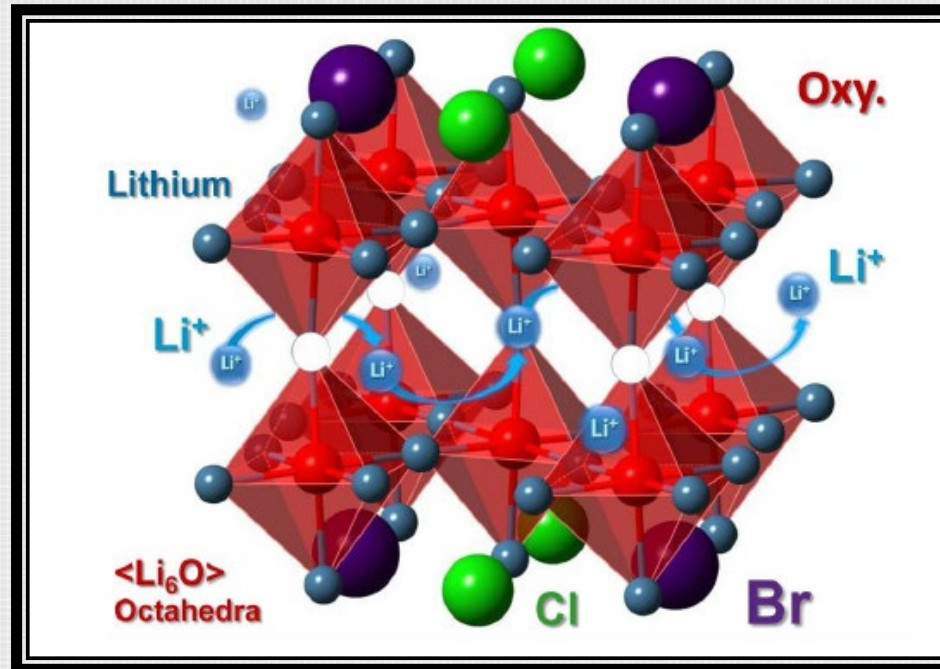


Battery Research at UNLV



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

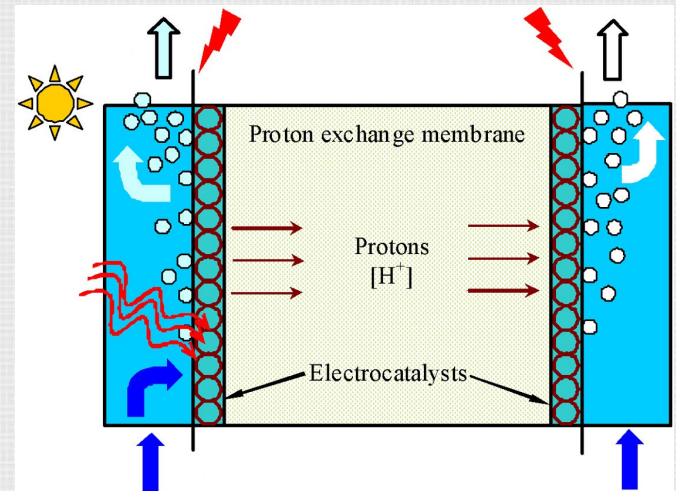
Dr. Hui Zhao

Professor, Department of Mechanical Engineering



Collaboration

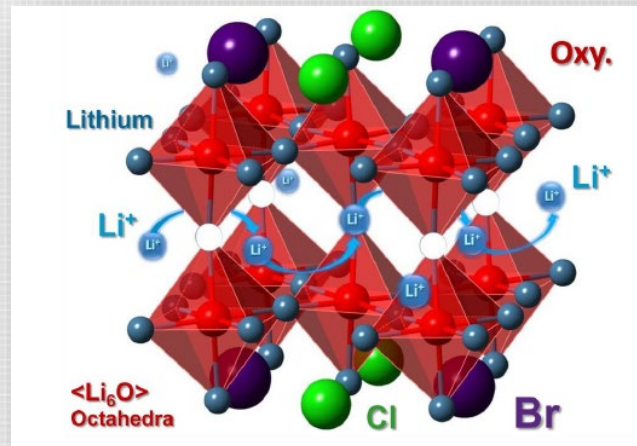
- UNLV researchers have been addressing various critical needs in battery research in conjunction with national laboratories, other universities and the battery industry.
- Past and present partners include:
 - K2 Energy Solutions, Inc.
 - Lawrence Berkeley National Laboratory
 - Los Alamos National 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

