

Rajiv Giridharagopal, Ph.D.

Department of Chemistry
University of Washington
Seattle, WA

+1-206-395-9763
raj@rajgiri.net, rgiri@uw.edu
www.rajgiri.net

EDUCATION

| | |
|---|------|
| Ph.D. in Electrical and Computer Engineering, Rice University | 2010 |
| <i>Scanning Probe Analysis of Polydiacetylene Nanowires and Poly(3-Hexylthiophene) Thin Films</i> | |
| M. S. in Electrical and Computer Engineering, Rice University | 2007 |
| B. S. in Electrical Engineering (high honors), University of Texas at Austin | 2004 |

RESEARCH EXPERIENCE

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| Senior Research Scientist | 2015 – present |
| <i>Ginger Lab, University of Washington, Department of Chemistry, Seattle, WA</i> | |
| • Managed the atomic force microscopy research subgroup | |
| • Expanded the lab's research into several new areas: ion transport devices, applying data science methods to "big data" microscopy, new instrumentation development | |
| • Developed large suite of code (Python, C++) for acquiring and analyzing microscopy and transistor data | |
| • Actively collaborated across departments and universities on grants and papers | |
| Failure Analysis and Microscopy Tool Development Engineer | 2012 – 2015 |
| <i>Intel, Hillsboro, OR</i> | |
| • Led development of several new microscopy tools for 14 nm and 10 nm manufacturing | |
| ◦ Patented a visible laser voltage probing (LVP) technique | |
| ◦ Published the first atomic force microscopy imaging of functioning processors | |
| ◦ Developed electron beam probing for through-silicon imaging | |
| • Company-wide award for super-resolution/structured illumination microscopy of processors | |
| • Managed joint Intel-external vendor developments including first-of-kind optical tools | |
| Postdoctoral Researcher with Prof. David S. Ginger | 2009 – 2012 |
| <i>University of Washington, Department of Chemistry, Seattle, WA</i> | |
| • Patented sub-microsecond time-resolved electrostatic force microscopy (trEFM) technique | |
| • Studied organic solar cells using photoconductive atomic force microscopy (pcAFM) and trEFM | |
| Graduate Researcher with Prof. Kevin F. Kelly | 2004 – 2009 |
| <i>Rice University, Department of Electrical and Computer Engineering, Houston, TX</i> | |
| • Scanning tunneling microscopy studies of polymer nanostructures, ultrahigh vacuum and ambient | |
| Honors Scholar Researcher | 2003 – 2004 |
| <i>Applied Research Labs, Austin, TX</i> | |

PATENTS

- "Visible Laser Probing for Circuit Debug and Defect Analysis." T. M. Eiles, **R. Giridharagopal**, D. N. Shykind. Patent 9,651,610

- "Sub-Microsecond-Resolution Time-Domain Time-Resolved Electrostatic Force Microscopy." D. S. Ginger, **R. Giridharagopal**, D. T. Moore, O. G. Reid, G. E. Rayermann. Patent Number 8,686,358

PUBLICATIONS (1000+ CITATIONS, H-INDEX 18)

