

CURRENT Research Scientist

POSITION Lawrence Berkeley National Laboratory
Advanced Light Source Division: Instrumentation Group
Berkeley, California, 94720 USA

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EDUCATION **Massachusetts Institute of Technology**, Cambridge, MA, USA
Ph.D., Nuclear Science and Engineering, February 2014
 Thesis advisors, D.G. Whyte, R.C. Lanza, G. Wright, GPA: 4.5/5.0
S.M., Nuclear Science and Engineering, 2009
 Thesis advisors, D. G. Whyte, B. Lipschultz

Cornell University, Ithaca, NY, USA
B.S., Applied and Engineering Physics, 2006

RESEARCH INTERESTS

- Synchrotron X-ray micro-tomography (μ CT)
- Resonant inelastic X-ray scattering (RIXS)
- Instrumentation development for materials characterization
- Accelerator/synchrotron based techniques for materials analysis (Imaging, spectroscopy, beam optics, and modeling)
- High temperature composite materials for aerospace applications
- Applied Science: design, engineering, instrumentation
- Design of fusion and fission reactors and other energy systems

CURRENT PROJECTS

- Design and Implementation of the X-ray spectrometer for the 6.0.2 QERLIN beamline
- Instrumentation development for X-ray micro-Tomography.
- Technical/User support for tomography users on beamline 8.3.2.
- Development of python-based software tools for tomography data processing.
- Development of novel sample environments for in-situ X-ray micro-tomography.

- High temperature mechanical testing of ceramic matrix composites for aerospace and nuclear energy applications.
- High temperature analysis of carbon fiber materials for spacecraft atmospheric entry thermal protection systems.
- Analysis of plants under freeze/thaw cycles and drought
- High pressure analysis of geological systems for oil and gas extraction, carbon sequestration, and geothermal energy.

ENGINEERING EXPERIENCE

Prototyping: accelerator/beamline hardware, instrumentation, mechanical design.

Electrical Eng.: analog circuit design, automation, DC/RF/pulsed power systems

Mechanical Eng.: structural/thermal analysis, FEA, pneumatics, vacuum systems

CAD Modeling: SolidWorks, AutoCAD, Eagle

Scientific Computing: Python, MATLAB, ANSYS (Structural, modal, thermal)

Neutron Transport Modeling: MCNP

Fabrication: machining, welding, brazing, electrical soldering, carpentry

RESEARCH EXPERIENCE

- **LBNL: Advanced Light Source**, Feb 2015 – present

Research Scientist, April 2020 – present, Supervisor: Alastair MacDowell

- Implementation and commissioning of the 6.0.2 QERLIN beamline
- Design of the next generation high temp tomography cell for mechanical testing
- User support for complex in-situ micro-tomography experiments

Project Scientist, Feb 2016 – March 2019, Supervisor: Alastair MacDowell

- Opto-mechanical design, alignment procedures, and metrology planning for the spectrometer section of the 6.0.2 QERLIN beamline
- Design of synchrotron beamline hardware, optics, and instrumentation.
- Development of novel in-situ sample environments for x-ray micro-tomography.
- X-ray micro-tomography beamline user support.

Postdoctoral Research Associate, Feb 2015 – Feb 2016, Supervisor: Alastair MacDowell

- Development of novel in-situ sample environments for x-ray micro-tomography.
- X-ray micro-tomography beamline user support.

