

Venkatraman Gopalan

Professor, Department of Materials Science and Engineering (home), Physics (courtesy)
and Engineering Science and Mechanics (courtesy)
Materials Research Institute
Pennsylvania State University, University Park, PA 16802
Email: vgopalan@psu.edu; Tel: (814) 865-2910

EDUCATION

- Cornell University**, Ithaca, NY, USA *May 1995*
 - Ph. D. in Materials Science and Engineering
 - M. S. in Materials Science and Engineering *August 1991*
- Indian Institute of Technology**, Madras, India *August 1989*
 - B. Tech, Metallurgical Engineering

AWARDS

- Distinguished Alumni Award, IIT Chennai (Madras)** *February 2024*
 - Awarded by the Indian Institute of Technology, Chennai
- Fellow, American Ceramics Society** *October 2023*
 - Awarded by the American Physical Society
- **Wilson Faculty Fellowship** *November 2022*
 - Awarded by the College of Earth and Mineral Sciences at Penn State.
- **David J. Green Materials Faculty Service Award** *April 2022*
 - Awarded by MatSE at Penn State.
- **Wilson Award for Excellence in Service** *April 2019*
 - Awarded by EMS at Penn State.
- **CREATIV** *August 2015*
 - Invited grant awarded by the National Science Foundation, Division of Materials Research.
- **MatSE Faculty Member of the Year** *Spring 2015*
 - Nominated / Selected by the students.
- **Faculty Mentoring Award** *Spring 2014*
 - Awarded by the College of Earth and Mineral Sciences for mentoring young faculty
- **Fellow, American Physical Society** *Nov 2012*
 - Awarded by the American Physical Society
- **Faculty Scholar Medal** *May 2012*
 - Awarded by Pennsylvania State University in all of Engineering
- **Richard M. Fulrath Award** *Oct. 2009*
 - American Ceramics Society, in recognition of US-Japan collaborations
- **Eshbach Faculty Fellowship** *Jan. 2007*
 - Northwestern University, as a visiting faculty fellow
- **Wilson Award for Excellence in Research** *April 2005*
 - Awarded by Penn State.
- **National Research Council Summer Faculty Fellowship** *May 2004*
 - Eight-week research at Wright Patterson Air Force Base, Dayton, OH.
- **Corning Faculty Fellowship in Ceramics Science and Engineering** *June 2004*
 - Granted by Corning Inc. and Materials Science and Engineering Dept. at Penn state
- **Robert R. Coble Award** *April 2002*
 - Awarded by the American Ceramic Society for a young researcher
- **NSF Career Award** *Feb. 2000*

Awarded by the National Science Foundation
- **Director-funded Fellowship** Sept. 1996
Los Alamos National Laboratory

EXPERIENCE

- **Associate Director (2014-2020) & Group Leader (2008 -2020)**,
NSF-MRSEC Center for Nanoscale Science, Pennsylvania State University
- **Visiting Faculty (Eschbach Fellow)** 2007
Northwestern University, Evanston, IL
- **Visiting Faculty (Sabbatical)** 2006
Stanford University, Palo Alto, CA, and U. California Berkeley, Berkeley, CA
Worked on Magneto-optic and nonlinear optical probing of multiferroics (M. M. Fejer, A. Kapitulnik, R. Ramesh).
- **Associate Director, Center for Optical Technologies** 2003-2010
Pennsylvania State University, University Park, PA 16802
Joint center between Lehigh University and Penn State universities. Setting center's research directions, and managed 3 million dollars research funds over 6 years at Penn State.
- **Professor, Department of Materials Science and Engineering** 2008-present
- Associate Professor of Materials Science and Engineering, 2004-2008
- Assistant Professor of Materials Science and Engineering, 1999-2004
Pennsylvania State University, University Park, PA 16802
Established a research program in optical and electronic materials and devices, in particular complex oxides, metamaterials, and symmetry explorations. Teaching undergraduates and graduates in the Dept. of Materials Science and Engineering.
- **Director funded Post-Doctoral Fellow** Sept 1996- Nov 1998
Los Alamos National Laboratory, Center for Materials Science, Los Alamos, NM
Initiated several funded programs internally on complex oxides. Developed the Electro-Optic Imaging Microscope (EOIM) to image ferroelectric domain motion in real-time.
- **Post Doctoral Research Fellow** March 1995 -August 1996
Carnegie Mellon University, Dept. of Electrical and Computer Engr., Pittsburgh, PA: Demonstrated the *first* integrated solid-state device consisting of a solid-state blue laser and a scanner, all built on the same crystal.