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Associate Director, Center for Energy Research

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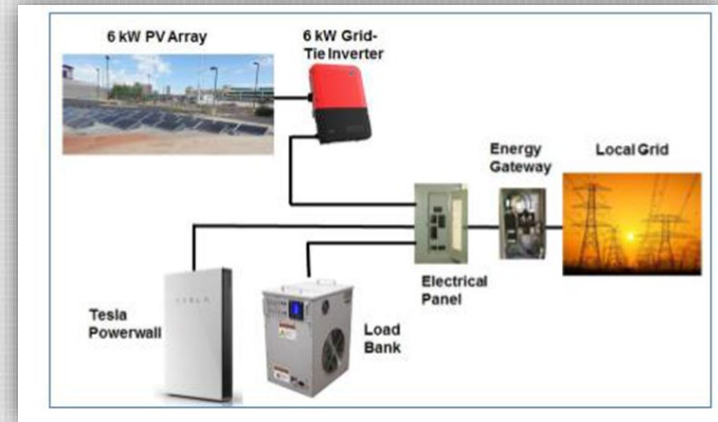
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- **Research Areas**

- Cell electrical characteristics
- Static and dynamic equivalent circuits
- Cell impedance, life cycle 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

- M.A.R Shaon, Y. Baghzouz. "Day-Ahead Residential Customer Load Forecasting Using Prophet". Proceedings - 2023 IEEE International Conference on Environment and Electrical Engineering and 2023 IEEE Industrial and Commercial Power Systems Europe, EEEIC / I and CPS Europe 2023.
- M.A.R Shaon, Y. Baghzouz. "On the accuracy of open-source and commercial solar forecasting tools". Proceedings of the 2022 International Conference and Utility Exhibition on Energy, Environment and Climate Change, ICUE 2022.
- R. Hossian, M. Gautam, M. Mansourlakouraj, H. Livani, M. Benidris, Y. Baghzouz. "Soft Actor Critic Based Volt-VAR Co-optimization in Active Distribution Grids". IEEE Power and Energy Society General Meeting, July, 2022.
- M.A.R Shaon, Y. Baghzouz. "Customer Bill Management Using Thermal and Virtual Electricity Storage". Proceedings of International Conference on Harmonics and Quality of Power, ICHQP, May, 2022.
- 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

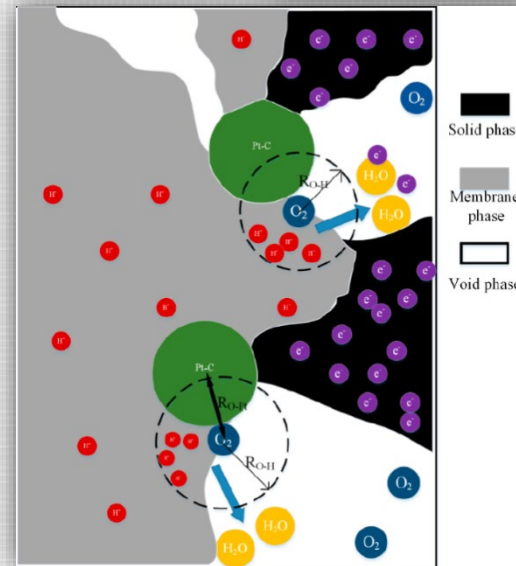
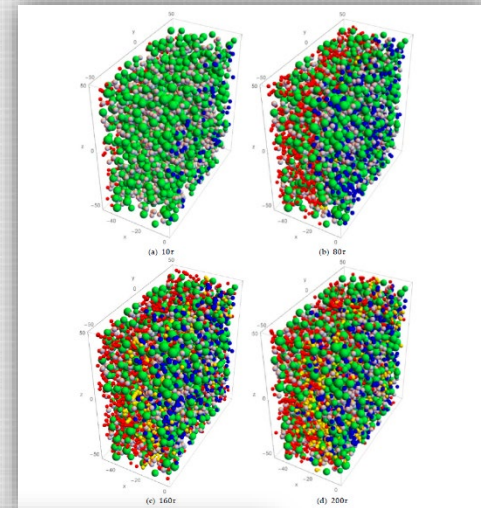
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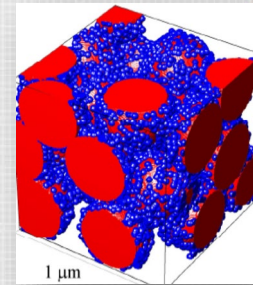
- **Research Areas**

