

J. Tyler Mefford, Ph.D.

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Education

Stanford University	Postdoctoral Scholar Department of Materials Science and Engineering Stanford Institute for Materials & Energy Sciences SLAC National Accelerator Laboratory	10/2016 – 4/2020
The University of Texas at Austin	Doctor of Philosophy in Analytical Chemistry Certification in Nanoscience and Nanotechnology Dissertation: “Perovskite Oxide Electrode Materials for Energy Conversion and Storage”	8/2012 – 8/2016
Stanford University	Bachelor of Science in Chemistry Minor in Materials Science and Engineering	9/2008 – 6/2012

Research Experience

Senior Staff Research Scientist 4/2020 - Present

Department of Materials Science and Engineering, Stanford University, Stanford, CA

- Developed novel approaches to grid-scale electrochemical energy storage with a focus on expanding the capabilities of aqueous electrolyte-based technologies.
- Responsibilities include grant proposal writing, hands-on lab experiments, and managing a team of 2 Postdoctoral students, 5 Ph.D. students, and 1 Masters students.
- Projects include fundamental research on oxygen evolution design principles using atomically-flat pulsed laser deposited oxide thin films, development and *operando* characterization of novel metal anodes, tuning the functional behavior of oxide electrocatalysts through voltage-dependent ion-insertion mechanisms, frequency modulated electrochemistry coupled to *operando* spectroscopic characterization techniques for enhancing surface signal localization of electrocatalysts, and developing organic semiconducting polymer electrocatalysts for energy relevant conversion reactions (OER/ORR, HER/HOR, NRR, CO₂RR, etc.)

Postdoctoral Scholar 10/2016 - 3/2020

William C. Chueh Group

Department of Materials Science and Engineering, Stanford University, Stanford, CA

- Development of *operando* electrochemical/microscopy characterization methods to provide correlative insight into the relationships between electrochemical reactivity and the physical, chemical, and electronic structure of transition metal oxides during active operation as electrochemical energy storage and conversion electrodes.
- Expertise in *Operando* Electrochemical X-ray Diffraction, *Operando* Electrochemical Scanning Transmission X-ray Microscopy, *Operando* Electrochemical Atomic Force Microscopy, Scanning Electrochemical Cell Microscopy, Electrochemical Quartz Crystal Microbalance measurements, and UV-Vis Spectroelectrochemistry [X-ray microscopy work done at: Stanford Synchrotron Radiation Lightsource (SSRL) at SLAC National Accelerator Laboratory, Menlo Park,

CA; Advanced Light Source (ALS) at Lawrence Berkeley National Lab, Berkeley, CA; and BESSY II at Helmholtz-Zentrum Berlin, Berlin, Germany].

- Developed improved models that explain mechanistic behavior of consecutive multi-electron transfer reactions on functional electrodes through the combination of *ab initio* thermodynamic calculations with steady-state and quasi-equilibrium kinetic approaches.

Graduate Research Assistant

8/2012 - 8/2016

Keith J. Stevenson Group

Department of Chemistry, The University of Texas at Austin, Austin, TX

- Nanoparticle synthesis and electrochemical characterization of perovskite oxides for energy storage and conversion, including pseudocapacitor applications and electrocatalysis for water electrolysis and urea oxidation.
- Proposed and characterized “anion-based intercalation pseudocapacitance” in perovskite oxides with substantial oxygen vacancies, such as $\text{LaMnO}_{3-\delta}$, and $\text{La}_{1-x}\text{Sr}_x\text{BO}_{3-\delta}$ (B = Mn, Fe, Co).
- Proposed “Lattice Oxygen Evolution” mechanism for highly covalent perovskite oxides (for example $\text{La}_{1-x}\text{Sr}_x\text{CoO}_{3-\delta}$ for $x \geq 0.4$) in which over oxidation of late 3d transition metal active sites (Co, Ni) results in oxidation of ligand-oxygen in the surface layers of the oxide liberating O_2 gas in a cyclic mechanism leading to much higher activities.
- Developed kinetic modeling to explain the coupling between carbon supports and metal oxides for the oxygen reduction reaction which demonstrated that the reaction is initiated on the carbon surface followed by spillover and complete reduction on the oxide.