Journal Articles

- **R. Giridharagopal**, J. Guo, J. Kong, D. S. Ginger. "Nanowire Architectures Improve Uptake Kinetics in Conjugated Polymer Electrochemical Transistors." *ACS Applied Materials and Interfaces* **13**, 34616-34624 (2021).
- D. E. Shea, **R. Giridharagopal**, D. S. Ginger, S. L. Brunton, and J. Nathan Kutz. "Extraction of Instantaneous Frequencies and Amplitudes in Nonstationary Time-Series Data." *IEEE Access*. **9**, 83453-83466 (2021).
- J. Yu, **R. Giridharagopal**, Y. Li, K. Xie, J. Li, T. Cao, X. Xu, D. S. Ginger. "Imaging Graphene Moiré Superlattices via Scanning Kelvin Probe Microscopy." *Nano Letters* **21**, 3280-3286 (2021)
- E. Jedlicka, J. Wang, J. Mutch, Y.-K. Jung, P. Went, J. Mohammed, M. Ziffer, **R. Giridharagopal**, A. Walsh, J.-H. Chu, and D. S. Ginger. "Bismuth Doping Alters Structural Phase Transitions in Methylammonium Lead Tribromide Single Crystals." *Journal of Physical Chemistry Letters* **12**, 2749 (2021).
- Y. Gong, R. Qiu, C. Niu, J. Fu, E. Jedlicka, **R. Giridharagopal**, Q. Zhu, Y. Zhou, W. Yan, S. Yu, J. Jiang, S. Wu, D. S. Ginger, W. Huang, and H. Xin. "Ag Incorporation with Controlled Grain Growth Enables 12.5% Efficient Kesterite Solar Cell with Open Circuit Voltage Reached 64.2% Shockley–Queisser Limit." *Advanced Functional Materials* 2101927 (2021).
- Y. Gong, Y. Zhang, E. Jedlicka, **R. Giridharagopal**, J. A. Clark, W. Yan, C. Niu, R. Qiu, J. Jiang, S. Yu, S. Wu, H. W. Hillhouse, D. S. Ginger, W. Huang, and H. Xin. "Sn⁴⁺ Precursor Enables 12.4% Efficient Kesterite Solar Cell from DMSO Solution with Open Circuit Voltage Deficit below 0.30 V." *Science China Materials* **64**, 52 (2021).
- F. Jiang, J. Pothoof, F. Muckel, **R. Giridharagopal**, J. Wang, and D. S. Ginger. "Scanning Kelvin Probe Microscopy Reveals That Ion Motion Varies with Dimensionality in 2D Halide Perovskites." *ACS Energy Letters* **6**, 100 (2021).
- J. Jiang, **R. Giridharagopal**, E. Jedlicka, K. Sun, S. Yu, S. Wu, Y. Gong, W. Yan, D. S. Ginger, M. A. Green, X. Hao, W. Huang, and H. Xin. "Highly Efficient Copper-Rich Chalcopyrite Solar Cells from DMF Molecular Solution." *Nano Energy* **69**, 104438 (2020).
- **R. Giridharagopal**, J. T. Precht, S. Jariwala, L. Collins, S. Jesse, S. V. Kalinin, D. S. Ginger. "Time-Resolved Electrical Scanning Probe Microscopy of Layered Perovskites Reveals Spatial Variations in Photoinduced Ionic and Electronic Carrier Motion." *ACS Nano* **13**, 2812-2821 (2019)
- J. S. Harrison, D. A. Waldow, P. A. Cox, **R. Giridharagopal**, M. Adams, V. Richmond, S. Modahl, M. Longstaff, R. Zhuravlev, D. S. Ginger. "Noncontact Imaging of Ion Dynamics in Polymer Electrolytes with Time-Resolved Electrostatic Force Microscopy." *ACS Nano* **13**, 536-543 (2018).
- A. Fakharuddin, M. Seybold, A. Agresti, S. Pescetelli, F. Matteocci, M. I. Haider, S. T. Birkhold, H. Hu, **R. Giridharagopal**, M. Sultan, I. M. Sero, A. Di Carlo, L. Schmidt-Mende. "Perovskite-Polymer Blends Influencing Microstructure, Non-Radiative Recombination Pathways and Photovoltaic Performance of Perovskite Solar Cells." *ACS Applied Materials & Interfaces* **10**, 42542-42551 (2018)
- L. Q. Flagg, **R. Giridharagopal**, J. Guo, D. S. Ginger. "Anion-Dependent Doping and Charge Transport in Organic Electrochemical Transistors." *Chemistry of Materials* **30**, 5380-5389 (2018).
- J. Kong, **R. Giridharagopal**, J. S. Harrison, D. S. Ginger. "Identifying Nanoscale Structure-Function Relationships Using Multimodal Atomic Force Microscopy, Dimensionality Reduction, and Regression Techniques." *Journal of Physical Chemistry Letters* **9**, 3307-3314 (2018).

