# Eli Fahrenkrug

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## Education

**University of Michigan** *Ann Arbor, MI* 2011 – Present
Ph.D. Candidate, Department of Chemistry
Advisor: Dr. Stephen Maldonado
Thesis: *Electrochemical Liquid Liquid Solid Growth of Crystalline Group IV and III-V Semiconductor Nanomaterials.*

**The Evergreen State College** *Olympia, WA* 2007 – 2011
B.S. Chemistry, Minor in Chemical Biology
Advisor(s): Dr. Clyde Barlow, Dr. Lydia McKinstry
Thesis: *Synthesis of metallocene-bridged diphosphines as Suzuki coupling catalysts.*

## Awards

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| Rackham Predoctoral Fellowship | 2015 |
| Sokol Graduate Summer Research Fellowship | 2013 |
| Rackham Centennial Fellowship | 2013 |
| NSF GRFP Honorable Mention | 2013 |
| Rackham Merit Fellowship | 2011 – 2013 |
| Dean's Scholar Award | 2008 – 2011 |
| NSF S-STEM Scholarship | 2007 – 2011 |

## Publications

**Fahrenkrug, E**., Gu, J. & Maldonado, S. Electrodeposition of Crystalline GaAs on Liquid Gallium Electrodes in Aqueous Electrolytes. *J. Am. Chem. Soc.* 135, 330-339 (2012).

Gu J, **Fahrenkrug E**, Maldonado S. Direct Electrodeposition of Crystalline Silicon at Low Temperatures. *J. Am. Chem. Soc.* 135, 1684-1687 (2013).

**Fahrenkrug E,** Gu J, Jeon S, Veneman PA, Goldman RS, Maldonado S. Room-Temperature Epitaxial Electrodeposition of Single-Crystalline Germanium Nanowires at the Wafer Scale from an Aqueous Solution. *Nano Lett.* 14, 847-852 (2014).

Ma, L.; Gu, J.; **Fahrenkrug, E.**; Maldonado, S., Electrochemical Liquid-Liquid-Solid Deposition of Crystalline Ge Nanowires as a Function of Ga Nanodroplet Size. *J. Electrochem. Soc.* 161, D3044-D3050 (2014).

**Fahrenkrug, E**., Gu, J. & Maldonado, S. Electrochemically-Gated Alloy Formation of Crystalline InAs Thin Films at Room Temperature in Aqueous Electrolytes. *Chem. Mat*. 2014, 26, 4535.

Gu J, **Fahrenkrug E**, Maldonado S. Analysis of the Electrodeposition and Surface Chemistry of CdTe, CdSe, and CdS Thin Films through Substrate-Overlayer Surface-Enhanced Raman Spectroscopy. *Langmuir* 30, 10344-10353 (2014).

Lee S, **Fahrenkrug E**, Maldonado S. Synthesis of photoactive ZnSnP2 semiconductor nanowires. *J. Mater. Res*. 30, 2170-2178 (2015).

**Fahrenkrug E.**, Biehl J, Maldonado S. Electrochemical Liquid–Liquid–Solid Crystal Growth of Germanium Microwires on Hard and Soft Conductive Substrates at Low Temperature in Aqueous Solution. *Chem. Mater.* 27, 3389-3396 (2015).

**Fahrenkrug E,** Maldonado S. Electrochemical Liquid–Liquid–Solid (ec-LLS) Crystal Growth: A Low-Temperature Strategy for Covalent Semiconductor Crystal Growth. *Acc. Chem. Res*. 48, 1881-1890 (2015).

DeMuth, J.; Ma, L.; **Fahrenkrug E**, Maldonado S. Electrochemical Liquid-Liquid-Solid Deposition of Crystalline Gallium Antimonide. *Electrochim. Acta*, Under Review.