Undergraduate Research Assistant

11/2010 - 6/2012

Hongjie Dai Group

Department of Chemistry, Stanford University, Stanford, CA

- Synthesis of composite materials for energy storage, coupling redox active metal oxides with graphene and carbon nanotubes for battery and supercapacitor electrodes.

Funding and Successful Grant Proposals

Co-Investigator: “Sn metal anodes for aqueous batteries,” **\$1,000,000**
Shell International Exploration and Production

8/2020 – 8/2022

Manuscripts In Preparation (* indicates equal contribution authorship, † indicates corresponding authorship)

24. Akbashev, A.R.; Roddatis, V.; Raman, A.S.; Baeumer, C.; Liu, T.; **Mefford, J.T.**; Vojvodic, A.; Chueh, W.C., “Probing degradation of SrIrO_3 electrocatalyst during the electrochemical water oxidation,” Manuscript in preparation.

23. Szumska, A.A.; Maria, I.P.; Flagg, L.Q.; Savva, A.; Surgailis, J.; Paulsen, B.D.; Moia, D.; Chen, X.; Griggs, S.; **Mefford, J.T.**; Inal, S.; Ginger, D.; Giovannitti, A.; Nelson, J., “Reversible electrochemical charging of n-type conjugated polymer electrodes in aqueous electrolytes,” To be submitted to **Journal of the American Chemical Society** in April 2021.

22. Baeumer, C.; Liang, A. Y.-L.; Trstenjak, U.; Lu, Q.; Waser, R.; Dittman, R.; **Mefford, J.T.**; Gunkel, F.; Nemšák, S.; Chueh, W.C. *Carbonate formation lowers the electrocatalytic activity of perovskite oxides for water electrolysis.* To be submitted to **J. Mater. Chem. A** in April 2021

Publications (* indicates equal contribution authorship, † indicates corresponding authorship)

