



Exponent[®]
Engineering & Scientific Consulting

Keith Beers, Ph.D., P.E.

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Professional Profile

Dr. Beers's areas of expertise include failure analysis of batteries and polymer materials, battery technology, and polymer science. He has significant expertise and experience in the design, qualification, performance, reliability, safety, and failure analysis of batteries of varying formats, chemistries, and applications - with particular emphasis on lithium-ion, solid state, and secondary lithium metal battery chemistries.

Additionally, Dr. Beers has specialized understanding of polymer materials used in electrochemical and filtration systems, and the associated transport phenomena. He has extensive experience applying his expertise in solving complex technical problems for his clients in a variety of industries including consumer products, medical devices, vehicles, and military and industrial equipment. He is also a member of standards committees related to batteries and battery safety.

In his battery consulting practice, Dr. Beers assists clients with issues related to the full life cycle of battery-containing products, ranging from the early design and qualification of batteries to the analysis of field returns for safety and performance issues. During the qualification stage, he utilizes a variety of methods to assist clients such as quality assessments, risk assessments (FMEA, fault tree analysis), non-standard testing tailored to end-use, accelerated aging, and forced thermal runaway testing. Dr. Beers also conducts investigations related to potential product recalls associated with battery safety concerns and provides technical support to attorneys engaged in legal proceedings involving battery technology, lawsuits and arbitrations. For his work in this area, he utilizes a variety of in-house testing capabilities, including: X-ray CT scanning, cell teardowns, full cell cross sections, reference electrode testing, charge / discharge cycling, electrochemical impedance spectroscopy (EIS), imaging techniques (SEM, FIB), chemical analysis techniques (FTIR, EDS, GC-MS, and LC-MS), and mechanical and thermal testing. His work in this area builds upon previous experience in his graduate studies where he used X-ray scattering and electron imaging to characterize polymeric components in batteries, including solid polymer electrolytes, polymer separators, and polymer electrode binders.

In the field of polymer science, Dr. Beers consults on topics ranging from materials compatibility, small molecule migration and transport, adhesion, failure analysis, and polymers used in electrochemical and filtration applications. He has contributed to technology and product development, and the evaluation and mitigation of performance-based risk. Prior to joining Exponent, he conducted research focused on the design, synthesis, and characterization of model proton conducting semi-crystalline block copolymers for use in fuel cells. He determined how polymer crystallization affects the self-assembly, conductivity, and water uptake of these systems. In addition, Dr. Beers developed a method of surface modifying battery separators to make them hydrophilic, facilitating their use as water filtration membranes and porous ion-exchange resins.

Academic Credentials & Professional Honors

Ph.D., Chemical Engineering, University of California, Berkeley, 2012

B.S., Chemical Engineering, University of Colorado, Boulder, 2007

Licenses and Certifications

Professional Engineer Chemical, California, #6695

Prior Experience

Graduate Student Research Assistant, Lawrence Berkeley National Laboratory, 2008-2012

Summer Intern, Oceanit, Summer 2007

Undergraduate Researcher, University of Colorado, 2006-2007

Summer Undergraduate Researcher, Hawaii Natural Energy Institute, Summer 2005

Professional Affiliations

Institute of Electrical and Electronic Engineers – IEEE

- IEEE Senior Member
- IEEE Product Safety Engineering Society Member
- IEEE P1725 Working Group (Standard for Rechargeable Batteries for Cellular Telephones) Member

American Society for Quality – ASQ

- ASQ Member

Society of Automotive Engineers – SAE

- SAE Member
- SAE Micromobility Battery Standards Committee Member

Publications

Beers KM, Wong DT, Jackson AJ, Wang X, Pople JA, Hexemer A, Balsara NP. Effect of crystallization on proton transport in model polymer electrolyte membranes. *Macromolecules* 2014; 47(13):4330-4336.

Chen X, Wong DT, Yakovlev S, Beers KM, Downing KH, Balsara NP. Effect of morphology of nanoscale

hydrated channels on proton conductivity in block copolymer electrolyte membranes. *Nano Letters* 2014; 14(7):4058-4064.

Beers KM, Yakovlev S, Jackson AJ, Wang X, Hexemer A, Downing KH, Balsara NP. Absence of Schroeder's paradox in a nanostructured block copolymer. *Journal of Physical Chemistry B* 2014; 118(24):6785-6791.

Jackson A*, Beers KM*, Chen XC, Hexemer A, Pople JA, Kerr J B, Balsara NP. Design of a humidity controlled sample stage for simultaneous conductivity and synchrotron X-ray scattering measurements. *Review of Scientific Instruments* 2013; 84:075114.

*Authors contributed equally.

Wong DT, Wang C, Beers KM, Kortright JB, Balsara NP. Mesoporous block copolymer morphology studied by contrast-matched resonant soft X-ray scattering. *Macromolecules* 2012; 45(22):9188-9195.

Beers KM, Balsara NP. Design of cluster-free polymer electrolyte membranes and implications on proton conductivity. *ACS Macro Letters* 2012; 1(10):1155-1160.

Patel SN, Javier AE, Beers KM, Pople JA, Ho V, Segalman RA, Balsara NP. Morphology and thermodynamic properties of a copolymer with and electronically conducting block: poly(3-ethylhexylthiophene)-block-poly(ethylene oxide). *Nano Letters* 2012; 12(9):4901-4906.

