

Dr. Jacob T. Held

Research interests

- Understanding electronic and photonic materials using analytical electron microscopy
- Nanocrystal synthesis and thin film deposition

Education

- 2013 – 2020 **Ph.D. – Chemical Engineering, University of Minnesota**
Thesis: *Atomic-scale analysis of nanocrystals*
Advisor: Dr. K. Andre Mkhoyan
- 2009 – 2013 **B.S. – Chemical Engineering, The Pennsylvania State University**
Schreyer Honors College
Thesis: *Analysis of intermetallic catalysts for selective hydrogenation*
Advisors: Dr. Michael Janik and Dr. Robert Rioux

Research and Professional Appointments

- 2020 – Present **Postdoctoral Researcher, ETH Zürich**
Optical Materials Engineering Laboratory, Dr. David Norris
Synthesis and atomic-scale characterization of magic-sized nanocrystals
- 2013 – 2020 **Graduate Research Assistant, University of Minnesota**
Advisor: Dr. K. Andre Mkhoyan
Thesis: *Pushing the limits of STEM analysis and its application toward the characterization of nanocrystals and nanomaterials*
- Developed a method to establish standard core-loss EELS spectra and to decompose overlapping signals in STEM-EELS spectrum images, enabling the detection and spectral analysis of dopant atoms in nanocrystals at an atomic scale.
 - Developed a model-based approach to determine the radial distribution of elements in core/shell and core/double-shell nanocrystals from STEM-EDX spectrum images.
 - Simulated STEM images and electron beam propagation in nanocrystals and bulk specimens.
 - Characterized the structural properties and atomic-scale elemental distributions in nanocrystal and thin-film device systems.
- 2012 **Technical Intern, 3M Corporate Research Process Laboratory, Woodbury, MN**
Supervisor: Mark Strobel
- Evaluated atmospheric pressure plasma systems for 3D surface treatment.
 - Optimized plasma systems for 3D surface treatment in two 3M product applications.
- 2011 – 2013 **Undergraduate Research Assistant, Penn State University**
Advisors: Dr. Michael Janik and Dr. Robert Rioux
Analysis of intermetallic catalysts for selective hydrogenation
- Modeled the catalytic hydrogenation of acetylene and crotonaldehyde over Ni and NiZn surfaces using DFT calculations in VASP 5.2.
 - Performed calculations of reaction kinetics based on DFT simulations of transition states.
 - Designed and built reactor control hardware to integrate condition monitoring and control with a PC.

2010 **Undergraduate Research Assistant, Penn State University**

Advisor: Dr. Jay Amicangelo

Characterization of silicon nitride intermediates using matrix isolation spectroscopy

- Used pyrolysis and microwave discharge to generate and trap reactive species in solid N₂ matrices.
- Built a pyrolysis source for the lab's matrix isolation equipment.

2003 – 2013 **Self-Employed Craftsman, Jake's Woodens, Cambridge Springs, PA**

- Designed and crafted high-quality wooden kitchen utensils, decorations, and furniture.

Teaching

ETH Zürich

Fall 2022 Lab instructor; Practica in Process Engineering I.

University of Minnesota

Spring 2019 Instructional Video Developer; MATS 3141: Numerical Methods
Fall 2018 Substitute Lecturer; MATS 3012: Metals and Alloys
Spring 2018 Recitation Instructor; MATS 3141: Numerical Methods
Spring 2017 Lab Instructor; MATS 3851W: Materials Properties Lab
Fall 2016 Substitute Lecturer; MATS 3012: Metals and Alloys
Spring 2014 Teaching Assistant; MATS 3011: Introduction to Materials Science and Engineering

The Pennsylvania State University

Spring 2013 Undergraduate Grader; CHEM 466 Molecular Thermodynamics
Fall 2010 Undergraduate Grader; CHEM 110 General Principles I
2009 – 2010 Learning Resource Center Tutor

Advising and mentoring

Summer 2018 **Jennifer Conner** Summer REU – Arizona State University
Summer 2017 **Phong Nguyen** Summer REU – University of Missouri – 1 Publication
Summer 2016 **Kevin Sanchez** Summer REU – University of Puerto Rico
2015 **Samuel Duncan** University of Minnesota – 1 Publication

Awards and recognition

University of Minnesota

- Doctoral Dissertation Fellowship, 2018-2019
- College of Science and Engineering Fellowship, 2013-2015

External Sources

- 1st place poster presentation – Microscopy and Microanalysis, Aug. 2017
"Elemental distribution analysis of core/shell nanocrystals with STEM/EDX."
- 1st place poster presentation – Microscopy and Microanalysis, Aug. 2016
"Quantification of the effects of small mistilts on dopant visibility in nanocrystals"
- Editor's Pick in the Journal of Vacuum Science & Technology A
M. L. Odlyzko, **J. T. Held**, K. A. Mkhoyan "Atomic bonding effects in annular dark field scanning transmission electron microscopy. II. Experiments" J. Vac. Sci. Technol. A 34, 041603 (2016).

