



**Exponent<sup>®</sup>**  
Engineering & Scientific Consulting

**Sam Madden, Ph.D., P.E.**

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## Professional Profile

Dr. Madden supports clients by solving technical problems involving materials science, battery science, metallurgy, and electrochemistry. He has conducted research and failure analysis involving energy storage devices, corrosion, environmentally assisted cracking, and hydrogen embrittlement.

Dr. Madden has experience in analyzing manufacturing defects in microelectronics (e.g. solder ball void analysis and trace characterization), batteries (e.g. Lithium-ion, lead-acid, Ni-Cd), and medical devices.

Dr. Madden has extensive experience with material and analytical surface science characterization techniques including scanning electron microscopy (SEM), electron dispersive spectroscopy (EDS), X-ray diffraction (XRD), Raman spectroscopy, and Rutherford backscatter electron spectroscopy (RBS). He is also skilled in computed tomography (CT) and 3D volume metrology. Dr. Madden has experience with diffusible hydrogen concentration studies in steels, including barnacle electrode and permeation method analysis. His research has included the use of AC and DC techniques to evaluate the electrochemical behavior of batteries, metals, and coatings. He has experience with mechanical testing techniques, fractography, metallurgical analysis, and microscopy as well as glass and silicon fracture analysis.

Dr. Madden has extensive experience in advanced aging of lithium ion cells with focus on damage tolerance and failure modes, including materials characterization, gas generation, thermal properties, and mechanical damage. He has managed the research and analysis behind several reports issued to the CPSC regarding product recalls for lithium ion cells.

## Academic Credentials & Professional Honors

Ph.D., Materials Science and Engineering, University of Virginia, 2014

B.S., Physics, Union College, 2007

## Prior Experience

Graduate Research Assistant, University of Virginia, 2008-2014

Graduate Teaching Assistant, University of Virginia, 2010-2014

## Professional Affiliations

The Electrochemical Society (2010-present)

National Association of Corrosion Engineers—NACE (2009-present)

ASTM International (2015-present)

Sigma Xi, National Scientific Research Society

Sigma Pi Sigma, National Physics Honor Society

## Publications

Harding, Jonathon R., Binghong Han, Samuel B. Madden, and Quinn C. Horn. 2022. "Examining the Performance of Implantable-Grade Lithium-Ion Cells after Overdischarge and Thermally Accelerated Aging" *Energies* 15, no. 4: 1405. <https://doi.org/10.3390/en15041405>

Reitman, M. T. F., Dimitriou, M. D., Vargas, J. R., & Madden, S. B. (2020). Why is service life prediction of polymers and plastics exposed to outdoor weathering important? An industrial perspective. In C. C. White, M. E. Nichols, & J. E. Pickett (Eds.), *Service Life Prediction of Polymers and Coatings* (pp. 19-32). William Andrew Publishing. <https://doi.org/10.1016/B978-0-12-818367-0.00002-3>

Cain T, Madden SB, Birbilis N, Scully JR. Evidence of the enrichment of transition metal elements on corroding magnesium surfaces using Rutherford backscattering spectrometry. *Journal of the Electrochemical Society*, 2015; 162:C228.

Madden SB, Scully JR. Inhibition of AA2024-T351 corrosion using permanganate. *Journal of the Electrochemical Society*, 2014; 161:C162.

Madden SB, Moosbauer DJ, Scully JR. Effects of chromate and molybdate ions on scratch repassivation behavior of precipitation hardened aluminum alloys. *ECS Transactions*, 2013; 50:57.

Madden SB, Scully JR. Investigation of permanganate as an environmentally friendly inhibitor of corrosion on aluminum 2024-T351. *Conference Proceedings, NACE DoD*, 2011, Palm Springs, CA, July 2011.

## Speaking Engagements

Claim and Litigation Management CLM Nashville, TN 2022 - Product Liability: It's Electric!

The Future of Lithium-ion Battery Litigation in the Automotive Industry, PlugVolt, Plymouth, MI 2019 - Service Life Prediction for Lithium-Ion Batteries

## Presentations

King AD, Bland LG, Madden SB, Cain T, Birbilis N, Scully JR. Electrochemical measurement of magnesium corrosion rates: A combined impedance, mass-loss and hydrogen collection study. *RTS, NACE*, San Antonio, TX, 2014.