21. **Mefford, J.T.**[‡]; Akbashev, A.R.; Kang, M.; Bentley, C.L.; Gent, W.E.; Alsem, D.H.; Salmon, N.J.; Unwin, P.R.; Chueh, W.C. Correlative *operando* microscopy of oxygen evolution electrocatalysts. **Nature**. *Accepted*
20. Sood, A.*; Poletayev, A.D.*; Cogswell, D.A.*; Csernica, P.*; **Mefford, J.T.***; Fraggedakis, D.; Toney, M.F.; Linderberg, A.; Bazant, M.Z.; Chueh, W.C. Electrochemical Ion Insertion: From Atoms to Devices. *Invited Review Article* in **Nature Reviews Materials**. *Accepted*.
19. Baeumer, C.; Li, J.; Lu, Q.; Liang, A. Y.-L.; Jin, L.; Perin Martins, H.; Duchon, T.; Gloss, M.; Gericke, S.; Wohlgemuth, M.A.; Giesen, M.; Penn, E.E.; Dittmann, R.; Gunkel, F.; Waser, R.; Bajdich, M.; Nemšák, S.; **Mefford, J.T.**; Chueh, W.C. Tuning surface composition and transformation pathways in atomically-flat LaNiO₃ thin films for enhanced water electrolysis. **Nature Materials**. *Accepted*.
18. Gu, H.; Shi, G.; Chen, H.-S.; Xie, S.; Li, Y.; Li, J.; Tong, H.; Yang, C.; Zhu, C.; **Mefford, J.T.**; Xia, H.; Zhou, J.; Zhang, S.; Chueh, W.C.; Chen, H.; Zhang, L. Strong catalyst-support interactions in electrochemical oxygen evolution on Ni-Fe layered double hydroxide. **ACS Energy Letters**, 5, 3185-3194 (2020).
17. Giovannitti, A.; Rashid, R.B.; Thiburce, Q.; Paulsen, B.D.; Cendra, C.; Thorley, K.; Moia, D.; **Mefford, J.T.**; Hanifi, D.; Weiyuan, D.; Moser, M.; Salleo, A.; Nelson, J.; McCulloch, I.; Rivnay, J. Energetic Control of Redox-Active Polymers toward Safe Organic Bioelectronic Materials. **Advanced Materials**, 32, 1908047 (2020).
16. **Mefford, J.T.**^{*†}; Zhao, Z.*; Bajdich, M.; Chueh, W.C. Interpreting Tafel Behavior of Consecutive Electrochemical Reactions through Combined Thermodynamic and Steady State Microkinetic Approaches. **Energy & Environmental Science**, 13, 622-634 (2020).
15. **Mefford, T.**; Karki, K.; Alsem, D.H.; Shapiro, D.; Salmon, N.; Chueh, W.C. *Operando* Scanning Transmission X-ray Microscopy of Co(OH)₂ Oxygen Evolution Electrocatalysts. **Microscopy and Microanalysis**, 24, 324-325 (2019).
14. **Mefford, J.T.**[‡]; Akbashev, A.R.; Zhang, L.; Chueh, W.C. Electrochemical Reactivity of Faceted β-Co(OH)₂ Single Crystal Platelet Particles in Alkaline Electrolytes. **The Journal of Physical Chemistry C**, 123, 18783-18794 (2019).
13. **Mefford, J.T.**; Kurilovich, A.A.; Saunders, J.; Hardin, W.G.; Abakumov, A.M.; Forslund, R.P.; Bonnefont, A.; Dai, S.; Johnston, K.P.; Stevenson, K.J. Decoupling the roles of carbon and metal oxides on the electrocatalytic reduction of oxygen on La_{1-x}Sr_xCoO_{3.6} perovskite composite electrodes. **Physical Chemistry Chemical Physics**, 21, 3327-3338 (2019).
12. Alexander, C.T.*; **Mefford, J.T.***; Saunderson, J.; Forslund, R.P.; Johnston, K.P.; Stevenson, K.J. Anion-Based Pseudocapacitance of the Perovskite Library La_{1-x}Sr_xBO_{3.6}. **ACS Applied Materials & Interfaces**, 11, 5084-5094 (2019).
11. Kirsanova, M.A.; Okatenko, V.D.; Aksvonov, D.A.; Forslund, R.P.; **Mefford, J.T.**; Stevenson, K.J.; Abakumov, A.M. Bifunctional OER/ORR catalytic activity in the tetrahedral YBaCo₄O_{7.3} oxide. **Journal of Materials Chemistry A**, 7, 330-341 (2019).
10. Forslund, R.P.; Hardin, W.G.; Rong, X.; Abakumov, A.M.; Filimonov, D.; Alexander, C. T.; **Mefford, J.T.**; Iyer, H.; Kolpak, A.M.; Johnston, K.P.; Stevenson, K.J. Exceptional electrocatalytic oxygen evolution via tunable charge transfer interactions in La_{0.5}Sr_{1.5}Ni_{1-x}Fe_xO_{4±δ} Ruddlesden-Popper oxides. **Nature Communications**, 9: 3150 (2018).
9. Karki, K.; **Mefford, J.T.**; Alsem, D.H.; Salmon, N.; Chueh, W.C. Replicating Bulk Electrochemistry in Liquid Cell Microscopy. **Microscopy and Microanalysis**, 24, 324-325 (2018).