**Fahrenkrug, E.**, Rafson, J., Gu, J. & Maldonado, S. Direct Aqueous Electrodeposition of Crystalline InSb Films on Reactive Indium Electrodes. *In Preparation.*

**Fahrenkrug, E.**, Yang, M., Kavenagh, K., & Maldonado, S. Influence of Liquid Metal Electrode Composition on Ge Crystal Structure and Electrical Properties. *In Preparation.*

## Research & Experience

**Graduate Research** *Dept. of Chemistry, U. of Michigan* 2011 – present
Advisor: Prof. Stephen Maldonado
*Development and Characterization of an Electrochemical-Liquid-Liquid-Solid Growth Platform for the Facile Preparation of Crystalline Group IV and III-V Semiconductor Nanomaterials.*

- Pioneered novel metallic solution-based electrochemical crystal growth strategy for synthesizing crystalline semiconductor nanomaterials and thin films including Ge, Si, GaAs, InAs and InSb and heterostructures thereof.
- Designed and fabricated numerous pressurized, compression-type, and high temperature electrochemical reaction vessels to facilitate semiconductor synthesis over wide temperature and pressure ranges.
- *Skills*: Powder and Grazing Incidence X-ray diffraction, S/TEM, SEM, FIB Lift-out & Nanomanipulation, Scanning Auger Nanoprobe Spectroscopy, Conductive Atomic Force Microscopy, Raman micro-spectroscopy, Microfabrication, Photolithography, Electrochemical & Photoelectrochemical Methods, 3D CAD Modelling and Design.

**Engineer** *Hummingbird Scientific, Olympia, WA* 2010 – 2011
Supervisor: Dr. Daan Hein Alsem

- Developed and conducted thermal and flow characterization of integrated MEMS heater/fluid cells for *in-situ* transmission electron microscopy (TEM) experiments.
- Designed and constructed ultra-low volume, high precision, gas mixing system for *in-situ* TEM experiments.
- Created and operated precision metrology lab. Assisted and educated users with metrological equipment.
- Developed and implemented non-aqueous titanium electropolishing strategy.
- *Techniques*: SEM, S/TEM, 3D-CAD (Solidworks, AutoCAD), interfacing (LabVIEW), PCB assembly & soldering, UHV, He leak test, mass flow control,

optical metrology, laser metrology, surface profilometry, project management (MyWorkPLAN), electropolishing.

**Undergraduate Research** *The Evergreen State College* 2008 – 2010
Advisor: Dr. Clyde Barlow, Dr. Lydia McKinstry
*Synthesis of metallocene-bridged diphosphines as Suzuki reaction catalysts.*

- Used Schlenk line chemistry to prepare metallocene-bridged diphosphine compounds with various coordinated transition metals.
- Quantified catalytic behavior in Suzuki reaction as function of metal 'bite size' and identity.
- Constructed and interfaced a home-built potentiostat using LabVIEW software for electrochemical characterization of prepared compounds.

Advisor: Dr. Clyde Barlow 2008 – 2009
*Chemical depth profilometry of two E. Washington meromictic lakes*

- Conducted complete chemical, temperature, and density depth profiles of two previously undocumented meromictic lakes in E. Washington.
- Proposed and confirmed mechanism of formation for meromictic state.
- Calculated probability and implications of future lake turnover
- *Techniques*: dynamic reaction cell inductively coupled plasma mass spectrometry, ion & gas chromatography, PHREEQC modeling, alkalinity titrations, pXRD.

Invited Talks

PittCon, First Annual Student Symposium in Electroanalysis 2014
*In-situ Spectroelectrochemical Investigation of the Reactive Aqueous Electrodeposition of Crystalline III-V Semiconductor Thin Films*
Evergreen State College, Hummingbird Scientific 2011
*Correlating Properties and Microstructure of Materials Using in-situ TEM*

Oral Presentations

ECS Spring National Meeting, Chicago 2015
*Direct Electrochemical Synthesis of Epitaxial Nano- and Micro-wire Arrays at Room Temperature in Water*
Ohio Inorganic Weekend 2014
*Room Temperature Aqueous Electrochemical Synthesis of Epitaxial Germanium Nano- and Micro-wire Arrays*
ACS, Central Regional Meeting Fall 2014
*Epitaxial Electrodeposition of Single Crystal Germanium Nanowire Arrays at Room Temperature in Water*
PittCon Conference* 2014
*In-situ Spectroelectrochemical Investigation of the Reactive Aqueous Electrodeposition of Crystalline III-V Semiconductors*
**Invited, First Annual Society of Electroanalytical Chemists*
Materials Research Society Spring Meeting, San Francisco 2014
*Aqueous Electrochemical Synthesis of Crystalline III-V Thin Films and Group IV Nanowires at or Near Room Temperature*
ACS, Central Regional Meeting Spring 2013
*Non-innocent Group III Metal Electrodes for Aqueous Electrodeposition of Crystalline III-V Semiconductors*