- S. T. Birkhold, J. T. Precht, **R. Giridharagopal**, G. E. Eperon, L. Schmidt-Mende, D. S. Ginger. "Direct Observation and Quantitative Analysis of Mobile Frenkel Defects in Metal Halide Perovskites Using Scanning Kelvin Probe Microscopy." *Journal of Physical Chemistry C* **122**, 12633-12639 (2018).
- S. T. Birkhold, J. T. Precht, H. Liu, **R. Giridharagopal**, G. E. Eperon, L. Schmidt-Mende, X. Li, D. S. Ginger. "Interplay of Mobile Ions and Injected Carriers Creates Recombination Centers in Metal Halide Perovskites Under Bias." *ACS Energy Letters* **3**, 1279-1286 (2018).
- S. M. Vorpahl, **R. Giridharagopal**, G. E. Eperon, I. M. Hermes, S. A. L. Weber, D. S. Ginger. "Orientation of Ferroelectric Domains and Disappearance upon Heating Methylammonium Lead Triiodide Perovskite from Tetragonal to Cubic Phase." *ACS Applied Energy Materials* **1**, 1534-1539 (2018).
- **R. Giridharagopal**, L. Q. Flagg, J. S. Harrison, M. E. Ziffer, J. Onorato, C. K. Luscombe, D. S. Ginger. "Morphology-Induced Variations in Ion Uptake and Performance in Organic Electrochemical Transistors Probed with Electrochemical Strain Microscopy." *Nature Materials* **16**, 767 (2017).
- P. A. Cox, L. Q. Flagg, **R. Giridharagopal**, D. S. Ginger. "Cantilever Ringdown Dissipation Imaging for the Study of Loss Processes in Polymer/Fullerene Solar Cells." *Journal of Physical Chemistry C* **120**, 12369 (2016).
- D. U. Karatay, J. S. Harrison, M. S. Glaz, **R. Giridharagopal**, D. S. Ginger. "Fast Time-Resolved Electrostatic Force Microscopy: Achieving Sub-Cycle Time Resolution." *Review of Scientific Instruments* **87**, 053702 (2016).
- G. Gramse, E. Brinciotti, A. Lucibello, S. B. Patil, M. Kasper, C. Rankl, **R. Giridharagopal**, P. Hinterdorfer, R. Marcelli, F. Kienberger. "Quantitative Sub-Surface and Non-Contact Imaging Using Scanning Microwave Microscopy." *Nanotechnology* **26**, 135701 (2015).
- Max. Pech-Canul, **R. Giridharagopal**, Mar. Pech-Canul, E. Coral-Escobar. "Corrosion Characteristics of an Al-1.78%Si-13.29%Mg Alloy in Chloride Solutions." *Journal of Materials Engineering and Performance* **22**, 3922-3932 (2013)
- **R. Giridharagopal**, G. E. Rayermann, G. Shao, D. T. Moore, O. G. Reid, A. F. Tillack, D.J. Masiello, and D. S. Ginger. "Sub-Microsecond Time Resolution Atomic Force Microscopy for Probing Nanoscale Dynamics." *Nano Letters* **12**, 893-898 (2012)
- **R. Giridharagopal**, J. Zhang, and K. F. Kelly. "Antenna-Based Ultrahigh Vacuum Microwave Frequency Alternating Current Scanning Tunneling Microscopy System." *Review of Scientific Instruments* **82**, 053710 (2011) [cover article]
- A. H. Rice, **R. Giridharagopal**, S. X. Zheng, F. S. Ohuchi, D. S. Ginger, C. K. Luscombe. "Controlling Vertical Morphology Within the Active Layer of Organic Photovoltaics Using Poly(3-Hexylthiophene) Nanowires and Phenyl-C₆₁-Butyric Acid Methyl Ester." *ACS Nano* **5**, 3132-3140 (2011)
- J. H. Worne, **R. Giridharagopal**, K. F. Kelly, and D. Natelson. "Interfacial Charge Transfer in Nanoscale Polymer Transistors." *Nano Research* **1**, 341-350 (2008)
- **R. Giridharagopal** and K. F. Kelly. "Substrate-Dependent Properties of Polydiacetylene Nanowires on Graphite and MoS₂." *ACS Nano* **2**, 1571-1580 (2008)
- **R. Giridharagopal** and K. F. Kelly. "STM-Induced Desorption of Polydiacetylene Nanowires and Reordering Via Molecular Cascades." *Journal of Physical Chemistry C* **111**, 6161-6166 (2007)
- P. Landon, J. Gutierrez, J. Ferraris, I. Martinez, **R. Giridharagopal**, et al. "Inverse Gold Photonic Crystals and Conjugated Polymer Coated Opals for Functional Materials." *Physica B: Condensed Matter* **338**, 165-170 (2003)

