

**Andrew R. Lupini**

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**Senior R&D Staff Member**

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**Education**

University of Cambridge, UK	BA	1996	Natural Sciences
University of Cambridge, UK	MSci	1997	Natural Sciences
University of Cambridge, UK	PhD	2001	Physics

**Fellowships**

- 2021 – American Physical Society (APS). *For groundbreaking contributions to the fields of electron microscopy and aberration-correction in scanning transmission electron microscopy and for the development of new image and spectroscopy capabilities, higher-resolution, and better sensitivity to atomic-resolution imaging and spectroscopy.*
- 2023 – Microscopy Society of America (MSA). *For foundational contribution of theory and practice of aberration correction STEM, and applications for high-resolution EELS and e-beam atomic fabrication.*

**Professional Experience**

2022 – present	Group Leader, Center for Nanophase Materials Science, Oak Ridge National Laboratory, Oak Ridge, TN, United States
2017 – 2022	Senior R&D Staff member, UT-Battelle LLC. Center for Nanophase Materials Science, Oak Ridge National Laboratory.
2009 – 2017	R&D Staff member, UT-Battelle LLC. Center for Nanophase Materials Science, Oak Ridge National Laboratory.
2005 – 2009	R&D Associate, UT-Battelle LLC. Center for Nanophase Materials Science, Oak Ridge National Laboratory.
2001 – 2005	Post-Doctoral Research Associate, Oak Ridge Associated Universities, Oak Ridge National Laboratory. Installation and operation of aberration-corrected microscopes. Supervisor: Dr. S.J. Pennycook.
1997 – 2001	Cavendish Laboratory, Cambridge University. Graduate research in electron microscopy. Supervising undergraduates in experimental work and math.

**Thesis**

Aberration Correction in STEM, *University of Cambridge*, March 2001. Supervisor: Dr. A.B. Bleloch.

**Patents:**

- *Autoadjusting Charged-Particle Probe-Forming Apparatus* (2000) Patent number: 6552340.
- *Bulk nanofabrication with single atomic plane precision via atomic-level sculpting of crystalline oxides* (2019) Patent number: 10400351.

**Publication Summary**

Over 160 refereed publications, with more than 8000 total citations and h-index of 51 (Web of Science). 10 Book chapters and 39 Invited talks as presenting author.

**Research Interests:**

Electron microscopy and analysis, particularly the development and application of aberration corrected imaging in the scanning transmission electron microscope. Innovative methods to measure aberrations and quantify electron microscope images and spectra. Electron energy loss spectroscopy at high spatial and energy resolution. Using the electron microscope for controlling atoms as well as imaging.

**Graduate and Postdoctoral Advisors:**

PhD Advisor: A. B. Bleloch.

Postdoctoral Advisor: S. J. Pennycook.

**Post-Doctoral Advisees (including joint advisees):**

B.M. Hudak, now at U.S. Naval Research Laboratory.

R. Ishikawa, now at University of Tokyo.

**Partial:** K. Roccapriore (ORNL), S. Yoon (Gachon University), Y. Guo (Micron)

**Partial (current):** E. Tiukalova, H. Kim. E. Hoglund, J. G. Smith, Z. Fang.

**Awards**

- Winner of Microscopy Today Innovation Award 2019 – *AICrystallographer*
- Winner of R&D 100 Award 2018 – *The Atomic Forge*
- Winner of R&D 100 Award 2021 – *UCC Ultraconductive Copper-CNT Composite*
- ORNL Research Accomplishment Award, 2023
- ORNL Outstanding Scholarly Output Award, 2021
- ORNL Significant Event Award, 2015 – *An advanced multi-modal control system for high-speed data acquisition/analysis and nanofabrication for aberration-corrected STEM*
- ORNL Significant Event Award, 2014 – *Super-Hydrophobic Materials*
- Microscopy and Microanalysis journal Best Techniques and Instrumentation Development Paper (2012) – *Single atom microscopy*
- Microscopy and Microanalysis journal Best Techniques and Instrumentation Development Paper (2011) – *The three-dimensional point spread function of aberration-corrected scanning transmission electron microscopy*

### Synergistic Activities:

- Chairman of ACEM Focused Interest Group of the Microscopy Society of America
- Guest Lecturer at the annual SuperSTEM Summer School in Daresbury, UK
- Reviewer for a wide variety of Journals, including: Ultramicroscopy, Microscopy, Microscopy and Microanalysis, Nature Materials, Nature Comms, Scientific Reports, NPJ group, ACS Nano, PRX, IEEE journals, Journal of Applied Physics.
- Reviewer for US Department of Energy and National Science Foundation.