The Pennsylvania State University

- Larry Duda Undergraduate Student Research Award, 2012
- Penn State REU in Chemical Engineering, 2011
- Award for Scholastic Achievement in Chemistry, 2010
- Penn State Behrend Summer Research Fellowship, 2010
- Schreyer Honors College Academic Excellence Scholarship, 2009-2013
- McMannis Educational Trust Fund Scholarship, 2009-2012
- Behrend Chancellor's Scholarship, 2009-2010

Outreach and service

- 2015 – 2020 **Outreach Volunteer**, Minnesota Microscopy Society
- Managed a table exploring "Everyday Cool Stuff" at the annual Microscope Day at the Science Museum of Minnesota.
 - Presented hands-on microscope demonstrations at the annual Math and Science Family Fun Fair at the University of Minnesota.
- 2016 – 2019 **Student Representative**, Minnesota Microscopy Society
- Helped organize volunteers for annual outreach events.
 - Served as a contact for new student members of the society.
- 2015 – 2018 **Characterization Facility Tour Guide**, Discover STEM
- Guided lab tours for groups of 11th and 12th grade students attending the University of Minnesota STEM summer day camps.
- 2016 **Science Fair Judge**, Sun Path Elementary School Science Fair
- Discussed science projects with students and judged their work.
- 2016 **Outreach Volunteer**, MRSEC IRG-2
- Designed and led experiments for local middle school girls interested in STEM attending a day-long visit to the University of Minnesota.

Professional organizations

American Association for the Advancement of Science
American Institute of Chemical Engineers
Microscopy Society of America
Minnesota Microscopy Society
Tau Beta Pi, The Engineering Honor Society

Publications

26. Z. Xiong, H. P. Andaraarachchi, **J. T. Held**, R. W. Dorn, Y. J. Jeong, A. Rossini, U. R. Kortshagen. "Inductively coupled nonthermal plasma synthesis of size-controlled gamma-Al₂O₃ nanocrystals" *Nanomaterials* (2023) [Under Review]
25. S. Mazzotti, A. S. Mule, A. B. Pun, **J. T. Held**, D. J. Norris. "Growth Synchronization and Size Control in Magic-Sized Semiconductor Nanocrystals" *ChemRxiv* (2022)
24. R. Xiao, **J. T. Held**, J. Rable, S. Ghosh, K. Wang, K. A. Mkhoyan, N. Samarth. "Challenges to magnetic doping of thin films of the Dirac semimetal Cd₃As₂" *Phys. Rev. Mater.* (2022)
23. W. Yanez, Y. Ou, R. Xiao, J. Koo, **J. T. Held**, S. Ghosh, J. Rable, T. Pillsbury, E. González Delgado, K. Yang, J. Chamorro, A. J. Grutter, P. Quarterman, A. Richardella, A. Sengupta, T. McQueen, J. A. Borchers, K. A. Mkhoyan, B. Yan, N. Samarth. "Spin and Charge Interconversion in Dirac-Semimetal Thin Films" *Phys. Rev. Appl.* (2021)
22. A. B. Pun, A. S. Mule, **J. T. Held**, D. J. Norris. "Core/shell magic-sized CdSe nanocrystals" *Nano Lett.* (2021)
21. C. Trevino De Leo, G. C. Dannangoda, M. A. Hobosyan, **J. T. Held**, F. Safi Samghabadi, M. Khodadadi, D. Litvinov, K. A. Mkhoyan, K. S. Martirosyan. "Carbon combustion synthesis of Janus-like particles of magnetoelectric cobalt ferrite and barium titanate" *Ceram. Int.* (2021)
20. X. Hang, M. Matsuda, **J. T. Held**, K. A. Mkhoyan, J. P. Wang. "Magnetic structure of Fe₁₆N₂ determined by polarized neutron diffraction on thin film samples" *Phys. Rev. B* (2020)
19. C. A. Beaudette, J. T. Held, K. A. Mkhoyan, U. R. Kortshagen. "Nonthermal plasma enhanced chemical vapor deposition of two-dimensional molybdenum disulfide" *ACS Omega* (2020)
18. X. Wu, B. L. Greenberg, Y. Zhang, **J. T. Held**, D. Huang, J. G. Barriocanal, K. A. Mkhoyan, E. S. Aydil, U. Kortshagen, X. Wang. "Thermal Transport in ZnO Nanocrystal Networks Synthesized by Nonthermal Plasma" *Phys. Rev. Mater.* (2020)
17. C. A. Beaudette, **J. T. Held**, B. L. Greenberg, P. H. Nguyen, K. A. Mkhoyan, E. S. Aydil, U. R. Kortshagen. "Plasmonic nanocomposites of zinc oxide and titanium nitride" *J. Vac. Sci. Technol. A* 38, 042404 (2020) [Highlighted on JVST-A Cover]