8. Akbashev, A.R.; Zhang, L.; **Mefford, J.T.**; Park, J.; Butz, B.; Luftman, H.S.; Chueh, W.C.; Vojvodic, A. Activation of Ultrathin SrTiO₃ with Subsurface SrRuO₃ for the Oxygen Evolution Reaction. **Energy & Environmental Science**, *11*, 1762-1769 (2018).
7. Piburn, G.W.; **Mefford, J.T.**; Zinni, N.; Stevenson, K.J.; Humphrey, S.M. Synthesis and charge storage properties of templated LaMnO₃-SiO₂ composite materials. **Dalton Transactions**, *46*, 977-984 (2017).
6. Forslund, R.P.; **Mefford, J.T.**; Hardin, W.G.; Johnston, K.P.; Stevenson, K.J. Nanostructured LaNiO₃ Perovskite Electrocatalyst for Enhanced Urea Oxidation. **ACS Catalysis**, *6*, 5044-5051 (2016).
5. **Mefford, J.T.**; Rong, X.; Abakumov, A.M.; Hardin, W.G.; Dai, S.; Kolpak, A. M.; Johnston, K.P.; Stevenson, K.J. Water electrolysis on La_{1-x}Sr_xCoO_{3-δ} perovskite electrocatalysts. **Nature Communications**, *7*: 11053 (2016).
 - Highlighted by *MIT News, Renewable Energy Magazine, Phys.org, Then Energy Collective, and the Electrochemical Society*
 - Web of Science Highly Cited Paper in Chemistry
4. Hardin, W.G.*; **Mefford, J.T.***; Slanac, D.; Patel, Bijal B.; Wang, X.; Dai, S.; Zhao, X.; Ruoff, Rodney S.; Johnston, K.P.; Stevenson, K.J. Tuning the Electrocatalytic Activity of Perovskites through Active Site Variation and Support Interactions. **Chemistry of Materials**, *26*, 3368-3376 (2014).
3. **Mefford, J.T.***; Hardin, W.G.*; Dai, S.; Johnston, K.P.; Stevenson, K.J. Anion charge storage through oxygen intercalation in LaMnO₃ perovskite pseudocapacitor electrodes. **Nature Materials**, *13*, 726-732 (2014).
 - Web of Science Highly Cited Paper in Materials Science
2. Wang, H.; Liang, Y.; Gong, M.; Li, Y.; Chang, W.; **Mefford, T.**; Zhou, J.; Wang, J.; Regier, T.; Wei, F.; Dai, H. An ultrafast nickel-iron battery from strongly coupled inorganic nanoparticle/nanocarbon hybrid materials. **Nature Communications**, *3*, 917-925 (2012).
 - Highlighted by *AAAS EurekAlert, ScienceNews, Los Angeles Times, and Nanoweb Nanotechnology News*
 - Web of Science Highly Cited Paper in Chemistry
1. Mefford, I.N.; **Mefford, J.T.**; Burris, C.A. Improved Diabetes Control and Pancreatic Function in a Type 2 Diabetic after Omeprazole Administration. **Case Reports in Endocrinology**, *2012*, 1-4 (2012).

Invited Talks

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| 2/2021 | Material Science: Characterisation and Applications of Advanced Nanophotonic Materials and Structures , Oxford Instruments, Virtual
<i>Correlative operando structural, chemical, and electrochemical microscopy of oxygen evolving electrocatalysts</i> |
| 11/2020 | Materials Research Society Fall Meeting , Materials Research Society, Virtual
<i>Correlative operando structural, chemical, and electrochemical microscopy of oxygen evolving electrocatalysts</i>
Recipient of Symposium Best Oral Contribution Award |
| 6/2020 | StorageX Tech Talk , Precourt Institute for Energy, Stanford, CA
<i>Correlative operando microscopy of the chemistry, nanostructure, and reactivity of oxygen evolving electrocatalysts</i> |

- 8/2019 **Stanford Energy Student Lectures**, Precourt Institute for Energy, Stanford, CA
Insights into Oxygen Evolution Electrocatalysts through Operando Spectromicroscopy
- 3/2019 **PittCon**, Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Philadelphia, PA
Operando Electrochemical Methods for Studying Energy Storage and Conversion Materials in Action
- 12/2017 **Stanford-Chalmers Workshop on Advancing Materials Innovatively**, Chalmers Institute, Gothenburg, Sweden
Operando Electrochemical Scanning Transmission X-ray Microscopy of Energy Conversion and Storage Electrode Materials
- 11/2017 **Materials Research Society Fall Meeting**, Materials Research Society, Boston, MA
Operando Electrochemical Scanning Transmission X-ray Microscopy of Energy Conversion and Storage Electrode Materials
- 4/2016 **Nano Portfolio Student Presentations**, The University of Texas at Austin, Austin, TX
Perovskite Oxides for Energy Conversion and Storage
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Contributed Research Presentations