### Selected Peer-Reviewed Publications:

1. O. Dyck, A.R. Lupini, S. Jesse, A Platform for Atomic Fabrication and In Situ Synthesis in a Scanning Transmission Electron Microscope (2023) *Small Methods*.
2. S.V. Kalinin, S. Jesse, A.R. Lupini, A Quantum Lab in a beam, *Physics Today* **75**(6), 30-36 (2022).
3. 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).
4. B. M. Hudak, J. M. Song, H. Sims, M. C. Tropicovsky, T. S. Humble, S. T. Pantelides, P. C. Snijders, and A. R. Lupini, Directed Atom-by-Atom Assembly of Dopants in Silicon, *ACS Nano* **12**, (6) 7873-5879 (2018).
5. J. C. Idrobo, A. R. Lupini, T .L. Feng, R. R. Unocic, F. S. Walden, D. S. Gardiner, T. C. Lovejoy, N. Dellby, S. T. Pantelides, and O. L. Krivanek, Temperature Measurement by a Nanoscale Electron Probe Using Energy Gain and Loss Spectroscopy, *Phys. Rev. Lett.* **120**, (9) 095901 (2018).
6. J. C. Idrobo, J. Ruzs, J. Spiegelberg, M. A. Mcguire, C. T. Symons, R. R. Vatsavai, C. Cantoni, and A. R. Lupini, Detecting Magnetic Ordering with Atomic Size Electron Probes, *Advanced Structural and Chemical Imaging* **2**, (5) (2016).
7. R. Ishikawa, R. Mishra, A. R. Lupini, S. D. Findlay, T. Taniguchi, S. T. Pantelides, and S. J. Pennycook, Direct Observation of Dopant Atom Diffusion in a Bulk Semiconductor Crystal Enhanced by a Large Size Mismatch, *Phys. Rev. Lett.* **113**, 155501 (2014).
8. R. Ishikawa, A. R. Lupini, S. D. Findlay, T. Taniguchi, and S. J. Pennycook, Three-Dimensional Location of a Single Dopant with Atomic Precision by Aberration-Corrected Scanning Transmission Electron Microscopy, *Nano Letters* **14**, 1903-1908 (2014).
9. A. Bleloch and A. R. Lupini, "Imaging at the picoscale", *Materials Today* **7** (12), 42 (2004).
10. P.D. Nellist, M. F. Chisholm, N. Dellby, O. L. Krivanek, M. F. Murfitt, Z. S. Szilagyi, A. R. Lupini, A. Borisevich, W. H. Sides, Jr., and S. J. Pennycook, Direct Sub-Angstrom Imaging of a Crystal Lattice, *Science* **305**, (5691) 1741-1741 (2004).
11. M. Varela, S. D. Findlay, A. R. Lupini, H. M. Christen, A. Y. Borisevich, N. Dellby, O. L. Krivanek, P. D. Nellist, M. P. Oxley, L. J. Allen, and S. J. Pennycook, Spectroscopic imaging of single atoms within a bulk solid, *Phys Rev Lett*, **92**(9) 095502 (2004).
12. O. L. Krivanek, N. Dellby, A. R. Lupini, Towards sub-Angstrom electron beams, *Ultramicroscopy* **78**, (1-4), 1-11 (1999).