Beers KM, Hallinan DT, Wang X, Pople JA, Balsara NP. Counterion condensation in Nafion. *Macromolecules* 2011; 44(22):8866-8870.

Wang X, Beers KM, Kerr JM, Balsara NP. Conductivity and water uptake in block copolymers containing protonated polystyrene sulfonate and its imidazolium salt. *Soft Matter* 2011; 7(9):4446-4452.

Balsara NP, Beers KM. Proton conduction in materials comprising conducting domains with widths less than 6 nm. *European Polymer Journal* 2011; 47(4):647-650.

Wang X, Yakovlev S, Beers KM, Park MJ, Mullin SA, Downing KH, Balsara NP. Origin of slow changes in ionic conductivity of model block copolymer electrolyte membranes in contact with humid air. *Macromolecules* 2010; 43(12):5306-5314.

Turn SQ, Keffer V, Beers KM. Physiochemical analysis of selected biomass materials in Hawaii. Report prepared for the State of Hawaii Department of Business, Economic Development and Tourism, 2005.

Conference Presentations and Published Abstracts

Beers K, Licht R, Bogart T, Cohn A, Burke C, Cai Z, Horn Q, Spray R. Looking Under the Hood: Case Studies in 18650 Component and Performance Degradation. Oral presentation, NASA Aerospace Battery Workshop, Virtual, November 2020.

Beers K, Vickery J, Barry M, Spray R. Understanding How Testing Conditions Affect Hazard Quantification in Lithium-Ion Abuse Tests. Oral presentation, Advanced Automotive Battery Conference (AABC), Virtual, November 2020.

Burke C, Licht R, Cohn A, Cai Z, Lee K, Godshaw J, Beers K, Adams R, Bogart T. Evaluating Internal Structural Changes in Commercial 18650's. Poster presentation, Advanced Automotive Battery Conference (AABC), Virtual, November 2020.

Beers K. Do's and Don'ts of Wearable Batteries. Oral presentation, WEAR, Virtual, October 2020.

Bassett K, Beers, K. Bridging Academic and Industrial Perspectives on Battery Testing and Design. Oral

presentation, American Chemical Society Fall 2020 Virtual Meeting and Expo, Virtual, 2020.

Beers K, White K, Horn Q, Spray R, Licht R, Harding J, Faenza N. The Role of Temperature in Lithium-ion Battery Failure. Oral presentation, Advances in Thermal Management, Virtual, August 2020.

Licht R, Cohn A, Beers K. The Effects of Cycling Protocols on Internal Cell Structure. Oral presentation, PlugVolt Battery Seminar 2019, Plymouth, MI, July 16, 2019.

Beers K, Licht R, Spray R, Burke C, Cohn A, Bogart T, Forman J, Rucker R, Godshaw J, Harding J, White K, Horn Q. Oral presentation, Testing Tools and Methodologies for Lithium-ion Cell Qualification. 2019 IEEE Symposium on Product Safety and Compliance Engineering (ISPCE), San Jose, CA, May 2019.

Beers K, Spray R, White K, Horn Q, Bogart T, Forman J, Licht R. Fundamentals of Lithium-ion Technology: Cell Safety and Performance. Oral presentation, 2018 Safety Summit San Diego (SSSD), San Diego, CA, October 2018.

Bogart T, Licht R, Beers K, Godshaw J, Rucker R, Forman J, White K. Understanding Degradation of Lithium-Ion Battery Performance. Poster presentation, Advanced Automotive Battery Conference (AABC), San Diego, CA, 2018.

Beers K, White K, Spray R, Horn Q, Harding J. Safety of Lithium-ion Batteries. Oral presentation, IEEE SCV Product Safety Engineering Society Meeting (PSES), Menlo Park, CA, 2017.

Beers K, Breitenkamp K, White K, McNulty J. The Do's and Don'ts of Wearable Device Design. Oral presentation, SMTA Dallas Expo & Tech Forum, Dallas, TX, March 2017.

Beers K, White K, Spray R. Failure Modes and Risk Mitigation Strategies for Batteries in Wearable Devices. Oral presentation, Medical Electronics Symposium, Portland, OR, September 2016

Chen C, Wong DT, Beers KM, Balsara NP. Morphology and proton transport in sulfonated block copolymer and mesoporous polymer electrolyte membranes. Oral presentation, National Meeting of the American Physical Society, Baltimore, MD, March 2013.

Beers KM, Jackson A, Balsara NP. Characterization of the disorder-order transition in hydrated block copolymers using humidity controlled SAXS. Poster presentation, Synchrotron Radiation in Polymer Science Conference, San Francisco, CA, March 2012.

Beers KM, Jackson A, Balsara NP. Disorder-order transitions in humidified block copolymer electrolytes studied by in situ SAXS. Oral presentation, National Meeting of the American Physical Society, Boston, MA, March 2012.

Wong DT, Beers KM, Wang C, Kortright J, Balsara, NP. Characterizing mesoporous block copolymers by resonant soft X-ray scattering. Oral presentation, National Meeting of the American Physical Society, Boston, MA, March 2012.

Beers KM, Wang X, Balsara NP. Characterization of a model polyelectrolyte membrane using a semi-crystalline block copolymer. Oral presentation, National Meeting of the American Physical Society, Dallas, TX, March 2011.

Wang X, Balsara NP, Beers KM, Park MJ. Conductivity and water content in asymmetrical sulfonated block copolymers. Oral presentation, National Meeting of the American Physical Society, Portland, OR, March 2010.