- 1/2020 **Gordon Research Conference: Electrochemistry**, Ventura, CA
- 1/2020 **Gordon Research Seminar: Electrochemistry**, Ventura, CA
- 8/2018 **Stanford-Zhejiang University Symposium**, Stanford, CA
- 1/2018 **Gordon Research Conference: Electrochemistry**, Ventura, CA
- 1/2018 **Gordon Research Seminar: Electrochemistry**, Ventura, CA
- 1/2016 **Gordon Research Conference: Electrochemistry**, Ventura, CA
- 1/2016 **Gordon Research Seminar: Electrochemistry**, Ventura, CA
- 10/2015 **Analytical Student Seminar**, The University of Texas at Austin, Austin, TX
- 4/2015 **Nano Night**, Center for Nano and Molecular Science, The University of Texas at Austin, Austin, TX
- 2/2015 **UT Energy Week**, UT Energy Institute, The University of Texas at Austin, Austin, TX
- 2/2015 **CEC Annual Workshop on Electrochemistry**, Center for Electrochemistry, Austin, TX
- 11/2014 **IDN Research Symposium**, Industrie De Nora, Concord, OH
- 8/2014 **International Conference on the Physics of Semiconductors**, Austin, TX
- 4/2014 **Analytical Student Seminar**, The University of Texas at Austin, Austin, TX
- 3/2014 **Nano Night**, Center for Nano and Molecular Science, Austin, TX
- 2/2014 **CEC Annual Workshop on Electrochemistry**, Center for Electrochemistry, Austin, TX
- 11/2013 **IDN Research Symposium**, Industrie De Nora, Concord, OH
- 10/2013 **Electrochemical Society Fall Meeting**, The Electrochemical Society, San Francisco, CA
- 4/2013 **Nano Night**, Center for Nano and Molecular Science, The University of Texas at Austin, Austin, TX
- 2/2013 **CEC Annual Workshop on Electrochemistry**, Center for Electrochemistry, Austin, TX
- 10/2011 **Stanford Undergraduate Research and Policy Symposium**, Stanford University, Stanford, CA.
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Teaching/Mentorship

- 8/2016-3/2020 **Research Mentor**, Stanford University, Stanford, CA.

- 4 Ph.D. Students, 1 Masters Student, and 1 Undergraduate Student
- Projects include: Frequency modulated electrochemistry coupled to *operando* spectroscopic characterization techniques for enhancing surface signal localization of electrocatalysts; Synthesis of faceted $\text{LaNiO}_{3.6}$ perovskite single crystal nanoparticles and characterization of the effect of oxygen vacancy content on their OER/ORR activities; Synthesis and characterization of PLD epitaxial thin films of LaCoO_3 for the OER

8/2012-8/2016 **Research Mentor**, The University of Texas at Austin, Austin, TX.

- 2 Ph.D. Students, 2 Undergraduates, and 2 High School Students
- Projects included: Synthesis and characterization of Sr-substituted $\text{La}_{1-x}\text{Sr}_x\text{BO}_3$ (B = Cr, Mn, Fe, Co, Ni) for asymmetric oxygen intercalation pseudocapacitors, bifunctional oxygen electrocatalysis; Perovskite electrocatalysts for small alcohol oxidation. Synthesis and characterization of LaBO_3 (B = Mn, Co, Ni, $\text{Ni}_{0.75}\text{Fe}_{0.25}$) perovskites nanoparticles for oxygen electrocatalysis; Stability characterization of different carbon materials as supports for water electrolysis catalysts. Now an undergraduate student at the California Institute of Technology.

