Kartik Venkatraman

Postdoctoral Research Associate w/ Dr. Miaofang Chi
STEM for Quantum and Energy Materials
Scanning Transmission Electron Microscopy Group
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Education

Ph.D., Materials Science & Engineering, **3.97/4.00 GPA** **2015 – 20**
Arizona State University, August 2020
Thesis co-supervisors : **Prof. Peter A. Crozier & Prof. Peter Rez**
Thesis title : **Towards high spatial resolution vibrational spectroscopy in a scanning transmission electron microscope**

Bachelor, Metallurgical Engineering, **8.13/10.00 GPA** **2011 – 15**
Indian Institute of Technology (BHU) Varanasi, UP, India

Skills

Experimental Electron Microscopy: Aberration-corrected S/TEM imaging, Monochromated EELS, EDXS, SEM
Sample Prep: Mechanical polishing & ion milling, nanoparticle synthesis
Optical Spectroscopy: UV-visible absorption, Photoluminescence, FTIR & DRIFTS
Software Digital Micrograph, ImageJ, MATLAB, Python, COMSOL Multiphysics
Professional Skills Leadership, project management, mentorship, scientific writing

Research Experience

Postdoctoral Research Associate | Oak Ridge National Laboratory, TN, U.S.A. **2020 – Present**

Scanning Transmission Electron Microscopy for Quantum and Energy Materials
In this role, I have two-fold responsibilities: a) leading my projects on energy and quantum materials research, and b) helping external users take advantage of the state-of-the-art electron microscopy facility at the Center for Nanophase Materials Sciences to further their scientific endeavors. Research projects that I am leading include:

- Estimating the ion transport behavior at individual nanoscale interfaces in battery materials by correlating the activation energy for Li-ion conduction with nanoscale vibrational spectra recorded with EELS in a STEM.
- Studying the variation in optoelectronic and thermal properties at Moiré lattice points in twisted homogeneous/heterogeneous bilayer 2D materials using STEM EELS.
- Measuring the effect of anionic electrons and hydrogen incorporation at anionic electron sites on the electronic properties of electrides using 4D STEM and monochromated EELS.
- Investigating the nanoscale variation in electronic properties below and above the transition temperature in materials sustaining charge density waves using cryo STEM EELS.

Graduate Research Associate, Arizona State University, AZ, U.S.A. **2015 – 2020**

In this role, I worked on research projects that contributed to my Ph.D. thesis, "Towards High Spatial Resolution Vibrational Spectroscopy in a Scanning Transmission Electron Microscope". Some of the projects that I led include:

Role of convergence and collection angles in the excitation of long and short wavelength phonons in h-BN
Microscopy & Microanalysis, 27 (5), pp. 1069-1077, 2021.

- For the first time, phonons were detected simultaneously from the center and boundaries of Brillouin zones in Boron Nitride with STEM-EELS based vibrational spectroscopy. It was shown that while phonons from the center of a Brillouin zone can be delocalized to a few nanometers, those from zone boundaries have sub-nanometer localization.

Vibrational spectroscopy at atomic spatial resolution with electron impact scattering
***Nature Physics*, 15 pp. 1237-1241, 2019.**

- Atomic spatial resolution vibrational spectroscopy was realized for the first time using Silicon as a model specimen and EELS as the characterization technique. This approach can be used to study chemistry at elemental semiconductor homo- or hetero-interfaces at the atomic scale.

The influence of interfaces and surfaces on high spatial resolution vibrational EELS from SiO_2
***Microscopy*, 67 (suppl_1), pp. i14-i23, 2018.**
***Physical Review B*, 98, 205409, 2018.**

- Performed nanometer spatial resolution EELS mapping of vibrations in amorphous SiO2 across the SiO2/Si interface showing the presence of an interfacial vibrational mode at a different oscillating frequency than the bulk. This is not possible by common vibrational spectroscopies like FTIR, Raman, and inelastic neutron scattering.