ADVISING

Graduated with Thesis

1. Lujin Min (2023) *Studies of Quantum Transport and Magnetic Properties of Novel Materials*, October (2023) (co-advised with Prof. Zhiqiang Mao).
2. Jingyang He, Ph. D. *Design and Discovery of High-Performance Nonlinear Optical Crystals for Laser Applications*, August (2023) (works at Samsung) *Alumni Association Dissertation Award 2023, Graduate Research Poster Competition, Penn State 2023, Robert E. Newnham Award for Research Excellence 2022*
3. Rui Zu, Ph.D. #SHAARP, *An Open-source Package for Modeling Nonlinear Optical Processes for Integrated Photonics*, August (2023) (working at 3M) *Alumni Association Dissertation Award 2023*
4. Huaiyu (Hugo) Wang, Ph.D. *Phonons at Phase Boundaries in electronic and Structural Transitions*, May (2023) (Postdoc at Stanford/SLAC) *Robert E. Newnham Award for Research Excellence 2022*
5. Devin Goodling, Masters, *Compositional Dependence of Ferroelectric Properties in Thin Film $Zn_{1-x}Mg_xO$* , May (2023) (works at Northrop Grumman)

6. Haricharan Padmanabhan, Ph.D. *Illuminating Spin-Lattice Coupling Pathways in Layered Magnets*, (2021) (Postdoc at Harvard) *Robert E. Newnham Award for Research Excellence 2018*
7. Disha Talreja, Ph.D. *Time-Domain Thermoreflectance Probing of Tunable Thermal Transport in Silicon Metalattices*, (2020) (postdoc at University of Pennsylvania; presently at Intel).
8. Alexander Hendrickson (co-advised with J. Badding), Ph. D. *Synthesis and Design of Zinc Selenide and Multi-Material Optical Fibers for High Power Mid-Infrared Applications*, (2020) (Postdoc at Sandia National Laboratory).
9. Carly Mathewson, Masters, *Design of a high thermal expansion coefficient, high glass transition temperature glass for fiber optic use*, (2020) (pursuing PhD in Chemistry at Penn State).
10. Yakun Yuan, Ph. D, *Probing Emergent Phenomena in Complex Oxides away from the Ground States*, Ph.D. Dissertation (2018). (postdoc at UCLA / Lawrence Berkeley).
11. Yoonsang Park, Masters, *Spectroscopic Ellipsometry study on transparent conducting metal SrNbO₃*, Masters Dissertation (2018). (Ph.D. at Penn State).
12. Shiming Lei, Ph.D., *Coupled Phenomena in domains and domain walls in complex polar oxides*, Ph.D. Dissertation (2017). (Currently a postdoc at Princeton University; applying for faculty positions). *The Howard and Jean Beaver Award, May 2013; Intercollege Graduate Student Outreach Achievement Award for 2016-17*.
13. Xiaoyu Ji, Ph. D, *Semiconductor fabrics and single crystal fibers for optoelectronic applications*, Ph.D. Dissertation (2017). (Manager at Microvision).
14. Ryan C. Haislmaier, Ph. D, *Strain-induced phenomena in complex oxide thin films*, Ph.D. Dissertation (2016). (working at Intel).
15. Arnab SenGupta, Ph. D, *Topochemical synthesis & characterization of octahedral rotation induced noncentrosymmetric layered perovskites*, Ph.D. dissertation, (2016). (working at Intel)
16. Brian K. VanLeeuwen, Ph.D., *The symmetry and antisymmetry of distortions*, Ph.D. dissertation, (2015). (Analyst at Two Sigma) *Rustum and Della Roy Innovation in Materials Research Award*.
17. Jessica Leung, Masters, *Emergent monoclinic phase in KNbO₃ discovered using optical second harmonic generation*, Master's thesis, (2011). (working at Northrop Grumman)
18. Eftihia Vlahos, Ph. D, *Phase transitions and domain structures in multiferroics*, Ph.D. dissertation, (2011). (staff scientist at Los Alamos National Laboratory)
19. Mahesh Krishnamurthy, Ph. D, *Optoelectronic materials for sub-wavelength imaging and laser beam manipulation*, Ph.D. dissertation, (2010). (group leader, for lidar at Lyft, San Francisco)
20. Amit Kumar, Ph. D, *Spin-charge lattice coupling in multiferroics and strained ferroelectrics*, Ph.D. dissertation, (2009). (Senior Lecturer, School of Mathematics and Physics, Queens University, Belfast)
21. V. Aravind, Ph. D, *Probing local structure and dynamics of ferroelectric domain walls using nonlinear optics and scanning probe microscopy*, PhD dissertation (2009). (Professor in Mathematics and Physics, Penn West University)
22. L. Tian, Ph. D, *Nanoscale probing and photonic applications of ferroelectric domain walls*, PhD dissertation (2006). (working at Newport, Inc)
23. E. Vlahos, Masters, *High dynamic range, long-arm autocorrelation measurements of ultrashort pulses used in femtosecond laser micromachining* (2005). (staff scientist at Los Alamos National Laboratory). *NSF Graduate Fellow*
24. D. Scrymgeour, Ph. D, *Local structure and shaping of domain walls for photonic applications*, PhD dissertation (2004). (Staff scientist, Sandia National Labs) awarded the *Truman Fellowship at Sandia, the National Research Council Fellowship, and the International Center for Young Scholars Fellowship from Japan*.
25. S. Kim, Ph. D, *Optical, electrical and elastic properties of domain walls in lithium niobate and lithium tantalate*, PhD dissertation (2003). (working at Intel Inc.) *Alumni dissertation award*
26. C. Lin, Masters, *Structure-optical property relations in proton exchanged waveguides in stoichiometric lithium niobate*, Masters Thesis (2003). (Director of Corporate Development Department in TSRC).

