

Curriculum Vitae

Tyler Matthews, Ph.D.

Fortescue Future Industries
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Education

Applied Data Science Program, MIT Professional Education, Fall 2022

University of California, Berkeley, California, 2008-2013

Ph.D. in Materials Science and Engineering, 2013, Area of Specialization: Photoelectrochemistry

M.S. in Materials Science and Engineering, 2011

University of Illinois, Urbana-Champaign, IL, 2005-2007

B.S. in Chemistry, 2007, concentration in Specialized Chemistry, cum laude with Highest Honors

Awards and Honors

Circle of Technical Excellence and Innovation (3M), 2021

Jane Lewis Fellowship (UC Berkeley), 2010-2011

Chancellor's Fellowship (UC Berkeley), 2008-2010

Outstanding Graduate Student Instructor Award (UC Berkeley), 2010-2011

Outstanding Scholar Award (College of Lake County), 2005

Work Experience

Principal Electrochemist: Fortescue Future Industries Colorado Innovation Center, Boulder Colorado, 2023-Current

- Planned and executed research and development efforts in support of Fortescue's decarbonization projects with the aim of identifying and minimizing technological risks
- Principal investigator on a Direct Electrochemical Reduction of Iron pilot facility targeting a 95% reduction in GHG emissions compared to coke-based iron ore reduction technologies
- Performed technology evaluation and due diligence on strategic acquisitions and investment opportunities across multiple green energy industries including hydrogen production, ammonia production, long duration energy storage, and renewable power generation
- Advisor and technical oversight of a direct solar to hydrogen start-up investment
- Technical advisor for the Hydrogen Production Systems business unit focused on low temperature electrolysis (PEM and AEM) MEA component-level scouting and characterization
- Three invention submissions

Specialist Chemist: Electronic Materials Solutions Division, 3M Company, St. Paul Minnesota, 2018-2023

Senior Electrochemist: Energy Components Program, 3M Company, St. Paul Minnesota, 2013-2018

- Technical lead on multi-discipline carbon dioxide recycling project funded in part by the Advanced Research Projects Agency – Energy (ARPA-e, <https://arpa-e.energy.gov/impact-sheet/dioxide-materials-open-2012>)
- Co-author on ARPA-e plus-up application (awarded) as follow-on to successful CO₂ recycling project
- Anion exchange membrane polymer synthesis and characterization for solid state CO₂ electrolyzer applications resulting in one granted U.S. patent
- Optimization of CO₂ reduction electrocatalyst development, from deposition/fabrication utilizing physical vapor deposition techniques including thermal evaporation, e-beam evaporation, and reactive ion DC sputtering, to *in situ* and *ex situ* characterization techniques including cyclic/linear

sweep voltammetry, chronoamperometry, chronopotentiometry, electrochemical impedance spectroscopy, and SEM/EDS

- Technical research member of an energy storage technology “deep dive” assessment team guiding future 3M research programs in the Corporate Research Materials Laboratory (CRML)
- Synthesis and characterization of redox flow battery materials including optimized PFSA-based ion exchange membranes and novel electrocatalysts for grid-level energy storage applications
- Designed, built, and operated rotating disc electrode electrochemical characterization capability to develop and optimize novel hydrogen fuel cell electrode ionomers
- Battery electric vehicle immersion cooling application development using 3M Novec™ brand dielectric fluids to mitigate risk of thermal runaway and improve battery performance
- Technical lead on a project to identify and mitigate electrochemical failure mechanism of a fluoroketone two-phase immersion cooling fluid for hyperscale datacenter applications
- Built and maintained datacenter server hardware in immersion cooling pilot studies
- Developed and maintained a general-purpose ETL software tool to automate data processing and visualization from disparate data sources and laboratory equipment (Visual C++ front-end with embedded user-customizable Python scripting and Linux web/FTP/OracleDB back-end)
- Built custom software & hardware apparatus to monitor hydrogen generation of unattended water electrolyzer test stations to enable emergency shutoff (Arduino hardware, Visual C++ user interface)
- 26 invention submissions, 10 patent filings, numerous 3M internal technical reports

Doctoral Research: Department of Materials Science and Engineering, University of California at Berkeley, 2008-2013 (research advisor: Prof. Junqiao Wu); Materials Science Division and the Joint Center for Artificial Photosynthesis, Lawrence Berkeley National Laboratory, 2011-2013 (research advisor: Dr. Joel W. Ager III)

