

BETHANY M. HUDAK

Naval Research Laboratory
Materials Science and
Technology Division
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EDUCATION

- July 2016 | **Doctor of Philosophy, University of Kentucky, Lexington, KY**
Dissertation title: “**Applying Conventional and *In Situ* Transmission Electron Microscopy Techniques to Understand Nanoscale Crystallography**”
Major: **Chemistry**
- May 2010 | **Bachelor of Science, Emory & Henry College, Emory, VA**
Major: **Chemistry**
Minor: **Business Management**
Honors: **Cum Laude**

RESEARCH EXPERIENCE

- May 2019-present | **Research chemist, Naval Research Laboratory, Washington, DC**
- Operating and maintaining Nion UltraSTEM 200X microscope
 - Advancing microscope capabilities toward single-atom energy dispersive X-ray spectroscopy (EDS)
 - Determining parameters for controlled modification of 2D and 3D materials using a focused electron probe
- July 2016-May 2019 | **Post-Doctoral Researcher, Oak Ridge National Laboratory, Oak Ridge, TN**
Mentor: **Dr. Andrew R. Lupini**
Supervisors: **Dr. Matthew Chisholm** and **Dr. Karren More**
- Using aberration-corrected scanning transmission electron microscope (STEM) to study single-atom dopants in silicon
 - Operating Nion UltraSTEM 200 and Nion UltraSTEM 100 microscopes

RESEARCH EXPERIENCE – CONTINUED

July 2016-
May 2019

- Acquiring and analyzing various signals, including high-angle annular dark field (HAADF), annular bright field (ABF), electron energy loss spectroscopy (EELS), and convergence beam electron diffraction (CBED) patterns
- Independently reconfiguring microscope operating conditions to meet experimental needs
- Training new users on Nion UltraSTEM instruments
- Manipulating and positioning single atoms in a 3D structure using STEM
- Controlling atomic-scale crystallization of silicon using STEM
- Preparing plan-view and cross-section parallel polished samples for STEM analysis

Jan 2016-
May 2016

Advanced Short Term Research Opportunity, Oak Ridge National Laboratory

Oak Ridge, TN

Mentor: **Dr. Karren L. More**

- Investigating phase transformation of HfO₂ nanorods using *in situ* heating in a transmission electron microscope

Jan 2011-
July 2016

Doctoral Research, University of Kentucky, Lexington, KY

Mentor: **Dr. Beth S. Gupton**

- Studying crystallographic effects of heating on multiple unique nanoscale systems using conventional and *in situ* S/TEM

2008-2009

Undergraduate Senior Research Project, Emory & Henry College, Emory, VA

Mentor: **Dr. Laura Hainsworth**

- Conducting research on ethylene production in American Chestnut bark and twig samples using gas chromatography to capture wound-response ethylene readings

