

# BETHANY M. HUDAK

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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)
  - Acquiring and analyzing data from a variety of materials that are useful for single-atom imaging and spectroscopy
- 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 HfO<sub>2</sub> 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. Guiton**

- 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

- [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  $\alpha$ -Ni(OH)<sub>2</sub> 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. Goonatilleke, 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. Troparevsky, 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:*

- [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:*

- [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*

*Contributed presentations (cont.):*

- [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<sub>2</sub> 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:*

- [11] **Microscopy & Microanalysis Meeting, Virtual** 2020  
*Fe-rich phase separation in doped BaTiO<sub>3</sub> 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 SnO<sub>2</sub> 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 SnO<sub>2</sub> Nanowires*
- [1] **Solid State Chemistry Gordon Research Conference, New London, NH USA** **2014**  
*Real-time Observation of the Solid-Liquid-Vapor Dissolution of SnO<sub>2</sub> Nanowires*

## FELLOWSHIPS/AWARDS

<b>2018</b>	<b>R&amp;D 100 Finalist – The Atomic Forge</b>	Oak Ridge National Laboratory
<b>2017</b>	<b>Significant Event Award</b>	Oak Ridge National Laboratory
<b>2017</b>	<b>Supplemental Performance Award</b>	Oak Ridge National Laboratory
<b>2016</b>	<b>Advanced Short-Term Research Opportunity (ASTRO)</b>	Oak Ridge National Laboratory
<b>2015</b>	<b>UK-SOPS Postdoctoral Symposium Poster Competition Second Prize</b>	University of Kentucky
<b>2013</b>	<b>NASA KY Graduate Fellowship</b>	University of Kentucky
<b>2013</b>	<b>Center for Advances Materials Research Assistantship</b>	University of Kentucky
<b>2012</b>	<b>KY NSF EPSCoR Research Scholars Program</b>	University of Kentucky
<b>2010</b>	<b>Kentucky Excellence Fellowship</b>	University of Kentucky
<b>2010</b>	<b>Littleton Chemistry Award</b>	Emory & Henry College

## SYNERGISTIC ACTIVITIES

**Volunteer & Outreach**, Activities include work with the Tennessee Science Bowl, participation in the ORNL Physical Sciences Directorate Science Fair trailer, Young-Williams Animal Center in Knoxville, TN, and Rhythm N' Blooms Music Festival in Knoxville, TN.

**Workshop**, One of 66 participants selected from the United States and Canada to participate in the two-week National School on Neutron and X-Ray Scattering (NXS) hosted by Argonne National Laboratory and Oak Ridge National Laboratory, funded by Department of Energy and National Science Foundation Experimental Program to Stimulate Competitive Research (EPSCoR), August 2013.

## REFERENCES

**Dr. Andrew R. Lupini**  
 Electron Microscopy (STEM)  
 Oak Ridge National Laboratory

**Dr. Beth S. Guiton**  
 Inorganic Chemistry  
 University of Kentucky

**Dr. Matthew Chisholm**  
 Electron Microscopy (STEM)  
 Oak Ridge National Laboratory

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