- **MIT: Plasma Science and Fusion Center**, Feb. 2014 – Feb. 2015
Postdoctoral Research Associate, Cambridge MA, Supervisor: Dennis Whyte
 - Continued development of accelerator-based in-situ materials diagnostics for the Alcator C-Mod tokamak (see doctoral research).
- **MIT: Plasma Science and Fusion Center**, Sept. 2009 - Jan. 2014
Doctoral Research, Cambridge MA, Advisor: Dennis Whyte
 - Developed a novel RFQ accelerator based in-situ materials diagnostic integrated with Alcator C-Mod tokamak. This diagnostic injects a 0.9 MeV deuterium beam into the tokamak vacuum vessel, using the magnetic field coils to steer the beam for targeted ion beam analysis of plasma facing components.
 - Refurbished and upgraded a radio frequency quadrupole (RFQ) accelerator controls to enable remote operation in a radiation test-cell environment with high magnetic fields.
 - Contributed to design studies for compact, steady-state fusion devices and accelerator-based materials test facilities.
- **MIT: Plasma Science and Fusion Center**, Sept. 2006 - Aug. 2009
Masters of Science Research, Cambridge MA, Advisor: Dennis Whyte
 - Reconstructed and refurbished a 1.7MV tandem accelerator and beam lines for ion beam analysis (IBA) of materials.
 - Constructed a beamline for Rutherford backscattering spectroscopy and external proton beam induced X-Ray and gamma spectroscopy.
 - Performed a IBA study of net plasma erosion and poloidal transport of tungsten in the Alcator C-Mod divertor.
- **General Atomics: Fusion Diagnostics Division**, June 2006 - Sept. 2006
Internship, San Diego CA, Supervisor: Rejean Boivin
 - Designed and built a test setup for measuring the time response of fast thermocouples used for heat flux measurement on plasma facing components in the DIII-D tokamak.
- **Sandia National Laboratories**, June 2005 - Sept. 2005
Internship, Albuquerque NM, Advisor Dr. John Maenchen
 - Fabricated and assembled components for the upgraded Radiographic Integrated Test Stand (RITS) accelerator.
 - Designed and built a calibration system for B-dot current sensors used in RITS.

- **Cornell Laboratory for Plasma Studies**, Sept. 2004 - April 2006
Undergraduate Research, Ithaca NY, Advisor: Prof. Bruce Kusse
 - Developed an electroplating technique for fabricating modulated-diameter wires for pulsed plasma experiments with X-ray radiography and Z-pinch applications.
- **Cornell High Energy Synchrotron Source**, Sept. 2003 - Sept 2004
Undergraduate Research, Ithaca NY, Advisor: Dr. Ernest Fontes
 - Fabricated and tested stepper motor control units for x-ray optics.
 - Built hardware and instrumentation for various beamline end-station applications.
- **U. Albany Institute for Materials/Albany Nanotech**, June 2003 - Sept. 2003
Undergraduate Research, SUNY Albany, Advisor: Dr James Castracane
 - Characterized and simulated micro-fabricated diffraction gratings.
- **U. Albany Institute for Materials/Albany Nanotech**, June 2001 - August 2002
Internship, Albany NY, Advisor: Dr James Castracane.
 - Designed and built a system for packaging, actuating, testing micro fluidic devices.

Teaching Experience at MIT

- Graduate Resident Tutor: Mentoring and advising undergraduate students. 2007 - 2013
- Assistant lab instructor: 22.071 - Electronics, Signals, and Circuits: Feb. - March 2011
- Teaching assistant: 22.63 - Eng. Principles for Fusion Reactors: Sept. - Dec. 2012

PUBLICATIONS

1. Obata Y, Bale HA, Barnard HS, Parkinson DY, Alliston TN, Acevedo C. Quantitative and qualitative bone imaging: A review of synchrotron radiation microtomography analysis in bone research. *Journal of the Mechanical Behavior of Biomedical Materials*. 2020 Jun 25;103887.
2. Liu D, Knol S, Ell J, Barnard H, Davies M, Vreeling JA, Ritchie RO. X-ray tomography study on the crushing strength and irradiation behaviour of dedicated tristructural isotropic nuclear fuel particles at 1000 C. *Materials and Design*. 2020;187:108382.
3. Voltolini M, Barnard H, Creux P, Ajo-Franklin J. A new mini-triaxial cell for combined high-pressure and high-temperature in situ synchrotron X-ray microtomography experiments up to 400° C and 24 MPa. *Journal of synchrotron radiation*. 2019 Jan 1;26(1):238-43.
4. Tripoli B, Manga M, Mayeux J, Barnard H. The Effects of Deformation on the Early Crystallization Kinetics of Basaltic Magmas. *Frontiers in Earth Science*. 2019 Sep 27;7.

