

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

CONTACT INFORMATION Mail: 1 Cyclotron Rd, MS: 015-0335C Phone: (518) 428-9014
Advanced Light Source Email: hbar@lbl.gov
Berkeley, California, 94720 Web: science.haroldbot.com

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
- Instrumentation development for materials characterization
- Accelerator based diagnostic techniques for materials analysis (hardware development, spectroscopy, beam optics and modeling)
- Applied Science: design, engineering, instrumentation
- Design of fusion and fission reactors and other energy systems

CURRENT PROJECTS

- Instrumentation development for X-ray micro-Tomography.
- Technical 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, COMSOL

Neutron Transport Modeling: MCNP

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

RESEARCH EXPERIENCE

- **LBNL: Advanced Light Source**, Feb 2015 – present
Project Scientist, Feb 2016 – present, Supervisor: Alastair MacDowell
Postdoctoral Research Associate, Feb 2015 – Feb 2016, Supervisor: Alastair MacDowell
 - Development of x-ray micro-tomography techniques for in-situ testing of materials in novel sample environments.
 - Design of synchrotron beamline hardware, optics, and instrumentation.
 - 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: SYNCHROTRON SCIENCE

1. 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.
2. 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.
3. 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.
4. 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).
5. 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.
6. Parkinson DY, Pelt DM, Perciano T, Ushizima D, Krishnan H, Barnard HS, MacDowell AA, Sethian J. Machine learning for micro-tomography. In Developments in X-Ray Tomography XI 2017 Sep 26 (Vol. 10391, p. 103910J). International Society for Optics and Photonics.
7. 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.

8. 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.
9. 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.
10. 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.

PUBLICATIONS: PLASMA AND FUSION SCIENCE

11. 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)
12. 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.
13. 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
14. 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).
15. 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).
16. 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).
17. 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.

18. 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.
19. 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.
20. Barnard, H. S., "External proton beam analysis of plasma facing materials for magnetic confinement fusion applications." S.M. Thesis, Massachusetts Institute of Technology, 2009.