Graduate Students (Current)

- Lujin Min, Ph. D. (co-advised with Prof. Z. Mao)
 Nicole Drew, Ph.D. (co-advised with Prof. M. Bojowald)

Sankalpa Hazra, Ph. D.
Albert Suceava, Ph.D
Saugata Sarker, Ph. D.
Akash Saha, Ph.D
Yasuyuki Iwabuchi, Masters

Postdoctoral Scholars

1. Post-doc: Jadupati Nag (2023-present)
2. Post-doc: Carlos Perez (2023-present)
3. Research Associate Professor: Suguru Yoshida (2021-present)
4. Post-doc: Xiaojiang Li (2022-present)
5. Research Associate Professor (2022-): Vladimir Stoica; Post-doc (2015-2022);
6. Post-doc: Alexej Pogrebnyakov (2017-2021)
7. Post-doc: Shukai Yu (2019-2021)
8. Post-doc: Shashank Pandey (2017-2018); Currently working at Intel
9. Post-doc: Hirofumi Akamatsu (2013-2016); Associate Professor, Department of Applied Chemistry, Kyushu University, Japan
10. Post-doc: Sergey Nikitin (2015-2016), working at Intel.
11. Post-doc: Greg Stone (Sept 2012-2015), working at Army Research Labs, Picatinny, NJ.
12. Post-doc: Thomas Lummen (Feb 2010-2013); Microscopist, ETH Zurich, Switzerland
13. Post-doc: Baigang Zhang (Sept 2012-2013); Research Scientist, KLA Tencor
14. Post-doc: Eftihia Vlahos (2011-2012); Research Scientist, Los Alamos National Laboratory
15. Post-doc: Sava Denev (April 2005-April 2011); Working in a Bank in Canada
16. Post-doc: Neil Baril (August 2008-2009); Staff Scientist at Army Night Vision Lab.
17. Post-doc: Mariola Ramirez (August 2006-2008); Ramon y Cajal professor, Universidad Autónoma de Madrid
18. Post-doc: Hoonsoo Kang (September 2005-September 2006); Professor, GIST, South Korea.
19. Post-doc: Hui-Fang (April 2004-March 2005); working in a company (unknown).
20. Post-doc: Natalia Malkova (August 2001 – Jan 2004); staff scientist, National Institute for Standards and Technology, MD.
21. Post-doc: Alok Sharan (August 2001 - 2003); Professor, Pondicherry University, India
22. Post-Doc: Yaniv Barad (Summer 1999 - Jan 2001); Director of Engineering, New Ridge Technologies, MD
23. Senior Personnel: Joseph Stitt (May 2006 - 2009); Technical staff at Penn State University.

