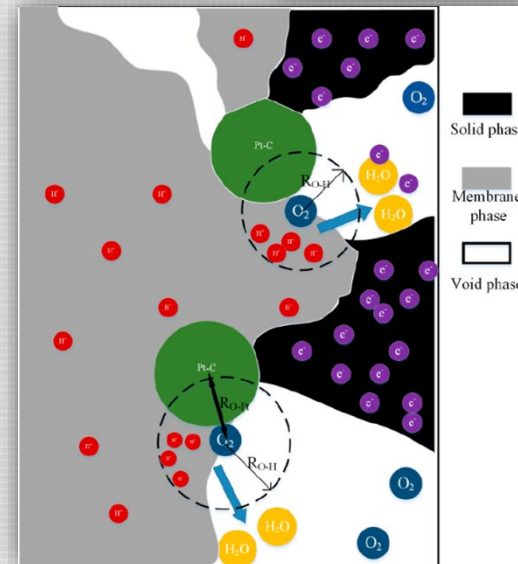
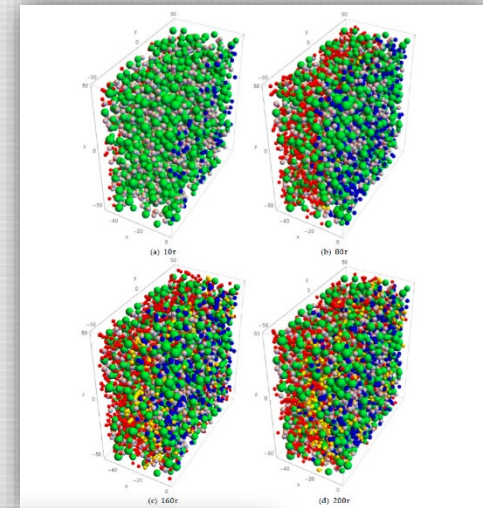
Co-Director, Center for Energy Research

Phone: (702) 895-1202

Email: yitung.chen@unlv.edu

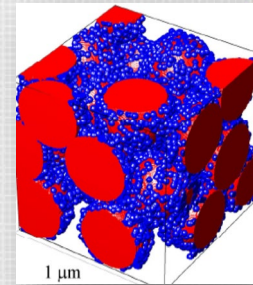
- **Research Areas**

- Coupled mass, electron, and charge transport in lithium-ion flow batteries
- Development of efficient and durable rechargeable batteries with bilayer oxygen ion conducting electrolyte and nano-structured electrodes
- Multi-physics model coupled transport and reaction processes in battery
- Lattice Boltzmann Method (LBM) simulation of gas transport in Solid Oxide Fuel Cell (SOFC) electrode
- SODC interconnect design



Dr. Yi-Tung Chen

Professor, Department of Mechanical Engineering
Co-Director, Center for Energy Research



Related Publications

- Ting Ma, Yitung Chen, Aleksandr N. Pavlenko, and Qiuwang Wang, "Heat and mass transfer advances for energy conservation and pollution control in a renewable and sustainable energy transition," *Renewable and Sustainable Energy Reviews*, 145, (2021), 111087, pp.1-3
- Zexin Yu, Lixia Sang, and Yitung Chen, "A novel route to visualize the hot electrons transfer process in Ag@SiO₂-TiO₂ for solar hydrogen conversion," *Applied Surface Science*, 527, (2020), 146772, pp. 1-10
- Emad Pouryazdanpanah Kermani, Yitung Chen, and Li Chen, "MRT-lattice Boltzmann simulation of high Schmidt and low Prandtl number fluids with heterogeneous reaction on surfaces," *Heat Transfer Research*, 51(5), (2020), pp. 433-445
- Tao Jiang, Shuming Peng, Mei Li, Zhongxuan Sun, Wei Han, and Yitung Chen, "Electrochemical behavior of Gd(III) on Bi electrode and thermodynamic data of Bi_xGd_y intermetallic compounds in eutectic LiCl-KCl molten salts," *Chemical Journal of Chinese Universities*, 39(8), (2018), pp. 1759-1767
- Baosheng Bai and Yitung Chen, "Simulation of the Oxygen Reduction Reaction (ORR) inside the Cathode Catalyst Layer (CCL) of Proton Exchange Membrane Fuel Cells using the Kinetic Monte Carlo Method," *Energies*, 11 (2018), 2529; pp.
- Karn Soontrapa and Yitung Chen, "Mono-sized Sphere Packing Algorithm Development Using Optimized Monte Carlo Technique," *Advanced Powder Technology*, 2, (2013), pp. 955-961.
- Jianhu Nie and Yitung Chen, "Numerical modeling of three-dimensional two-phase gas-liquid flow in the flow field plate of a PEM electrolysis cell," *International Journal of Hydrogen Energy*, 35 (2010), pp. 3183-3197.
- Chaiyod Soontrapa and Yitung Chen, "Optimization approach in variable-charge potential for metal/metal oxide systems," *Computational Materials Science*, 46 (2009), pp. 887-892.