**Book Chapters:**

1. M. P. Oxley, A. R. Lupini and S. J. Pennycook, “Ultra-High Resolution Electron Microscopy”, *Reports on Progress in Physics*, (2016) 80(2):026101 DOI:10.1088/1361-6633/80/2/026101
2. “Scanning Transmission Electron Microscopy”, A. R. Lupini, S. N. Rashkeev, M. Varela, A. Y. Borisevich, M. P. Oxley, K. van Benthem, Y. Peng, N. de Jonge, G. M. Veith, T. J. Pennycook, W. Zhou, R. Ishikawa, M. F. Chisholm, S. T. Pantelides and S. J. Pennycook *Nanocharacterisation: Edition 2* Editors: Angus I Kirkland, Sarah J Haigh
3. Complex Oxide Materials. Pennycook, Stephen J. Lupini, Andrew R., Borisevich, Albina Y., Oxley, Mark P. *Handbook of Nanoscopy* 2012 p109-152.
4. The Electron Ronchigram, Andrew R. Lupini (2011) in *Scanning Transmission Electron Microscopy: Imaging and Analysis*, Springer, eds Stephen J. Pennycook & Peter D. Nellist
5. S. J. Pennycook, M. Varela, M. F. Chisholm, A. Y. Borisevich, A. R. Lupini, K. van Benthem, M. P. Oxley, W. Luo, J. M. McBride, S. J. Rosenthal, S. H. Oh, D. L. Sales, S. I. Molina, K. Sohlberg and S. T. Pantelides, “Scanning Transmission Electron Microscopy of Nanostructures,” pp. 205-248 in *Frontiers of Nanoscience and Nanotechnology*, Vol. 2, ed. A. V. Narlikar, Oxford University Press, Oxford, UK, 2009.
6. S. J. Pennycook, M. F. Chisholm, A. R. Lupini, M. Varela, K. van Benthem, A. Y. Borisevich, M. P. Oxley, W. Luo and S. T. Pantelides, “Materials Applications of Aberration-Corrected STEM”, pp. 327-384 in *Aberration-corrected Electron Microscopy*, ed. by P. W. Hawkes, Academic Press, Oxford, UK, 2008.
7. “Magnetron sputtering to prepare supported metal catalysts” G. M. Veith, A. R. Lupini, N. J. Dudney, “Metal nanoclusters in catalysis and materials science: The issue of size control”, Eds. B. Corain, G. Schmid, N. Toshima, Elsevier, pg 347-353 (2007)
8. “Scanning Transmission Electron Microscopy for Nanostructure characterization”, S. J. Pennycook, A.R. Lupini, M. Varela, A. Y. Borisevich, Y. Peng, M. P. Oxley and M. F. Chisholm in “*Advanced Scanning Microscopy for Nanotechnology*”, ed. By W. Zhou and Z.L. Wang. Springer. In press (2006)
9. “Scanning Transmission Electron Microscopy”. A.R. Lupini, S.N. Rashkeev, M. Varela, A.Y. Borisevich, M.P. Oxley, K. van Benthem, Y. Peng, N. de Jonge, G.M. Veith, M.F. Chisholm and S.J. Pennycook, in “*Nanocharacterization*”, edited by the Royal Society of Chemistry, United Kingdom. (2006).
10. “The use of Magnetron Sputtering for the Production of Heterogeneous Catalysts” G. M. Veith, A. R. Lupini, S. J. Pennycook, N. J. Dudney, in *Studies of Surface Science and Catalysis - Vol.162*, Eds. E.M. Gaigneaux, M. Devillers, D.E. De Vos, S. Hermans, P.A. Jacobs, J.A.Martens and P. Ruiz., Elsevier, New York, New York, pg 71 (2006).

**Invited talks** (as presenting author only):

- IMC 2023, Scanning Transmission Electron Microscopy for Quantum Materials, Busan, South Korea, 09/11/2023.
- MRS 2022, “Atomic scale dopant control”, Boston, 12/01/2022.
- Microscopy and Microanalysis conference, “Accurately Imaging, Tracking and Moving Single Atoms”, 8/6/2020.
- ORNL PSD Seminar, “Imaging and Controlling Single Atoms”, 2019/07/19 Oak Ridge, TN
- Invited Seminar at University of Vienna, “Imaging and Controlling Single Atoms with an Electron Beam” 2019/03/28.