8/2012-8/2016 **Teaching Assistant**, The University of Texas at Austin, Austin, TX

- Oversaw the senior undergraduate Analytical Chemistry lab courses, CH456 and CH376K, and the graduate level Analytical Chemistry class, CH381M.

Outreach and Diversity, Equity, and Inclusion Efforts:

6/2020 – Present **Executive Leadership Team for EIC Committee, Chueh Group/Stanford University**

- Founded and served on the Executive Leadership team for the Chueh Group's internal Equity and Inclusion Committee (EIC).
- Developed new best practices for the recruitment and hiring of undergraduates through postdocs with a focus on equity for underrepresented minority groups. Our goal is to develop and strengthen access to higher education and STEM research for people who have either lacked the resources or pathways and improve representation in higher education.
- Developed an outreach and research experience opportunity for local high school students through a partnership with the Precourt Institute for Energy at Stanford. This work involved developing video lesson plans based around renewable energy research in academic labs, direct outreach through visiting and presenting at local high schools, and recruiting students for summer research opportunities in our lab.
- Developed recurring lesson plans and educational events for current members of the Chueh group and Materials Science department to discuss the issues of systemic racism and inequality in STEM and in the general framework of U.S. society.
- Developed a seminar series inviting rising talent (early career Professors and Industrial Researchers) working in renewable energy, materials, and electrochemistry to present on their work to the Chueh group and the Materials Science department at Stanford

1/2015-5/2016 **President of the Electrochemical Society Student Chapter, The University of Texas at Austin**

8/2013-12/2014 **Secretary of the Electrochemical Society Student Chapter, The University of Texas at Austin**

- Organized seminars and “chalk talks” for members to present and discuss their research, as well as invited distinguished speakers to give technical talks in their area of expertise. Developed electrochemical and solid state science demonstrations for K-12 events including Explore UT and science fairs at local schools to engage young minds to be interested in STEM fields.
- *Recipient of the 2014 ECS Outstanding Student Chapter Award*

8/2014-8/2016 **SciBridge, The University of Texas at Austin**

- Provided African students at the university level the equipment and access necessary to conduct research experiments. Created exciting experiment kits around the theme of "materials for energy" and ship them to universities in Africa. After students perform the experiment, we invite a U.S. researcher to give a live web seminar, which is followed by a Q&A and discussion session.
- *Recipient of the 2014 MRS Foundation Grassroots Grant Award*

Awards & Fellowships

- MRS Fall 2020 Best Oral Contribution Award for Symposium EN09: Developing In Situ and operando Methodology for Observation of Energy Conversion, Storage and Transport Processes in Materials and Devices
- Certificate in the Doctoral Portfolio Program in Nanoscience and Nanotechnology
- Best Spring 2016 Nano Portfolio Presentation Winner
- First Prize for Research Excellence in Renewable & Clean Energy at UT Energy Night
- Best Graduate Student Poster, Nano Night, Center for Nano and Molecular Science
- Office of Graduate Studies Professional Development Award, The University of Texas at Austin
- Graduate School Continuing Fellowship, The University of Texas at Austin
- National Science Foundation Graduate Research Fellowship Program Honorable Mention
- Graduate Recruitment Fellowship, The University of Texas at Austin
- First Year Graduate Student Fellowship, The University of Texas at Austin
- Bing Undergraduate Research Fellowship, Stanford University

Other Professional Activity

- Journal Reviewer for Science, Nature Chemistry, Nature Catalysis, Nature Communications, Angewandte Chemie International Edition, Advanced Materials, Advanced Energy Materials, Advanced Functional Materials, Journal of Power Sources, ChemSusChem, ChemElectroChem, MRS Communications, and Science and Technology of Advanced Materials
- External Evaluator for Skolkovo Institute of Technology Masters Student Theses
- Reviewer for Department of Energy Office of Basic Energy Sciences Grant Applications
- Evaluator for the Analytical Chemistry Ph.D. Qualifying Exams for the University of Texas at Austin, Chemistry Department

Professional References:

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