TEACHING

MatSE 435: Optical Properties of Materials
MatSE 540: Crystal Anisotropy
MatSE 504: Solid State Materials Physics

UNDERGRADUATE RESEARCH ADVISOR (41 STUDENTS):

1. Brynn Graybill, summer student, Grove City College (2024).
2. Javier Cano, summer student, U. C. Berkeley (2024).
3. Leonardo Ramos, summer student, Lewis University, IL (2023).
4. Brynn Graybill, summer student, Grove City College, PA (2023).
5. Javier Cano, summer student, University of California Berkeley (2022).
6. Jennifer Rittenhouse, summer student, Millersville college (2022).
7. Lincoln Weber, summer student, University of Southern Indiana (2021).
8. Caitlyn Martin, senior honors thesis, EScM (2020)
9. Rajeh Alsaadi, honors option in MatSE 435 (2020)

10. Christopher Jacobsen, Physics, Penn State (2019)
11. Ben Garland, Penn State (2019)
12. Bailey Nebgen, summer student, University of Minnesota (2019)
13. Vincent Liu, Freshman in Penn State, transferred to MIT. (2017) Published 3 papers: *Computational Materials*.5, 52 (2019)., *Acta Crystallographica A*74, 1-4 (2018)., *Physical Rev. B*, 98, 085107 (2018).
14. Silverio Delgado, Summer student from CSULA. (2017)
15. Taylor Repetto, Summer student from U. Florida. (2017)
16. Kathryn Sautter, Senior thesis;
17. Maggie Kingsland, University of Central Florida, REU in summer 2016. Authored a paper on space-time groups, published a paper on *Symmetry*, 9, 187 (2017).
18. Sarah Featherstone, Kansas State University, REU in summer 2016, worked on layered oxides as part of MRSEC Center for Nanoscale Science.
19. Byron Lara, REU from CSULA (Minority institution, predominantly Hispanic) in summer (2016).
20. Forrest Brown, undergraduate REU student. (2015) published 3 papers: *Advanced Funct. Mater.* (2018), 28, 1801856; *ACS Chemistry of Materials*, (2016); *Nature Chemistry*, 7, 1017-1023 (2015).
21. Ryan Page, REU student in summer (2015)
22. Pedro Valentin de Jesus, summer student from Puerto Rico (2014). *Acta Cryst. A*71, 150-160 (2015).
23. Aaron Claire, undergraduate, Penn State (2014)
24. Mantao Huang, senior thesis Penn State (2013). Published *Acta Crystallographica A*, A70, 373-381 (2014).
25. Ferdinando Romano, The Catholic University of America (2013)
26. Yifan Zhou, Undergraduate Research Fellow (2013)
27. Aaron Foster, Oklahoma Baptist University, (2011)
28. Xiaoran Fang, Penn State University, (2010)
29. Andrew Barnes (Penn State, Summer and Fall 2009)
30. Gabriella Shepard (Carnegie Mellon University, Summer 2009).
31. Bill Woodford, Honors thesis advisor, Penn State (2008).
32. Alex Adler, senior thesis, Penn State (2006)
33. Gaurav Mehta, Penn State University, (2005)
34. David Comstock, honors thesis MatSE, Penn State University (2003)
35. Luisa Soaterna, Summer *McNair Research Scholar*, Penn State University (2003).
36. Thomas J Dilazaro, honors thesis, ESM, (2002), Published in *Physical Review B*, 67, 125203 (2003).
37. Thomas Pribicko, honors option in MatSE 435, Penn State University (2002).
38. Evan Pickett, honors option, MatSE435, Penn State University (2002).
39. Steven Fulk, Senior thesis in MatSE (1999-2000).
40. Matthew Gentzel, senior honors thesis in EScM, Pennsylvania State University, published in *IEEE Journal of Lightwave Technology*, 23, 2772-2777 (2005).
41. Christopher Baxter, Electrical Engineering, Pennsylvania State University, (1999)
42. Charles C. Battle, MatSE (and later Aerospace engineering), Pennsylvania State University (1999). Published in *Appl. Phys Lett.*, 76, 2436-38 (2000).
43. Phillip Graham, Senior MatSE, Univ. Florida, Gainesville, summer (2000).
44. Sheila Chadman, undergrad Penn State Kensington, NSF-REU (2000)
45. Kelvin Ng, Physics, Penn State Kensington Campus, (2001).
46. Estefania Pickens, Computer science, Vanderbilt university (2001)
47. Henry Yee, Senior thesis, MatSE 435, Pennsylvania State University (2000)
48. Matthew Opitz, honors option in MSE435, Pennsylvania State University (1998)