Manipulating vibrational polaritons by patterning SiO_2 thin-films

- Manipulated hybrid phonon-photon excitations (phonon polaritons) in amorphous SiO_2 by patterning a thin-film. This approach can bring out one hybrid excitation over another in an extended structure. Applications include reduced optical dielectric losses and enhanced non-radiative heat transfer.

Detecting thin layers of adsorbates on individual catalyst nanoparticles

- Detected a monolayer of CO molecules on a single Pt microparticle to determine that the sensitivity of vibrational spectroscopy in a STEM is equivalent to FTIR and DRIFTS. This sensitivity combined with high spatial resolution enables the nanoscale study of the gas/catalyst interaction.

Revealing protein secondary structures using vibrational EELS
***Journal of Microscopy*, 282 (3), pp. 215-223, 2021.**

- Nanoscale vibrational response was recorded from individual nanocrystals of two proteins, OmpF porin, and bacteriorhodopsin, to reveal differences in the secondary structures of the proteins. These secondary structures reveal local information about protein misfolding, which is responsible for causing diseases like Alzheimer's.

Undergraduate Researcher, Arizona State University, AZ, U.S.A. **2013 – 2015**

- Studied the crystal structure of the superplastic alloy Ti-22Al-25Nb (at.%) using XRD. Cold rolled the alloy and characterized the texture formed with optical microscopy, SEM and EBSD. Subjected the rolled specimen to various heat treatments and studied its effect on the grain size using optical microscopy and SEM.
- Synthesized Bi nanoparticle/TiO_2 nanotube and Au nanoparticle/CdSe quantum dot heterostructures to enhance absorption over the entire visible electromagnetic spectral range for optoelectronic applications. Measured the enhanced absorption using UV-Visible spectroscopy and emission using PL spectroscopy.
- Demonstrated a working model of commercially feasible electricity production via wireless hydrogen generation through solar water splitting using Au deposited 1T-MoS_2/Nitrogen doped RGO composite as a photo catalyst.

Awards & Recognition

Engineering Graduate Fellowship **2020**
Ira A. Fulton Schools of Engineering, Arizona State University

Microscopy Society of America Castaing Award **2020**
For best student paper at Microscopy & Microanalysis (M & M) 2019, Portland, OR

Outstanding Graduate Student Travel Award **2018**
Microscopy Society of America, for Int'l Microscopy Congress, Sydney, Australia

Microscopy Society of America Presidential Scholar Award **2017**
For outstanding student abstract submitted to M & M 2017, St. Louis, MO

Best Poster Prize – Analytical Sciences **2017**
M & M 2017, St. Louis, MO

Teaching & Mentorship

Teaching Assistant, Nanomaterials in Energy Production and Storage, Arizona State University **Spring 2016**

- Evaluated problem sets submitted by undergraduate students, prepared solutions for and graded the midterm and final exams, clarified course concepts for students and coached them for exams

Undergraduate Student Mentor **2017 – 2019**

- Mentored an undergraduate student, Sunny Situ, to help with numerical simulations of vibrational and low-loss EELS using the classical dielectric theory and finite element method in COMSOL Multiphysics, which demonstrate that vibrational modes in polar dielectric materials can be manipulated by introducing nanostructural features

Leadership & Service

Treasurer, Oak Ridge Postdoctoral Association (ORPA) **2021 – 22**

- I oversee the ORPA budget and its expenses for the current fiscal year and help organize social events, contribute to a monthly newsletter, advocate for the ORNL postdoc community, and volunteer for ORPA based outreach activities.

Grand Awards Judge, International Science and Engineering Fair, Intel **2019**
Moderator, Tennessee Science Bowl **2021**

- Volunteered to judge the Materials Science and Engineering projects of high-school students and selected the winners of the top awards presented by the fair, and to moderate a state level Science quiz competition for high-school students.

Chair, Treasurer, & Liaison, The Student Council (StC), Microscopy Society of America **2017 – 20**

- I helped plan and solicited funding for an annual one-day conference for students, post-docs, and early career professionals organized by the StC, maintained a budget and oversaw expenses, promoted activities and funding opportunities by the MSA to student members across the U.S.