Poster Presentations

Gordon Research Symposium & Conference, Electrodeposition 2014
*Liquid Metal Electrodes for Direct Electrodeposition of Crystalline Ge Nano- and Microwires*

Gordon Research Symposium & Conference, Electrochemistry 2014
*Epitaxial Electrodeposition of Single Crystal Germanium Nanowire Arrays at Room Temperature in Water*

Michigan Green Chemistry and Engineering Conference 2013
*Bench-top Electrochemical Growth of Nanostructured Crystalline Inorganic Semiconductors*

Vaughan Research Symposium, U. of Michigan 2013
*Bench-top Electrochemical Growth of Nanostructured Crystalline Inorganic Semiconductors*

Gordon Research Symposium & Conference, Electrodeposition 2012
*Electrodeposition of c-GaAs on Sacrificial Ga(l) Cathodes: Insight into the Electrochemical-Liquid-Liquid-Solid Growth Model*

ECS Regional Conference, Detroit 2012
*Electrodeposition of Crystalline GaAs on Liquid Gallium Electrodes*

ACS Regional Conference, Puget Sound Spring 2010
*Synthesis of Metallocene-Bridged Diphosphines as Suzuki Reaction Catalysts*

U. Washington, Undergraduate Research Symposium Spring 2010
*Ferrocenyl Phosphine Derivatives as Suzuki Reaction Catalysts*

The Evergreen State College, Research Symposium 2009
*Correlating Chemical Composition and Physical Morphometry Depth Profiles with Meromictic Lake Stability in Two Eastern Washington Lakes*

Other Attended Meetings

Microscopy & Microanalysis Spring 2011
*Exhibitor, Hummingbird Scientific*

PittCon Conference and Exposition 2010

ACS, National Meeting Spring 2010

ACS, National Meeting Spring 2009

Teaching

**Guest Lecturer** *University of Michigan* 2013 – Current

- Conducted 50 min lectures in undergraduate analytical chemistry course on topics including propagation of error, systematic treatment of equilibria, and electrochemistry.

**Graduate Student Mentor** *University of Michigan* 2012 – Current

- Provided technical leadership to (1) high school, (5) undergraduate and (2) NSF REU students in projects related to advanced semiconductor electrodeposition. Constructed scientific framework for projects and guided students in proper modes of scientific inquiry and lab techniques.

**Graduate Student Instructor** *University of Michigan* 2011 – 2012

- Supervised and instructed students in general chemistry techniques. Emphasized keeping complete and accurate scientific notes.

**Instrumentation Instructor** *The Evergreen State College* 2008 – 2010

- Taught theory, sample preparation, operation, method development and data analysis for a variety of chemical instrumentation including: GC-MS, FT-NMR, FT-IR, DRC-ICP-MS, Ion Chromatograph, pXRD, E-SEM, UV-VIS
- Responsible for installation, maintenance, tuning and optimization

**Teaching/Lab Assistant** *The Evergreen State College* 2009 – 2010

- Assisted with grading, tutoring, and review sessions for quantum chemistry and inorganic chemistry.
- Prepared and purified reagents, assembled flash columns and assisted with general lab preparation for a course in advanced organic synthesis.

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| Service | Elected Chair, GRS Electrodep. | *Gordon Research Conferences* | 2014 |
| | Faculty Hire Committee | *The Evergreen State College* | 2008, 2009 |
| | Institutional Research Panel | *The Evergreen State* | |
| *College* | 2008 | | |
| Outreach | Energy Transfer Demos | *Greenhills School* | 2014-2015 |
| | Chemistry Demo Day | *Huron Valley ACS Chapter* | 2012 |
| | Electron Microscopy Demos | *The Evergreen State College* | 2007 – 2010 |
| | Kids & Chemistry | *Puget Sound ACS Chapter* | 2008 – 2009 |