TEACHING EXPERIENCE

Spring 2011
& 2012

Physical Chemistry Teaching Assistant, University of Kentucky, Lexington, KY

Supervisor: **Dr. Yuguang Cai**

Fall 2011

Analytical Chemistry Teaching Assistant, University of Kentucky, Lexington, KY

Supervisor: **Dr. Jason DeRouchey**

Fall 2010

General Chemistry Teaching Assistant, University of Kentucky, Lexington, KY

Supervisor: **Dr. Allison Sault**

PUBLICATIONS

- [21] R. Dziobek-Garrett, S. Hilliard, S. Sriramini, O. Ambrozaite, Y. Zhu, **B. M. Hudak**, T. H. Brintlinger, T. Chowdhury, and T. J. Kempa; Controlling Morphology and Excitonic Disorder in Monolayer WSe₂ Grown by Salt-Assisted CVD Methods. *ACS Nanoscience Au* (2023).
- [20] **B. M. Hudak** and R. M. Stroud; Atomically Precise Detection and Manipulation of Nitrogen-Vacancy Centers in Nanodiamonds. *ACS Nano*, **17**, 7241-7249 (2023).
- [19] Z. Hennighausen, **B. M. Hudak**, M. Phillips, J. Moon, K. M. McCreary, H.-J. Chuang, M. R. Rosenberger, B. T. Jonker, C. H. Li, R. M. Stroud, and O. M. J. van't Erve; Room-Temperature Oxygen Transport in Nanothin Bi₂O₃Se₃ Enables Precision Modulation of 2D Materials. *ACS Nano*, **16**, 13969–13981 (2022).
- [18] Z. Hennighausen, D. Wickramaratne, K. M. McCreary, **B. M. Hudak**, T. Brintlinger, H.-J. Chuang, M. A. Noyan, B. T. Jonker, R. M. Stroud, and O. M. van 't Erve; Laser-Patterned Submicrometer Bi₂Se₃–WS₂ Pixels with Tunable Circular Polarization at Room Temperature. *ACS Applied Materials and Interfaces*, **14**, 9504–9514 (2022).
- [17] B. Jugdersuren, X. Liu, J. C. Culbertson, C. N. Chervin, **B. M. Hudak**, and R. M. Stroud; Thermoelectric properties of nanocrystalline silicon film grown by PECVD. *MRS Advances* (2022).
- [16] S. W. Kimmel, B. J. Hopkins, C. N. Chervin, N. L. Skeelee, J. S. Ko, R. H. DeBlock, J. W. Long, J. F. Parker, **B. M. Hudak**, R. M. Stroud, D. R. Rolison and C.P. Rhodes; Capacity and Phase Stability of Metal-substituted α -Ni(OH)₂ Nanosheets in Aqueous Ni–Zn Batteries. *Materials Advances*. **2**, 3060 (2021).
- [15] C. N. Chervin, B. J. Hopkins, A. N. Hoffmaster, N. L. Skeelee, J. S. Ko, J. F. Parker, **B. M. Hudak**, J.W. Long, and D. R. Rolison; Sustainable Electrocatalytic Architectures Enable Rechargeable Zinc–Air Batteries with Low Voltage Hysteresis. *ACS Applied Energy Materials*. **3**, 10485-10494 (2020).
- [14] O. S. Ovchinnikov, A. O'Hara, S. Jesse, **B. M. Hudak**, S. Yang, A. R. Lupini, M. F. Chisholm, W. Zhou, S. V. Kalinin, A. Y. Borisevich, S. T. Pantelides; Detection of defects in atomic-resolution images of materials using cycle analysis. *Advanced Structural and Chemical Imaging*. **6**, 1-9 (2020).
- [13] J. Song, **B. M. Hudak**, A. R. Lupini; Evolution of lattice defects upon Bi-doping of epitaxial Si overlayers on Si (100); *Applied Surface Science*. **502**, 144284 (2020).
- [12] L. Yu, **B. M. Hudak**, A. Ullah, M. P. Thomas, C. C. Porter, A. Thisera, R. H. Pham, M. D. Goonatileke, B. S. Guiton; Unveiling the Microscopic Origins of Phase Transformations: An in Situ TEM Perspective. *Chemistry of Materials*. **32**, 639-650 (2020).
- [11] O. Dyck, M. Ziatdinov, D. B. Lingerfelt, R. R. Unocic, **B. M. Hudak**, A. R. Lupini, S. Jesse, S. V. Kalinin; Atom-by-atom fabrication with electron beams. *Nature Review Materials*. **7**, 497-507 (2019).