- 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

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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.

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• 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

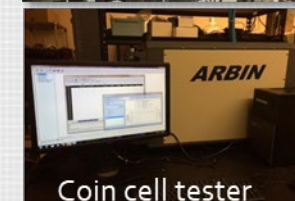
- Materials synthesis and coin cell assembly
 - All required equipment to synthesize battery electrode materials and assemble battery cells
- Battery cell assessment
 - Arbin BT2000 Battery Tester (20 channels)
 - Uniscan SECM370, Scanning Electrochemical Microscope

• 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.



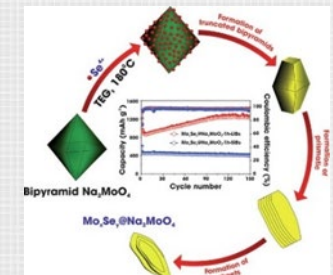
Coin cell cutter & crimper



Coin cell tester



Scanning Electrochemical Microscope

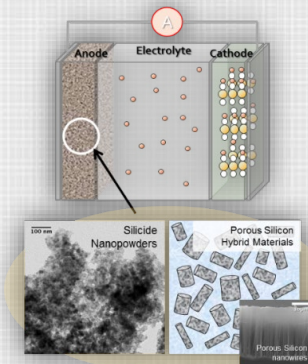


Dr. Jaeyun Moon

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): 1288-13.
- 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.
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- 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.



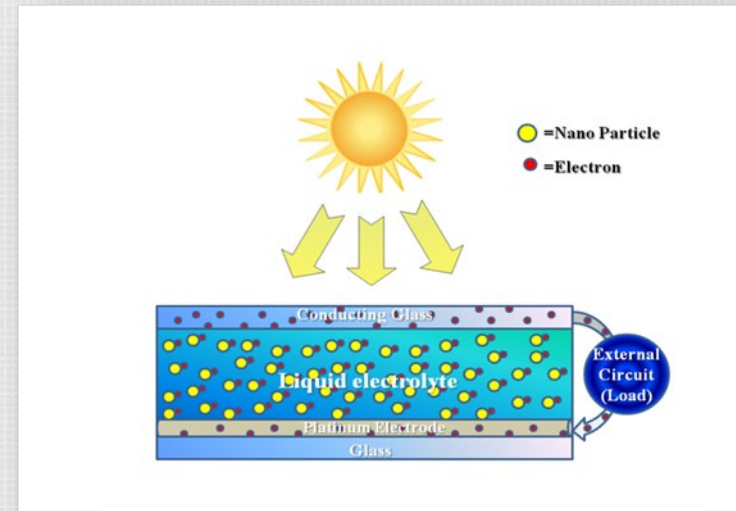
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- **Research Areas**

- 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

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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.
- Zhao, H., 2011, "Diffuse-charge dynamics of ionic liquids in electrochemical systems", *Physical Review E*, 84, 051504.
- 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.