Dr. Jaeyun Moon

Associate Professor, Department of Mechanical Engineering

Email: jaeyun.moon@unlv.edu

Phone: (702) 895-5611

Website: <http://jmoon.faculty.unlv.edu/>

Dr. Kwang J. Kim

Distinguished Professor, Department of Mechanical Engineering

Email: kwang.kim@unlv.edu

Phone: (702) 774-1419

Website: <http://www.kwangjinkim.org/>

• Research Interests

- Li-ion battery materials for high power and energy density
- Comprehensive evaluation of battery cells – performance, lifetime, and safety

• Research Capability and Facilities

- Materials synthesis and coin cell assembly
 - All required equipment to synthesize battery electrode materials and assemble battery cells
- Battery cell assessment
 - Arbin BT2000 Battery Tester (20 channels)
 - Uniscan SECM370, Scanning Electrochemical Microscope

• Representative Publication

- T. L. Nguyen, V. D. Phung, K. Ayalew, D. Chun, I. T. Kim, K. J. Kim, and J. Moon.
"Tailored synthesis of molybdenum-selenide/selenium/sodium-molybdate hybrid composites as a promising anode for lithium-ion and sodium-ion batteries." *Chemical Engineering Journal* 415 (2021): 128813.



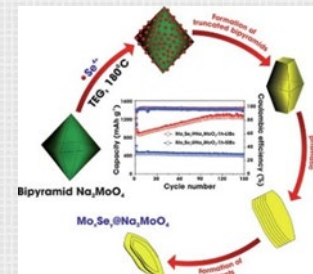
Coin cell cutter & crimper



Coin cell tester



Scanning Electrochemical Microscope

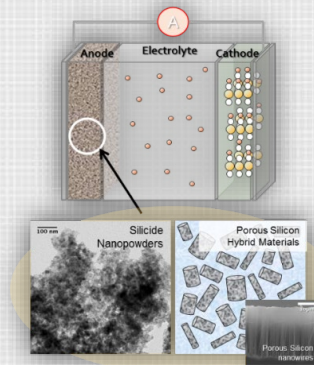


Dr. Jaeyun Moon

Associate Professor, Department of Mechanical Engineering

Related Publications

- T. L. Nguyen, V. D. Phung, K. Ayalew, D. Chun, I. T. Kim, K. J. Kim, and J. Moon. "Tailored synthesis of molybdenum-selenide/selenium/sodium-molybdate hybrid composites as a promising anode for lithium-ion and sodium-ion batteries." *Chemical Engineering Journal* 415 (2021): 128813.
- DE Karas, J Byun, J Moon, C Jose, "Copper-oxide spinel absorber coatings for high-temperature concentrated solar power systems" *Solar Energy Materials and Solar Cells* (2018) 182, 321-330.
- H An, D Karas, BW Kim, S Trabia, J Moon, "Flexible n-type thermoelectric composite films with enhanced performance through interface engineering and post-treatment" *Nanotechnology* (2018) 29 (27), 275403.
- J. Moon, T.K. Kim, B. VanSaders, C. Choi, Z. Liu, S. Jin, R. Chen, "Black oxide nanoparticles as durable solar absorbing material for high-temperature concentrating solar power system", *Solar Energy Materials & Solar Cells*, 134 (2015) 417-424.
- T.K. Kim, B. VanSaders, J. Moon, T. Kim, C.-H. Liu, J. Khamwannah, D. Chun, D. Choi, A. Kargar, R. Chen, "Tandem structured spectrally selective coating layer of copper oxide nanowires combined with cobalt oxide nanoparticles", *Nano Energy*, 11 (2015) 247-259.
- T.K. Kim, J. Moon, B. VanSaders, D. Chun, C.J. Gardner, J.Y. Jung, G. Wang, R.K. Chen, Z.W. Liu, Y. Qiao, S.H. Jin, "Si boride-coated Si nanoparticles with improved thermal oxidation resistance", *Nano Energy*, 9 (2014) 32-40.
- J. Moon, J.H. Kim, Z.C.Y. Chen, J. Xiang, R.K. Chen, "Gate-Modulated Thermoelectric Power Factor of Hole Gas in Ge-Si Core-Shell Nanowires", *Nano Lett*, 13 (2013) 1196-1202.