- [10] **B. M. Hudak**, W. Sun, J. Mackey, A. Ullah, A. Sehirlioglu, F. Dynys, S. T. Pantelides, B. S. Guiton; Observation of square-planar distortion in lanthanide-doped skutterudite crystals. *The Journal of Physical Chemistry C*. **23**, 14632-14638, (2019).
- [9] L. Yu, R. Han, X. Sang, J. Liu, M. P. Thomas, **B. M. Hudak**, A. Patel, K. Page, and B. S. Guiton; Shell-induced Ostwald ripening: Simultaneous structure, composition, and morphology transformations during the creation of hollow iron oxide nanocapsules. *ACS Nano*. **12**, 9051-9059, (2018).
- [8] **B. M. Hudak**, J. Song, H. Sims, M. C. Tropicovsky, S. T. Pantelides, P. C. Snijders, and A. R. Lupini; Directed atom-by-atom assembly of dopants in silicon. *ACS Nano*. **12**, 5873-5879, (2018).
- [7] S. Jesse, **B. M. Hudak***, E. Zarkadoula, J. Song, A. Maksov, M. Fuentes-Cabrera, P. Ganesh, I. Kravchenko, P. C. Snijders, A. R. Lupini, A. Borisevich, and S. V. Kalinin; Direct atomic fabrication and dopant positioning in Si using electron beams with active real time image-based feedback. *Nanotechnology*. **29**, 255303, (2018). *equal contribution
- [6] J. Song, **B. M. Hudak**, H. Sims, Y. Sharma, T. Z. Ward, S. T. Pantelides, A. R. Lupini, and P. C. Snijders; Homo-endotaxial one-dimensional Si nanostructures. *Nanoscale*. **10**, 260-267, (2017).
- [5] **B. M. Hudak**, S. W. Depner, G. R. Waetzig, A. Talapatra, R. Arroyave, S. Banerjee, and B. S. Guiton; Real-time atomistic observation of structural phase transformations in individual hafnia nanorods. *Nature Communications*. **8**, 15316, (2017).
- [4] L. Yu, Y. Zhang, **B. M. Hudak**, D. K. Wallace, D. Y. Kim, and B. S. Guiton; Simple synthetic route to manganese-containing nanowires with the spinel crystal structure. *Journal of Solid State Chemistry*. **240**, 23-29, (2016).
- [3] J. Mackey, F. Dynys, **B. M. Hudak**, B. S. Guiton, and A. Sehirlioglu; $\text{Co}_x\text{Ni}_{4-x}\text{Sb}_{12-y}\text{Sn}_y$ Skutterudites: processing and thermoelectric properties.** *Journal of Materials Science*. **51**, 6117-6132, (2016). **STEM data featured on cover.
- [2] G. Li, L. Yu, **B. M. Hudak**, Y.-J. Chang, H. Baek, A. Shundararajan, D. R. Strachan, G.-C. Yi, and B. S. Guiton; Direct observation of Li diffusion in Li-doped ZnO nanowires. *Material Research Express*. **3**, 054001, (2016).
- [1] **B. M. Hudak**, Y.-J. Chang, L. Yu, G. Li, D. N. Edwards, and B. S. Guiton; Real-time observation of the solid-liquid-vapor dissolution of individual Tin(IV) Oxide nanowires. *ACS Nano*. **8**, 5441-5448, (2014).

PRESENTATIONS

Invited presentations:

- [5] **Microscopy & Microanalysis Meeting, Minneapolis, MN, USA** **2023**
Direct Positioning of Point Defects in 3D Materials Using STEM
- [4] **TMS 2022, Anaheim, CA, USA** **2022**
Identification of NV centers in nanodiamond through STEM-EELS/EDS

- [3] **Materials Research Society Spring Meeting, Phoenix, AZ, USA** **2018**
Directed Positioning and Imaging of Single-Atom Dopants for Quantum Computing
- [2] **Microscopy & Microanalysis Meeting, Vendor Tutorial, St. Louis, MO, USA** **2017**
Dynamic Nanostructure Phase Transformations Studied Using Aduro Heating Stage in Nion UltraSTEM
- [1] **CNMS User Week, Oak Ridge, TN, USA** **2014**
Direct Observation of the Vapor-Liquid-Solid Mechanism in Reverse

Contributed presentations:

- [14] **International Microscopy Congress, Busan, KOR** 2023
Stabilization of Nanothin, Rhombohedral Bi_2O_3 for Room-Temperature Oxygen Transport
- [13] **Materials Research Society Spring Meeting, San Francisco, CA, USA** 2023
Nanothin $\text{Bi}_x\text{O}_y\text{Se}_z$ -Enabled Modulation of Photoluminescent Properties of WSe_2
- [12] **6.1 Basic Research Conference, Fairfax, VA, USA** 2022
Identification and Positioning of NV Centers in Nanodiamond Using Scanning Transmission Electron Microscopy
- [11] **Materials Research Society Spring Meeting, Honolulu, HI, USA** 2022
Locating NV centers in nanodiamond using simultaneous STEM-EELS/EDS
- [10] **Microscopy & Microanalysis Meeting, Virtual** 2021
Evolution of NV centers in nanodiamond using in situ heating with STEM-EELS/EDS
- [9] **Materials Research Society Spring Meeting, Virtual** 2021
Uncovering the Mechanism of Single-Atom E-Beam Manipulation of Pnictogen Dopants in Silicon
- [8] **Microscopy & Microanalysis Meeting, Portland, OR, USA** 2019
A STEM-based Path Towards Atomic-scale Silicon-based Devices
- [7] **American Physical Society Meeting, Los Angeles, CA, USA** 2018
Directed Positioning of Subsurface Single-Atom Dopants in Silicon for Quantum Computing
- [6] **Oak Ridge Postgraduate Research Symposium, Oak Ridge, TN, USA** 2017
Direct Atom-by-Atom Assembly of Dopants in Silicon
- [5] **Microscopy & Microanalysis Meeting, St. Louis, MO, USA** 2017
Movement and Imaging of Single-Atom Dopants in Silicon
- [4] **American Vacuum Society Meeting, Nashville, TN, USA** 2016
Direct Observation of the Growth and Dissolution Process of SnO_2 Nanowires
- [3] **CNMS User Week, Oak Ridge, TN, USA** 2015
Direct Observation of Structural Phase Transformations in Individual Hafnia Nanorods
- [2] **Microscopy & Microanalysis Meeting, Portland, OR, USA** 2015
Understanding Nanomaterial Synthesis with In situ Transmission Electron Microscopy
- [1] **Materials Research Society Fall Meeting, Boston, MA, USA** 2013
Direct Observation of the Vapor-Liquid-Solid Mechanism in Reverse