- Invited Seminar at Arizona State University, “Imaging and Controlling Single Atoms with an Electron Beam” 2018/11/26.
- Invited Talk at FEMMS conference, “Imaging and Controlling Single Atoms with an Electron Beam” 2019/9/6, Asheville, NC.
- Microscopy and Microanalysis 2017 (pre-meeting), “*STEM in the XXI century: 4D-imaging & single atom manipulation*”. St. Louis, MO, 6<sup>th</sup> Aug 2017
- CNMS user meeting 2017, “Aberration corrected STEM” ORNL CNMS, Oak Ridge, TN, 3<sup>rd</sup> Aug 2017.
- Nion Swift Workshop 2017, “*Beam Control with Swift and SuperScan*”, 3<sup>rd</sup> March 2017. Bad-Mitterndorf, Austria.
- CNMS User Meeting: Big, Deep, and Smart Data Analytics in Materials Imaging, “*Electron Ptychography in STEM*”, 10<sup>th</sup> June 2016. Oak Ridge National Laboratory, Oak Ridge, TN.
- Lupini, A.R., et al. Microscopy and Microanalysis 2016, “*Fast Aberration Measurement in Multi-Dimensional STEM*”. Columbus, OH.
- Nion Swift Workshop, 10th August 2015, “Electron Ptychography in STEM”, Kirkland, WA
- Quantum Computing Workshop, 20th July 2015, “Single Atom Analysis with Electron Microscopy: Locating a Single Dopant Atom”, ORNL, Oak Ridge, TN.
- Joint NSRC Meeting: Big, Deep, and Smart Data Analytics in Materials Imaging, “Electron Ptychography in STEM”, 10th June 2015. Oak Ridge National Laboratory, Oak Ridge, TN.
- Materials Characterization Short Course, “Aberration Corrected STEM”, 6th May 2015. University of Tennessee, Knoxville, TN.
- Data Acquisition and Analysis in the STEM, Nion Swift meeting, Reykjavik, Iceland, 24th March 2014.
- Principles of Aberration Correction and Measurement, SuperSTEM School, SuperSTEM facility, Daresbury, U.K., 4th July 2014.
- Lupini, A.R. Mapping Single Dopants with Quantitative STEM, Materials Science Dept, Oxford University, U.K., 9th July 2014.
- “Measurement and Diagnosis of Aberrations for HRTEM: Current Status and Future Prospects” 2011 MSA Pre-Meeting Congress, Nashville TN, Sunday, 8/7/2011.
- “3D STEM for Imaging Biological Samples and Nanoparticles” A.R. Lupini, S.J. Pennycook, N. de Jonge, Microscopy and Microanalysis 2011, Nashville TN, 8/9/2011.
- Theory and Techniques of Aberration-Corrected Microscopy, In week intensive workshop, Microscopy and Microanalysis 2011.
- “High resolution 300kV EELS” *EDGE 2009*: International EELS-Workshop, Banff, Alberta, Canada, May 17-22, 2009.
- 16. “Seeing Materials Through New Eyes” Invited talk at University of Missouri-Kansas City, April 17, 2009.
- 15. 3-hour workshop-tutorial: “Aberration Corrected STEM” *Microscopy and Microanalysis 2008*, Albuquerque, NM, Aug 5-9 2008.
- “Applications of Aberration-Corrected STEM” *Microscience 2008*, London, UK, June 23-26, 2008.
- “Aberration-Corrected Imaging in the STEM,” *Microscopy and Microanalysis 2007*, Ft. Lauderdale FL, Aug 6 – 9, 2007.
- “Aberration Corrected STEM” *Microscopy and Microanalysis pre-meeting congress*, Chicago, IL, July 29-30, 2006.

- “Aberration Corrected STEM: Some Implications and Applications” *The Second SuperSTEM summer school*, Cambridge, UK, June 23-25, 2006.
- “Aberration Corrected STEM Analysis of Nanowires” *American Institute of Chemical Engineering annual meeting*, Cincinnati, OH, October 30-November 4, 2005.
- “Materials Applications of Aberration corrected STEM and EELS” *Analytical Electron Microscopy Meeting*, Makuhari, Japan, August 30-31, 2005
- “Sub-Angstrom Aberration corrected STEM” *Microscopy and Microanalysis Annual Meeting*, Honolulu, Hawaii, July 31-August 4, 2005.
- “Aberration-Corrected STEM for Understanding of the Catalytic Mechanisms and Development of New Catalysts” *Microscopy and Microanalysis Annual Meeting*, Honolulu, Hawaii, July 31-August 4, 2005.
- “Sub-Anstrom and Sub-half-eV Analysis by STEM”, *Enhanced Data Generated by Electrons, EDGE2005 Meeting*, May 1-5, Grunlsee, Austria, 2005.
- “Applications of STEM and EELS to Nanoscience”, *Third International Workshop on Nanoscale Spectroscopy and Nanotechnology*, December 10-14, 2004, College Park, MD, 2004.
- “Prospects for Single Atom Location and Identification with Aberration-Corrected STEM”, *Microscopy of Semiconducting Materials*, Cambridge, UK, March 31-April 3, 2003.
- “Aberration Correction – A Revolution in Electron Microscopy”, Invited talk at North Carolina State University, Aug, 2002.
- “Aberration Corrected STEM: Towards the ultimate resolution for imaging and analysis”, *XIX Congress and General Assembly of the International Union of Crystallography*, Geneva, Switzerland, August 6-15, 2002.
- “Developments in Cs-Corrected STEM”, *Electron Microscopy and Analysis Group meeting*, Dundee, UK, September 5-7, 2001.