16. Y. Fan, H. Li, M. DC, **J. T. Held**, P. Sahu, J. Chen, T. Peterson, D. Zhang, K. A. Mkhoyan, and J. P. Wang "Spin pumping and large field-like torque at room temperature in sputtered amorphous W_xTe_{2-x} film" *APL Mater.* 8, 041102 (2020)
15. **J. T. Held**, H. Yun, K. A. Mkhoyan. "Simultaneous multi-region background subtraction for core-level EEL spectra". *Ultramicroscopy* 210, 112919 (2020)
14. S. Hill, R. Connell, **J. T. Held**, C. Peterson, M. Hillmyer, L. Francis, V. Ferry, U. Kortshagen. "Poly(methyl methacrylate) Films with High Concentrations of Silicon Quantum Dots for Visibly Transparent Luminescent Solar Concentrators" *ACS Appl. Mater. Interfaces* (2020)
13. B. L. Greenberg, Z. L. Robinson, Y. Ayino, **J. T. Held**, T. A. Peterson, K. A. Mkhoyan, V. S. Pribiag, E. S. Aydil, U. R. Kortshagen. "Metal-insulator transition in a semiconductor nanocrystal network". *Sci. Adv.* 5, eaaw1462 (2019)
12. A. Prakash, N. F. Quackenbush, H. Yun, **J. T. Held**, T. Wang, T. Truttmann, J. M. Ablett, C. Weiland, T. Lee, J. C. Woicik, K. A. Mkhoyan, B. Jalan. "Separating Electrons and Donors in $BaSnO_3$ via Band Engineering". *Nano Lett.* 19, 8920 (2019)
11. J. S. Jeong, H. Song, **J. T. Held**, K. A. Mkhoyan. "Sub-Atomic Channeling and Helicon-Type Beams in $SrTiO_3$ ". *Phys. Rev. Lett.* 122, 075501 (2019)
10. K. S. Schramke, Y. Qin, **J. T. Held**, K. A. Mkhoyan, U. R. Kortshagen. "Nonthermal Plasma Synthesis of Titanium Nitride Nanocrystals with Plasmon Resonances at Near-Infrared Wavelengths Relevant to Photothermal Therapy". *ACS Appl. Nano Mater.* 1, 2869 (2018)
9. K. Xie, K. Mork, **J. T. Held**, K. A. Mkhoyan, U. Kortshagen, M. C. Gupta. "Quasi continuous wave laser sintering of Si-Ge nanoparticles for thermoelectrics". *J. Appl. Phys.* 123, 094301 (2018)
8. **J. T. Held**, K. I. Hunter, N. S. Dahod, B. L. Greenberg, D. Reifsnyder Hickey, W. A. Tisdale, U. R. Kortshagen, K. A. Mkhoyan. "Obtaining Structural Parameters from STEM-EDX Maps of Core/Shell Nanocrystals for Optoelectronics". *ACS Appl. Nano Mater.* 1, 989 (2018)
7. **J. T. Held**, S. Duncan, K. A. Mkhoyan. "Effects of Small-Angle Mistilts on Dopant Visibility in ADF-STEM Imaging of Nanocrystals". *Ultramicroscopy* 177, 53 (2017)
6. K. Hunter, **J. T. Held**, K. A. Mkhoyan, U. Kortshagen. "Nonthermal Plasma Synthesis of Core/Shell Quantum Dots: Strained Ge/Si Nanocrystals". *ACS Appl. Mater. Interfaces* 9, 8263 (2017)
5. M. L. Odlyzko, **J. T. Held**, K. A. Mkhoyan "Atomic bonding effects in annular dark field scanning transmission electron microscopy. II. Experiments" *J. Vac. Sci. Technol. A* 34, 041603 (2016).
4. B. L. Greenberg, S. Ganguly, **J. T. Held**, N. J. Kramer, K. A. Mkhoyan, E. S. Aydil, U. R. Kortshagen. "Nonequilibrium-Plasma-Synthesized ZnO Nanocrystals with Plasmon Resonance Tunable via Al Doping and Quantum Confinement". *Nano Lett.* 15, 8162 (2015)
3. H. Almasi, D. Reifsnyder Hickey, T. Newhouse-Illige, M. Xu, M. R. Rosales, S. Nahar, **J. T. Held**, K. A. Mkhoyan, W. G. Wang. "Enhanced tunneling magnetoresistance and perpendicular magnetic anisotropy in Mo/CoFeB/MgO magnetic tunnel junctions" *Appl. Phys. Lett.* 106, 182406 (2015).
2. M. M. Sullivan, **J. T. Held**, A. Bhan "Structure and site evolution of molybdenum carbide catalysts upon exposure to oxygen". *Journal of Catalysis* 326, 82-91 (2015).
1. C. S. Spanjers, **J. T. Held**, M. J. Jones, D. D. Stanley, R. S. Sim, M. J. Janik, R. M. Rioux. "Zinc inclusion to heterogeneous nickel catalysts reduces oligomerization during the semi-hydrogenation of acetylene." *Journal of Catalysis.* 316, 164 (2014)