Poster presentations:

- [12] **Microscopy & Microanalysis Meeting, Portland, OR, USA** **2022**
Identification and manipulation of NV centers in nanodiamond
- [11] **Microscopy & Microanalysis Meeting, Virtual** **2020**
Fe-rich phase separation in doped BaTiO₃ as revealed by STEM-EDS
- [10] **Microscopy & Microanalysis Meeting, Baltimore, MD USA** **2018**
Towards Atomic-Scale Fabrication in Silicon
- [9] **Microscopy & Microanalysis Meeting, St. Louis, MO USA** **2017**
Direct Observation of Hafnia Structural Phase Transformation
- [8] **Enhanced Data Generated by Electrons Meeting, Okinawa, Japan** **2017**
EELS analysis of bonding in quantum computing materials
- [7] **Materials Research Society Fall Meeting, Boston, MA USA** **2015**
Direct Observation of Structural Phase Transformations in Individual Hafnia Nanorods
- [6] **CNMS User Week, Oak Ridge, TN USA** **2015**
Direct Observation of Structural Phase Transformations in Individual Hafnia Nanorods
- [5] **University of Kentucky Postdoctoral Symposium, Lexington, KY USA** **2015**
Direct Observation of Structural Phase Transformations in Individual Hafnia Nanorods
- [4] **North American Solid State Chemistry Conference, Tallahassee, FL USA** **2015**
Direct Observation of Structural Phase Transformations in Individual Hafnia Nanorods
- [3] **Appalachian Regional Microscopy Society Meeting, Oak Ridge, TN USA** **2014**
Real-time Observation of the Solid-Liquid-Vapor Dissolution of SnO₂ Nanowires
- [2] **ORNL Committee for Women Annual Poster Event 2014, Oak Ridge National Laboratory, Oak Ridge, TN USA** **2014**
Real-time Observation of the Solid-Liquid-Vapor Dissolution of SnO₂ Nanowires
- [1] **Solid State Chemistry Gordon Research Conference, New London, NH USA** **2014**
Real-time Observation of the Solid-Liquid-Vapor Dissolution of SnO₂ Nanowires

FELLOWSHIPS/AWARDS

- 2023** || **NRC/ASEE Postdoctoral Research Publication Award** Naval Research Laboratory
- 2022** || **MRS 2022 NM05 Young Researcher Award** Naval Research Laboratory
- 2018** || **R&D 100 Finalist – The Atomic Forge** Oak Ridge National Laboratory
- 2017** || **Significant Event Award** Oak Ridge National Laboratory

2017	Supplemental Performance Award	Oak Ridge National Laboratory
2016	Advanced Short-Term Research Opportunity (ASTRO)	Oak Ridge National Laboratory
2015	UK-SOPS Postdoctoral Symposium Poster Competition Second Prize	University of Kentucky
2013	NASA KY Graduate Fellowship	University of Kentucky
2013	Center for Advances Materials Research Assistantship	University of Kentucky
2012	KY NSF EPSCoR Research Scholars Program	University of Kentucky
2010	Kentucky Excellence Fellowship	University of Kentucky
2010	Littleton Chemistry Award	Emory & Henry College

SYNERGISTIC ACTIVITIES

Volunteer & Outreach, participation in the Skype a Scientist program, Baseball for All volunteer, and member of the NRL Diversity & Inclusion committee

REFERENCES

Dr. Alberto Pique

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Dr. Andrew R. Lupini

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Dr. Rhonda Stroud

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