Madden SB, Scully JR. The effects of chromate and molybdate anionic inhibitors on the scratch repassivation behavior of precipitation age hardened Al alloys. *Symposium Honoring Professor Clive Clayton, ECS Conference*, San Francisco, CA, 2013.

Madden SB, Scully JR. Effects of chromate and molybdate ions on scratch repassivation behavior of precipitation hardened aluminum alloys. *Hydrogen Interactions with Materials, ECS PRIME*, Waikiki, HI, 2012.

Madden SB, Scully JR. Inhibitor assisted regrowth of protective oxides over freshly scratched AA2024-T351 and AA7075-T6 electrodes. *University Corrosion Collaboration Meeting*, University of Virginia, Charlottesville, VA, 2012.

Madden SB, Scully JR. Mechanism of protection of selected chromate-free single inhibitors and inhibitor combinations Full immersion and droplet. University Corrosion Collaboration Meeting, University of Southern Mississippi, Hattiesburg, MS, 2012.

Madden SB, Scully JR. Investigation of permanganate as an environmentally friendly inhibitor of corrosion on aluminum 2024-T351. NACE DoD Corrosion Conference, Palm Springs, CA, 2011.

Madden SB, Scully JR. Investigation of selected inhibitor combinations as an environmentally friendly corrosion inhibitor strategy for AA2024. University Corrosion Collaboration Meeting, US Air Force Academy, Colorado Springs, CO, 2011.

Madden SB, Scully JR. Permanganate and permanganate inhibitor combinations as environmentally friendly corrosion inhibitor replacements for AA2024-T351. NACE Corrosion Conference 2011, Houston, TX, 2011.

Madden SB, Scully JR. Investigation of permanganate as an environmentally friendly corrosion inhibitor strategy for AA2024. University Corrosion Collaboration Meeting, The Ohio State University, Columbus, OH, 2010.

## Project Experience

Investigation of technical issues related to the recall of HVAC components including valve blockage, corrosion inhibition, and statistical evaluation of warranty database metrics. This involved warranty database refinement and Weibull distribution analysis.

Investigation of welding quality, process fluid chemistry, and process tank corrosion in piping and holding tanks for industrial facilities. My work included review of EPC contracts, industry standards, and on-site testing including radiographic, ultrasonic, magnetic, and holiday testing.

Investigation of fractures in filtration systems for industrial agriculture including assessment of manufacturing and installation issues. This investigation involved fractography, materials characterization of polymeric components, multiple site inspections, and extensive review of construction documentation.

Technical due diligence for private equity firms on discrete manufacturing companies in the aerospace industry specializing in thermal spray and additive manufacturing. My work included operations and technical competency assessments, and on-site technical audits of novel manufacturing techniques, quality systems, and manufacturing processes. I provided technical verification, management assessments, employee skill assessments, and evaluation of compliance with customer specification requirements.

Evaluation and testing in multi-year supplier qualification effort for lithium-ion batteries used in consumer handheld electronics. This investigation included cycling, damage tolerance assessments, electrolyte evaluations, and degradation mechanism reviews.

Root cause evaluation of battery energy storage system fire including evaluation of deposits in large format pouch cells and mapping of damage in modules via computed tomography analysis.

Evaluation of lithium-ion gaseous cell swelling in handheld and head mounted devices. My work included chemical analysis, cell teardown, and modeling and lifetime prediction. Analyses for the handheld device were submitted to the Consumer Product Safety Commission (CPSC).

Failure analysis and reformulation of lithium-ion, NiCd, and thionyl chloride cells including electrolyte distribution, electrolyte characterization, thermal properties, gas analysis, cross sectioning, and cycling performance.

Evaluation of trade secrets related to lithium-ion battery production including electrode coating processes and current collector properties.

Project management and litigation support for over 25 lithium-ion thermal event investigations including site inspection, expert reporting, deposition preparation, and client management.

### Advisory Appointments

DOE Energy Storage Safety Strategic Plan Advisory Committee Member

### Peer Reviews

Electrochimica Acta

Journal of the Electrochemical Society

Corrosion Journal