Presentations

8. **J. T. Held**, H. Yun, K. A. Mkhoyan. "Simultaneous Multi-Region Background Subtraction for EELS Spectra" *Microscopy and Microanalysis*, Portland, OR, Aug. 4-8 (2019). Poster Presentation.
7. **J. T. Held**, K. Hunter, U. R. Kortshagen, K. A. Mkhoyan. "Decomposition of Core-Loss EEL Edges into a Linear Combination of Refined 'Pure' Spectra" *Microscopy and Microanalysis*, Portland, OR, Aug. 4-8 (2019). Poster Presentation.
6. **J. T. Held**, K. I. Hunter, N. Dahod, B. Greenberg, D. Reifsnyder Hickey, W. A. Tisdale, U. Kortshagen, K. A. Mkhoyan. "Radial Elemental Distribution Analysis of Spherical Core/Shell Nanocrystals with STEM/EDX" *AiChE Annual Meeting*, Minneapolis, MN, Oct. 29 – Nov. 3, (2017). Oral Presentation.
5. **J. T. Held**, K. I. Hunter, N. Dahod, B. Greenberg, D. Reifsnyder Hickey, W. A. Tisdale, U. Kortshagen, K. A. Mkhoyan. "Elemental Distribution Analysis of Core/Shell Nanocrystals with STEM/EDX." *Microscopy and Microanalysis*, St. Louis, MO, Aug. 6 – 10 (2017). Poster Presentation.

4. **J. T. Held**, S. Duncan, K. A. Mkhoyan "Quantification of the Effects of Small Mistilts on Dopant Visibility in Nanocrystals". Microscopy and Microanalysis, Columbus, OH, July 25 – 28 (2016). Poster Presentation.
3. **J. T. Held**, K. Hunter, U. R. Kortshagen, K. A. Mkhoyan. "STEM-EDX Analysis of Elemental Distribution in Spherical Core-Shell Nanocrystals" Microscopy and Microanalysis, Columbus, OH, July 25 – 28 (2016). Poster Presentation.
2. **J. T. Held**, M. M. Sullivan, A. Bhan, K. A. Mkhoyan. "Structure evolution of M02C catalysts upon exposure to oxygen". Microscopy and Microanalysis, Hartford, CT, Aug. 4 – 8 (2015). Poster Presentation.
1. **J. T. Held**, C. Spanjers, S. Jana, M. Janik, R. Rioux. "Mechanistic Analysis of the Selective Hydrogenation of Acetylene Over NiZn" AiChE Annual Meeting, Pittsburgh, PA, Oct. 28 – Nov. 2, (2012). Oral Presentation.

References

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