Professional References

Miaofang Chi
Distinguished Scientist
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Peter A. Crozier
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Juan Carlos Idrobo
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Peter Rez
Professor
Arizona State University
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Ray Egerton
Professor
University of Alberta
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Journal Publications

8. Visualizing Magnetic Fields at the Atomic Scale
K. Venkatraman, J.A. Hachtel, M. Chi
Matter **5** (8), pp. 2414-2416 (2022)

7. Solution-phase Synthesis of $PdH_{0.706}$ Nanocubes with Enhanced Stability and Activity toward Formic Acid Oxidation
Y. Shi, R. Schimmenti, S. Zhu, K. Venkatraman, R. Chen, M. Chi, M. Shao, M. Mavrikakis, Y. Xia
Journal of the American Chemical Society **144** (6), pp. 2556-2568 (2022)

6. Role of Convergence and Collection Angles in the Excitation of Long and Short Wavelength Phonons in h-BN with Vibrational Electron Energy-Loss Spectroscopy
K. Venkatraman, P.A. Crozier
Microscopy and Microanalysis **27** (5), pp. 1069-1077 (2021)

5. Protein Secondary Structure Signatures from Energy Loss Spectra Recorded in the Electron Microscope
K. March, K. Venkatraman, C.D. Truong, D. Williams, P.L. Chiu, P. Rez
Journal of Microscopy **282** (3), pp. 215-223 (2021)

4. Properties of Dipole-Mode Vibrational Energy Losses Recorded from a TEM Specimen
R.F. Egerton, K. Venkatraman, K. March, P.A. Crozier
Microscopy and Microanalysis **26** (6), pp. 1117-1123 (2020)

3. Vibrational Spectroscopy at Atomic Resolution with Electron Impact Scattering
K. Venkatraman, B.D.A. Levin, K. March, P. Rez, P.A. Crozier
Nature Physics **15** (12) pp. 1237-1241 (2019)

2. Vibrational Electron Energy-loss Spectroscopy in Truncated Dielectric Slabs
A. Konečná, K. Venkatraman, K. March, P.A. Crozier, R. Hillenbrand, P. Rez, J. Aizpurua
Physical Review B **98**, 205409 (2018)

1. The Influence of Surfaces & Interfaces on High Spatial Resolution Vibrational Electron Energy-Loss Spectroscopy from SiO_2
K. Venkatraman, P. Rez, K. March, P.A. Crozier
Microscopy **67 (suppl_1)**, pp. i14-i23 (2018)

Refereed Conference Proceedings (2 pages)

21. Nanoscale Vibrational Spectroscopy to Probe Li Motion at Individual Interfaces in Battery Materials
K. Venkatraman, M. Zachman, M. Chi
Microscopy and Microanalysis 28 (S1), 2464-2466 (2022)

20. Correlating Inhomogeneity in Anionic Electron Density with Hydrogen Incorporation in Y_5Si_3 Electrides
K. Venkatraman, J.A. Hachtel, M. Chi
Microscopy and Microanalysis 27 (S1), 146-147 (2021)

19. Probing Properties of Nanomaterials with Advanced Electron Energy-Loss Spectroscopy
P.A. Crozier, J.L. Vincent, K. Venkatraman, Y. Wang, S. Yang
Microscopy and Microanalysis 27 (S1), 872-874 (2021)

18. What are the Applications of meV EELS?
P. Rez, K. March, K. Venkatraman
Microscopy and Microanalysis 26 (S2), 1748-1749 (2020)

17. Exploring Phononic and Photonic Excitations with Monochromated STEM EELS
K. Venkatraman, Q. Liu, B.D.A. Levin, K. March, P.A. Crozier
Microscopy and Microanalysis 26 (S2), 1494-1496 (2020)

16. Background Modelling for Quantitative Analysis in Vibrational EELS
B.D.A. Levin, K. Venkatraman, D.M. Haiber, K. March, P.A. Crozier
Microscopy and Microanalysis 25 (S2), 674-675 (2019)