- Growth and characterization of novel, Earth-abundant metal-oxide semiconductors in thin-film and nanostructured form to serve as the photoanode in an artificial water-splitting device to convert solar energy into chemical energy
- Optimization of thin-film metal-oxide semiconductor growth utilizing reactive-ion sputtering, electrochemical deposition, electron-beam evaporation, and chemical vapor deposition
- Developed process of anodic aluminum oxide (AAO) nanotemplate formation on Si and ITO-coated glass for the growth of highly-ordered semiconductor nanowire arrays using electrochemical deposition
- Structural, electronic, and electrochemical characterization of semiconductors utilizing SEM/EDS, TEM, XRD, XPS, AFM, Auger, Raman, IPCE, illuminated and dark I-V, UV-Vis spectroscopy, Photolithography, Hall Effect, Cyclic and Linear Sweep Voltammetry, Chronoamperometry, Chronopotentiometry, and Electrochemical Impedance Spectroscopy
- Graduate student instructor for MSE 241: Electron Microscopy and Microanalysis Techniques (TEM lab)

Applications Manager: CambridgeSoft Corporation (now PerkinElmer), Cambridge MA, June 2007 to June 2008

- Lead developer and project leader for the Inventory Enterprise application, a chemical inventory application with an ASP/Javascript front-end and Oracle DB with PL/SQL back-end
 - Managed the Enterprise 10 edition release, ensuring a successful and on-schedule delivery to our customers
 - Managed a team of two outsourced programmers located internationally
- Skills include .NET, ASP, Visual C++, C#, CSLA, Java, HTML/Javascript, XML, Oracle PL/SQL

Undergraduate Research: Department of Chemistry, University of Illinois at Urbana-Champaign, 2006-2007 (research advisor: Prof. Andrzej Wieckowski)

- Studied formic acid oxidation mechanism on Pt {100} single crystal and Pt polycrystalline electrodes in acidic media using cyclic voltammetry, linear sweep voltammetry, and chronoamperometry

- Learned and utilized a wide range of characterization techniques during coursework, including FT-IR, GC-MS, ICR-MS, LEED, LIF, HPLC, EPR, Raman, UV-Vis, NMR, XRD, and numerous electrochemistry techniques
- Developed software tool to automate electrochemical data collection, analysis and visualization (Visual C++ front-end and Lua scripting back-end, Excel document output)
- Developed web-based software tool to generate idealized titration curve graphs for arbitrary acid species using the Henderson-Hasselbalch equation (HTML/Javascript)

Business Systems Architect: Quill Corporation, Lincolnshire, IL (February 1997 to January 2004)

- Served as technical lead, project manager, systems architect, and programmer analyst for a 1000+ employee office supply company, developing n-tier applications to interface a variety of business-critical databases and external vendor systems
- Project lead and technical lead on an enterprise order entry database server conversion from MS-SQL Server 6.5 to MS-SQL 2000, delivered on-time and under budget
- Designed and developed a fully-automated script-based testing tool to perform extensive unattended load-testing of the company's mission-critical order entry database and user interface (Visual C++ front end with embedded Lua scripting for automation and MS-SQL back-end)
- Developed and maintained more than 20 n-tier client-server application systems in support of business requirements (ASP/HTML, Visual C++, MS-SQL Server)
- Managed a team of up to two programmers, and served as mentor to more junior-level programmers
- Skills include Visual C++ (MFC, STL), Visual Basic, Java, Python, Lua, MS-SQL, ASP, HTML/DHTML, Extended Stored Procedures, DTS, CORBA, COM, ADO, ISAPI, HLLAPI, MIME, ODBC, Microsoft domain and systems administration, Linux systems administration

Publications and Presentations

T.S. Matthews, R. Behrens, W.-P. Zhou, G.-Q. Lu, and A. Wieckowski, Oxidative Fuel Cell Catalysis. *Electrochemical Society Spring Meeting*, 2007 (oral presentation)

R.I. Behrens, G-Q. Lu, T. Matthews, A. Lagutchev, D.D. Dlott, and A. Wieckowski. Developments in the Formic Acid Oxidation Reaction Using Combined Electrochemistry and BB-SFG. *Electrochemical Society Fall Meeting*, 2007 (oral presentation)

T.S. Matthews, A. Tang, J.W. Ager, R. Ramesh, and J. Wu. Electrochemical Deposition and Characterization of Metal-Oxide Semiconductor Nanowires. *Materials Research Society Spring Meeting*, 2011 (poster)

T.S. Matthews, K.R. Balasubramaniam, S. Chen, E. Alarcon-Llado, L.-W. Wang, J. Wu, and J.W. Ager. Copper Tungstate Thin Film and Nanowire Photoanodes for Visible Light Water Splitting. *Materials Research Society Spring Meeting*, 2012 (poster)

Matthews, T.S., Sawyer, C., Ogletree, D.F., Liliental-Weber, Z., Chrzan, D.C. and Wu, J., 2012. Large reaction rate enhancement in formation of ultrathin AuSi eutectic layers. *Physical review letters*, 108(9), p.096102. (10 citations)