5. MacNeil JM, Ushizima DM, Panerai F, Mansour NN, Barnard HS, Parkinson DY. Interactive volumetric segmentation for textile micro-tomography data using wavelets and nonlocal means. *Statistical Analysis and Data Mining: The ASA Data Science Journal*. 2019 Aug;12(4):338-53.
6. MacNeil JM, Morozov D, Panerai F, Parkinson D, Barnard H, Ushizima D. Distributed Global Digital Volume Correlation by Optimal Transport. In 2019 IEEE/ACM 1st Annual Workshop on Large-scale Experiment-in-the-Loop Computing (XLOOP) 2019 Nov 18 (pp. 14-19). IEEE.
7. Barnard HS, MacDowell AA, Parkinson DY, Larson NM, Peterson JC, Panerai F, Mansour NN, Gao Y. Synchrotron X-ray Micro Tomography at the Advanced Light Source: In-Situ Sample Environments for Advanced Aerospace Materials. *Microscopy and Microanalysis*. 2018 Aug;24(S2):444-5.
8. Marcus MA, Amini S, Stifler CA, Sun CY, Tamura N, Bechtel HA, Parkinson DY, Barnard HS, Zhang XX, Chua JI, Miserez A. Parrotfish Teeth: Stiff Biominerals Whose Microstructure Makes Them Tough and Abrasion-Resistant to Bite Stony Corals. *ACS nano*. 2017 Nov 14;11(12):11856-65.
9. Liu D, Gludovatz B, Barnard HS, Kuball M, Ritchie RO. Damage tolerance of nuclear graphite at elevated temperatures. *Nature communications*. 2017 Jun 30;8:15942.
10. Panerai F, Borner A, Ferguson JC, Mansour NN, Stern EC, Barnard HS, Macdowell AA, Parkinson DY. X-Ray Micro-Tomography Applied to Nasa's Materials Research: Heat Shields, Parachutes and Asteroids. NASA Technical Report (2017).
11. Barnard HS, MacDowell AA, Parkinson DY, Mandal P, Czabaj M, Gao Y, Maillet E, Blank B, Larson NM, Ritchie RO, Gludovatz B. Synchrotron X-ray micro-tomography at the Advanced Light Source: Developments in high-temperature in-situ mechanical testing. *Journal of Physics: Conference Series* 2017 Jun (Vol. 849, No. 1, p. 012043). IOP Publishing.
12. Parkinson DY, Pelt DM, Perciano T, Ushizima D, Krishnan H, Barnard HS, MacDowell AA, Sethian J. Machine learning for micro-tomography. *Developments in X-Ray Tomography XI* 2017 Sep 26 (Vol. 10391, p. 103910J). International Society for Optics and Photonics.
13. Carlton HD, Lind J, Messner MC, Volkoff-Shoemaker NA, Barnard HS, Barton NR, Kumar M. Mapping local deformation behavior in single cell metal lattice structures. *Acta Materialia*. 2017 May 1;129:239-50.
14. Higa K, Zhao H, Parkinson DY, Barnard H, Ling M, Liu G, Srinivasan V. Electrode Slurry Particle Density Mapping Using X-ray Radiography. *Journal of The Electrochemical Society*. 2017 Jan 1;164(2):A380-8.
15. Barnard HS, MacDowell AA, Parkinson DY, Venkatakrishnan SV, Panerai F, Mansour NN. Developments in synchrotron x-ray micro-tomography for in-situ materials analysis at the Advanced Light Source. *Developments in X-Ray Tomography X* 2016 Oct 3 (Vol. 9967, p. 99671H). International Society for Optics and Photonics.