Reviews

- **R. Giridharagopal**, P. A. Cox, D. S. Ginger. "Functional Scanning Probe Imaging of Nanostructured Solar Energy Materials." *Accounts of Chemical Research* **49**, 1769 (2016).
- **R. Giridharagopal**, G. Shao, C. Groves, and D. S. Ginger. "New SPM Techniques for Analyzing OPV Materials." *Materials Today* **19**, 50-56 (2010).
- **R. Giridharagopal** and D. S. Ginger. "Characterizing Morphology in Bulk Heterojunction Organic Photovoltaic Systems." *Journal of Physical Chemistry Letters* **1**, 1160-1169 (2010).

Conference Proceedings

- **R. Giridharagopal**, T. M. Eiles, B. Niu. "Near-Field Scanning Optical Microscopy for Through-Silicon Imaging and Fault Isolation of Integrated Circuits." In *40th International Symposium on Test and Failure Analysis*, Houston, p. 299-303 (2014)
- **R. Giridharagopal** and K. F. Kelly. "Atomic-Scale Analysis of Polydiacetylene Nanowires by Scanning Tunneling Microscopy", In *7th IEEE International Conference on Nanotechnology*, Hong Kong, p. 1002-1006 (2007)

Book Chapters

- **R. Giridharagopal**, G. E. Rayermann, D. S. Ginger. "Electrical Scanning Probe Microscopy on Solar Cell Materials." In *Scanning Probe Microscopy for Energy Research*. D. A. Bonnell, S. V. Kalinin, eds. World Scientific, NJ, p. 39-71 (2013).

SELECTED INVITED CONFERENCE PRESENTATIONS

- **R. Giridharagopal**, D. S. Ginger. "Advances in Multimodal Scanning Probe Microscopy at the Nanoscale." nanoGe Fall Meeting. Berlin, Germany (2019)
- **R. Giridharagopal**, "AFM Characterization of Emerging Photovoltaics." *Materials Research Society Webinar*. (2018)
- **R. Giridharagopal**. "Electrical and Optoelectronic AFM: From Solar Cells to Electrochemical Transistors." *Asylum Research Workshop at University of Washington*. Seattle, WA (2018).
- **R. Giridharagopal**, G. E. Rayermann, D. T. Moore, O. G. Reid, D. S. Ginger. "Time-Resolved Electrostatic Force Microscopy for Organic Photovoltaics Applications." Presentation to Asylum Research. Santa Barbara, CA (2010)
- **R. Giridharagopal**, L. S. C. Pingree, O. G. Reid, and D. S. Ginger. "Probing Polymer Photocurrents: Imaging Photocurrents in Organic Solar Cells." *Electronics Packaging Symposium at GE Research*, Niskayuna, NY (2010)

HONORS

- Intel Achievement Award Nominee (2015)
- Intel Logic Technology Development Division Award (2013)
- CISSEM Innovative Research Seed Award (collaborative with U-Arizona, 2011)
- National Science Foundation Graduate Research Fellowship (2005-2008)
- Shell Corporation Award, Rice Quantum Institute Colloquium (2008)
- Micron Technology Award, Rice Quantum Institute Colloquium (2005)
- Honors Scholar Award from Applied Research Labs (2003-2004)
- Ernest J. Cockrell Scholarship in Engineering (2000-2004)
- Engineering Scholar Award (2002)
- National Merit Finalist Awardee (2000-2004)