Lee, M.H., Takei, K., Zhang, J., Kapadia, R., Zheng, M., Chen, Y.Z., Nah, J., Matthews, T.S., Chueh, Y.L., Ager, J.W. and Javey, A., 2012. p-Type InP nanopillar photocathodes for efficient solar-driven hydrogen production. *Angewandte Chemie International Edition*, 51(43), pp.10760-10764. (227 citations)

Tongay, S., Zhou, J., Ataca, C., Lo, K., Matthews, T.S., Li, J., Grossman, J.C. and Wu, J., 2012. Thermally driven crossover from indirect toward direct bandgap in 2D semiconductors: MoSe₂ versus MoS₂. *Nano letters*, 12(11), pp.5576-5580. (804 citations)

Diamond, A.M., Corbellini, L., Balasubramaniam, K.R., Chen, S., Wang, S., Matthews, T.S., Wang, L.W., Ramesh, R. and Ager, J.W., 2012. Copper-alloyed ZnS as a p-type transparent conducting material. *physica status solidi (a)*, 209(11), pp.2101-2107. (60 citations)

Tongay, S., Zhou, J., Ataca, C., Liu, J., Kang, J.S., Matthews, T.S., You, L., Li, J., Grossman, J.C. and Wu, J., 2013. Broad-range modulation of light emission in two-dimensional semiconductors by molecular physisorption gating. *Nano letters*, 13(6), pp.2831-2836. (442 citations)

T.S. Matthews, M. Kaplun, Z. Liu, Q. Chen, R. Kutz, S. Luopa, K. Lewinski, and R.I. Masel. On the Route to Commercialization of a CO₂ Electrolyzer: Lessons Learned from an Industry Effort to Fight Climate Change. *American Chemical Society Spring Meeting*, 2015 (oral presentation)

T.S. Matthews, M. Kaplun, Z. Liu, Q. Chen, R. Kutz, S. Luopa, K. Lewinski, and R.I. Masel. Electrochemical Reduction of CO₂ to CO with High Selectivity Using an All Solid-State Electrolyzer Cell. *227th Meeting of the Electrochemical Society*, Spring 2015 (oral presentation)

Q. Chen, Z. Liu, R. Kutz, H. Yang, R.I. Masel, K.A. Lewinski, M. Kaplun, and T.S. Matthews. New High Conductivity Membranes for Alkaline Electrolyzers. *227th Meeting of the Electrochemical Society*, Spring 2015 (oral presentation)

Z. Liu, R.I. Masel, Q. Chen, R. Kutz, H. Yang, K.A. Lewinski, T.S. Matthews, and M. Kaplun. A Novel Anion Exchange Membrane Enabling Generation of Syngas from Water and CO₂ at Industrially Important Rates. *227th Meeting of the Electrochemical Society*, Spring 2015 (oral presentation)

Patents and Published Applications

Matthews, T.S., Hamrock, S.J., Kaplun, M.M., Lewinski, K.A. and Luopa, S.M., 3M Innovative Properties Co., 2017. *Ionic polymer membrane for a carbon dioxide electrolyzer*. U.S. Patent 15/327,404 (granted).

Andrew T. Haug, John E. Abulu, Matthew J. Lindell, Tyler S. Matthews, Andrew J.L. Steinbach, Fuxia Sun, Michael A. Yandrasits., 3M Innovative Properties Co., 2019. *Fluoropolymer ionomers with reduced catalyst poisoning and articles therefrom*. International Patent Application WO 2020/128759 A1.

Fayemi, Bamidele O., Stegmaier, Petra M., Matthews, Tyler S., 3M Innovative Properties Co., 2019. *Space Fillers for Electrochemical Cell Packs*. International Patent Application WO 2020/230022 A1.

Bamidele O. Fayemi, Tyler S. Matthews, and Steven Y. Yu, 3M Innovative Properties Co., 2020. *Detection and capture of fluorine containing toxic byproducts of electrochemical cell packs*. International Patent Application WO 2021/059206 A1.

Bamidele O. Fayemi, Lawrence J. Stang, Joshua T. Hemelgarn, Tyler S. Matthews, Nicholas S. Johnson, and Sara Jouzdani, 3M Innovative Properties Co., 2021. *Rapid venting of electrochemical cell packs*. International Patent Application WO 2021/1144718 A1.

Daniel J. Harrison, Bamidele O. Fayemi, Tyler S. Matthews, Michael J. Bulinski, 3M Innovative Properties Co., 2020. *Fluids for immersion cooling of electronic components*. International Patent Application WO 2022/96995 A1.

Matthews, T.S., Tuma, P.E., Frankel, K.A., 3M Innovative Properties Co., 2021, *Fluorinated fluid conditioning system*. International Patent Application WO 2022/190013 A1.

Forrest A. Coughlin and Tyler S. Matthews, 3M Innovative Properties Co., 2022, *Immersion cooling system including hydrolysis-resistant fluoroketone*. International Patent Application WO 2023/031768 A1.