15. Nature of the Vibrational-Loss EELS Peaks Measured from Ionic Specimens
R.F. Egerton, K. March, K. Venkatraman, P.A. Crozier
Microscopy and Microanalysis 25 (S2), 618-619 (2019)

14. Nanoscale Probing of Adsorbates on Pt/CeO_2 with Aloof-beam Vibrational Electron Energy-loss Spectroscopy
K. Venkatraman, J.L. Vincent, K. March, P. Rez, P.A. Crozier
Microscopy and Microanalysis 25 (S2), 644-645 (2019)

13. Sensing Interfacial Visible Light Absorption in TiO_2-supported CeO_{2-x} Photocatalyst Nanoparticles
D.M. Haiber, K. Venkatraman, T.U. Phan, P.A. Crozier
Microscopy and Microanalysis 25 (S2), 2084-2085 (2019)

12. Atomic Resolution Vibrational Spectroscopy with On-Axis Detector Geometry
K. Venkatraman, B.D.A. Levin, K. March, P. Rez, P.A. Crozier
Microscopy and Microanalysis 25 (S2), 596-597 (2019)

11. Manipulation of Optical Phonon Polaritons in Patterned SiO_2 Thin-Films
K. Venkatraman, S. Situ, K. March, P. Rez, P.A. Crozier
Microscopy and Microanalysis 25 (S2), 646-647 (2019)

10. Aloof-beam Vibrational Electron Energy-loss Spectroscopy of Absorbate/Metal Particle Systems
K. Venkatraman, K. March, P. Rez, P.A. Crozier
19th International Microscopy Congress, Sydney, Australia (2018)

9. Spatially Resolved Vibrational Electron Energy-loss Spectroscopy across an Abrupt SiO_2/Si Interface
K. Venkatraman, K. March, P. Rez, P.A. Crozier
19th International Microscopy Congress, Sydney, Australia (2018)

8. Characterization of Mixed Metal Oxide Interfaces Based on TiO_2-supported CeO_{2-x} Nanoparticles
D.M. Haiber, T.U. Phan, K. Venkatraman, P.A. Crozier
Microscopy and Microanalysis **24** (S1), 458-459 (2018)

7. Utilizing Aloof-beam Vibrational EELS for the Detection of Hydrogen and Defect Heterogeneities in Carbon Nitrides
D.M. Haiber, K. Venkatraman, P.A. Crozier
Microscopy and Microanalysis **24** (S1), 426-427 (2018)

6. Aloof-beam Vibrational Electron Energy-loss Spectroscopy of Absorbate/Metal Particle Systems
K. Venkatraman, K. March, P. Rez, P.A. Crozier
Microscopy and Microanalysis **24** (S1), 460-461 (2018)

5. Spatially Resolved Vibrational Electron Energy-loss Spectroscopy Across an Abrupt SiO_2/Si Interface
K. Venkatraman, K. March, P. Rez, P.A. Crozier
Microscopy and Microanalysis **24** (S1), 414-415 (2018)

4. Exploring Vibrational and Valence Loss Spectra from Oxide Nanoparticles
P.A. Crozier, Q. Liu, K. Venkatraman, D.M. Haiber, W.J. Bowman, K. March, P. Rez
Microscopy and Microanalysis **23** (S1), 1544-1545 (2017)

3. Probing Interfacial and Surface Effects with Vibrational Electron Energy Loss Spectroscopy
K. Venkatraman, Q. Liu, K. March, P. Rez, P.A. Crozier
Microscopy and Microanalysis **23** (S1), 1562-1563 (2017)

2. Probing Interfacial Effects with Vibrational Electron Energy-loss Spectroscopy
K. Venkatraman, Q. Liu, K. March, T. Aoki, P. Rez, P.A. Crozier
Enhanced Data Generated by Electrons (EDGE), Okinawa, Japan (2017)

1. Investigating the Spatial Resolution of Vibrational Electron Energy-loss Spectroscopy
K. Venkatraman, Q. Liu, T. Aoki, P. Rez, P.A. Crozier
Microscopy and Microanalysis **22** (S3), 992-993 (2016)