16. MacDowell AA, Barnard H, Parkinson DY, Haboub A, Larson N, Zok F, Panerai F, Mansour NN, Bale H, Gludovatz B, Acevedo C. High temperature x-ray micro-tomography. AIP Conference Proceedings 2016 Jul 27 (Vol. 1741, No. 1, p. 050005). AIP Publishing.
17. Kesler, L. A., B. N. Sorbom, Z. S. Hartwig, H. S. Barnard, G. M. Wright, and D. G. Whyte. "Initial results of tests of depth markers as a surface diagnostic for fusion devices." *Nuclear Materials and Energy* 12 (2017): 1277-1281.
18. Sorbom, B.N., J.R. Ball, T.R. Palmer, F.J. Mangiarotti, J.M. Sierchio, P. Bonoli; C. Kasten, D.A. Sutherland, H. S. Barnard, C.B. Haakonsen; J. Goh, C. Sung; D.G. Whyte. "ARC: A compact, high-field, fusion nuclear science facility and demonstration power plant with demountable magnets" *Fusion Engineering and Design*, Vol 100, pp. 378-405 (2015)
19. Barnard, H. S., "Development of Accelerator Based Spatially Resolved Ion Beam Analysis Techniques for the Study of Plasma Materials Interactions in Magnetic Fusion Devices." Doctoral Thesis, Massachusetts Institute of Technology, 2014.
20. Hartwig, Z.S., H. S. Barnard, R.C. Lanza, B.N. Sorbom, P.W. Stahle, D.G. Whyte. "An in situ accelerator-based diagnostic for plasma-material interactions science on magnetic fusion devices." *Review of Scientific Instruments* 84, no. 12 (2013): 123503
21. Olynyk, G. M., Z. S. Hartwig, D. G. Whyte, H. S. Barnard, P. T. Bonoli, L. Bromberg, M. L. Garrett, C. B. Haakonsen, R. T. Mumgaard, and Y. A. Podpaly. "Vulcan: A steady-state tokamak for reactor-relevant plasma-material interaction science." *Fusion Engineering and Design* (2012).
22. Barnard, H. S., Z. S. Hartwig, G. M. Olynyk, and J. E. Payne. "Assessing the feasibility of a high-temperature, helium-cooled vacuum vessel and first wall for the Vulcan tokamak conceptual design." *Fusion Engineering and Design* (2012).
23. Whyte, D. G., G. M. Olynyk, H. S. Barnard, P. T. Bonoli, L. Bromberg, M. L. Garrett, C. B. Haakonsen, Z. S. Hartwig, R. T. Mumgaard, and Y. A. Podpaly. "Reactor similarity for plasma-material interactions in scaled-down tokamaks as the basis for the Vulcan conceptual design." *Fusion Engineering and Design* (2012).
24. Lipschultz, B., J. W. Coenen, H. S. Barnard, N. T. Howard, M. L. Reinke, D. G. Whyte, and G. M. Wright. "Divertor tungsten tile melting and its effect on core plasma performance." *Nuclear Fusion* 52, no. 12 (2012): 123002.
25. Barnard, H. S., B. Lipschultz, and D. G. Whyte. "A study of tungsten migration in the Alcator C-Mod divertor." *Journal of Nuclear Materials* 415, no. 1 (2011): S301-S304.
26. Wright, G. M., H. S. Barnard, Z. S. Hartwig, P. W. Stahle, R. M. Sullivan, K. B. Woller, and D. G. Whyte. "Plasma-Surface Interaction Research At The Cambridge Laboratory Of Accelerator Studies Of Surfaces." In *AIP Conference Proceedings*, vol. 1336, p. 626. 2011.

27. Barnard, H. S., "External proton beam analysis of plasma facing materials for magnetic confinement fusion applications." S.M. Thesis, Massachusetts Institute of Technology, 2009.

CONFERENCE PRESENTATIONS: INVITED SPEAKER

1. 4-D MicroCT Analysis of Spacecraft Heat Shield Materials Under Atmospheric Entry Conditions
International Conference on Tomography of Materials & Structures (ICTMS 2019)
Cairns, Australia, July 23, 2019
2. In-situ erosion and deposition measurements of plasma-facing surfaces in Alcator C-Mod
American Physical Society: Division of Plasma Physics (APS-DPP)
New Orleans, Louisiana, October 31, 2014

CONFERENCE ORAL PRESENTATIONS

3. Developments in X-ray Micro-Tomography at the Advanced Light Source
SPIE, August 2016
San Diego CA, USA
4. X-ray Micro-Tomography for Materials Research in Extreme Environments
Materials Research Society (MRS), March 2016,
Phoenix AZ, USA

SEMINARS

5. Synchrotron X-Ray MicroCT at Beamline 8.3.2: Overview of In-situ Sample Environments
Carl Zeiss Microscopy, Host: Sam Kalirai
Pleasanton, CA, USA, February 18, 2020
6. Synchrotron Instrumentation Development: Enabling Exciting New Science at the ALS
Advanced Light Source, special seminar, host: Alastair MacDowell
Berkeley, CA, USA, March 6, 2019
7. Synchrotron X-ray Tomography: High resolution 3D imaging and microstructural analysis of materials at the Advanced Light Source.
NASA Ames Research Center, Host: Francesco Panerai
Moffett Field, CA, USA, Feb 22, 2018

CONFERENCE POSTER PRESENTATIONS

1. Synchrotron X-ray Micro Tomography at the Advanced Light Source: In-Situ Sample Environments for Advanced Materials.
International Conference on X-Ray Microscopy (XRM 2018)
Saskatoon Saskatchewan, Canada, August 2018
2. Developments in Synchrotron X-Ray Tomography at the ALS
International Conference on Tomography of Materials & Structures (ICTMS 2017)
Lund Sweden, June 2017
3. Developments in Synchrotron X-Ray Tomography at the ALS
International Conference on X-Ray Microscopy (XRM 2016)
Oxford UK, August 2016