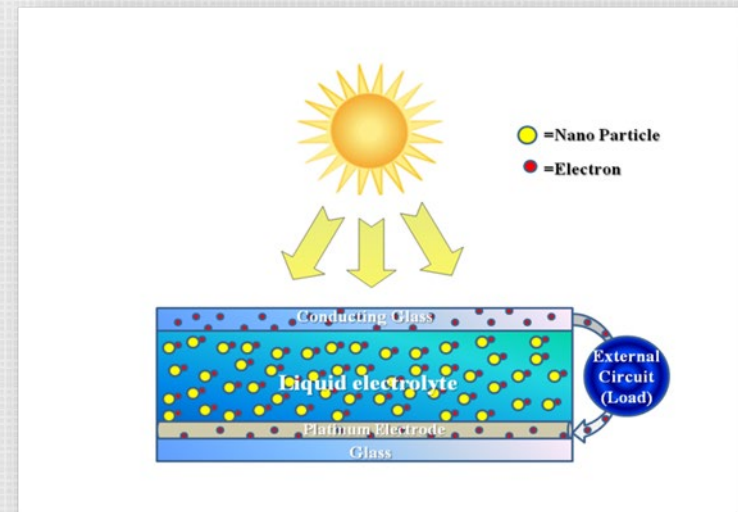
Dr. Hui Zhao

Professor, Department of Mechanical Engineering
Phone: (702) 895-1463

Email: hui.zhao@unlv.edu

- **Research Areas**

- Modeling electrochemistry and lithium ion batteries
- Ionic-liquid-based energy storage technology
- Third-generation dye-sensitized solar cell



Third-generation nanocrystal-enhanced dye-sensitized solar cell

Dr. Hui Zhao

Professor, Department of Mechanical Engineering

Related Publications

- Jiang, X., Huang, J., Zhao, H., Sumpter, B. G., and Qiao, R., 2014, "Dynamics of electrical double layer formation in room-temperature ionic liquids under constant-current charging conditions", *Journal of Physics: Condensed Matter*. 26 284109 (9pp).
- Zhao, H., 2012, "The influence of nonelectrostatic ion-ion interactions on double layer capacitance", *Physical Review E*, 86, 051502.
- Uppapalli, S. and Zhao, H., 2012, "The polarization of a diffuse soft particle subjected to an alternating current field", *Langmuir*, 28, 11164-11172.
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- Zhao, H., 2011, "The role of hydrodynamic behavior of DNA molecules in dielectrophoretic polarization under the action of an electric field", *Physical Review E*, 84, 021910.
- Zhao, H., 2011, "Double layer polarization of a non-conducting particle in an alternating current field with applications to dielectrophoresis", *Electrophoresis* 32, 2232-2244.
- Zhao, H., 2011, "Streaming potential generated by a pressure-driven flow over super-hydrophobic stripes", *Physics of Fluids*, 23, 022003 (selected for the Feb. 14, 2011 issue of Virtual Journal of Nanoscale Science & Technology) (Top 20 most downloaded articles in Feb. 2011).
- Zhao, H., 2010, "Electro-osmotic flow over a charged superhydrophobic surface", *Physical Review E*, 81, 066314.
- Zhao, H., 2010, "On the Influence of Ion Excluded Volume (Steric) Effects on the Double Layer Polarization of a Non-Conducting Nano Particle in an AC Field", *Journal of Physical Chemistry C*, 18, 8389-8397.
- Zhao, H., 2010, "On the Effect of Hydrodynamic Slip on the Polarization of a Non-conducting Spherical Particle in an AC Field", *Physics of Fluids*, 22, 072004.