BOOK CHAPTERS AND REVIEWS

1. Perspectives and progress on wurtzite ferroelectrics: Synthesis, characterization, theory, and device applications, Joseph Casamento, Steven M Baksa, Drew Behrendt, Sebastian Calderon, Devin Goodling, John Hayden, Fan He, Leonard Jacques, Seung Hoon Lee, Walter Smith, Albert Suceava, Quyen Tran, Xiaojun Zheng, Rui Zu, Thomas Beechem, Ismaila Dabo, Elizabeth C Dickey, Giovanni Esteves, Venkatraman Gopalan, Michael David Henry, Jon F. Ihlefeld, Thomas N Jackson, Sergei V Kalinin, Kyle P Kelley, Yongtao Liu, Andrew M Rappe, Joan Redwing, Susan Trolier-McKinstry, Jon-Paul Maria, *Appl. Phys. Lett.* 124, 080501 (2024).
2. *Antisymmetry: Fundamentals and Applications*, H. Padmanabhan, J. Munro, I. Dabo, V. Gopalan, *Annual Reviews of Materials Research*, **50**, 255, (2020).
3. Elastic strain engineering of ferroic oxides, D. G. Schlom, L. Q. Chen, C. J. Fennie, V. Gopalan, D. A. Muller, X.Q. Pan, R. Ramesh, R. Uecker, *MRS Bulletin*, **39**, 118-130 (2014) doi: 10.1557/mrs.2014.1
4. Investigating electric field control of magnetism, M. B. Holcomb, S. Polisetty, A. Fraile-Rodriguez, V. Gopalan, R. Ramesh, *Review article International J. Modern Physics B* **26**, 1230004-1/12 (2012).
5. Quantitative piezoelectric force microscopy: calibrated experiments, analytical theory, and finite element modeling, L. Tian, A. Vasudevarao, V. Gopalan, in *Scanning Probe Microscopy of Functional Materials: Nanoscale Imaging and Spectroscopy*, Editors, S. Kalinin, and A. Gruverman, Springer, New York (2010).
6. Defect-domain wall interactions in trigonal ferroelectrics, V. Gopalan, V. Dierolf, D. Scrymgeour, *Annual Reviews of Materials Research*, Editors: D. R. Clarke, V. Gopalan, **37**, pp. 449-489 (2007).
7. Probing Ferroelectrics using Optical Second Harmonic Generation, S. A. Denev, T. T. A. Lummen, E. Vlahos, V. Gopalan, *J. Amer. Cer. Soc.* 94[9], 2699-2727 (2011). <https://doi.org/10.1111/j.1551-2916.2011.04740.x>
8. Ferroelectric materials, V. Gopalan, K. Schepler, V. Dierolf, I. Biaggio, *Handbook of Photonics, Second Edition*, Editors: M. C. Gupta, J. Ballato, CRC Press LLC, FL. Pp. 6-1/67(2006).
9. Crystal growth, characterization, and domain studies in ferroelectric lithium niobate and tantalate, V. Gopalan, J. A. Aust, N. Sanford, K. Kitamura, Y. Furukawa in *Handbook of Advanced Electronic and Photonic materials*, Editor H. S. Nalwa, Vol. 4, p. 57-114, (Academic Press, NY) .

RESEARCH THEME

Symmetry and its applications to the physical world is at the core of my research interests. I am a materials scientist with a focus on condensed matter physics. The world of materials science is the world of atoms: the way atoms assemble, share electrons, move, rearrange under stimuli, and exhibit the plethora of emergent electrical, magnetic, optical, thermal, mechanical and chemical properties.

In this quest, my favorite tools are group theory and light-matter interactions.

Group theory is the mathematics underlying symmetry, and surprisingly much of modern physics as well. All laws of nature exhibit certain symmetries. When atoms organize themselves, their property tensors exhibit identical forms despite being very different; this is due to the underlying symmetry of the crystal structure. Thus, symmetry tools become essential to finding the underlying unity in diversity in the physical world.

Electromagnetic waves with frequencies ranging from x-rays to the ultraviolet, visible, infrared, terahertz and beyond interact with atoms and solids to resonantly illuminate atomic arrangements and electronic structure at high frequencies, to atomic vibrations, rotations, and magnetic order at lower frequencies.

My group therefore tries to understand crystalline matter starting from these two ends: On one end, we formulate and apply new group theory tools to understand matter. On the other, we perform experiments with lasers and x-rays to experimentally study the structure and properties of crystals. Current research interests in my group include ultrafast optics of strongly correlated electron systems, ferroelectrics and multiferroics, discovering new nonlinear

optical crystals for quantum optics, nonlinear optical microscopy, developing X-ray synchrotron diffraction techniques, group theory and discovering new symmetries in nature.

We thus straddle two worlds that bracket our approach to understanding our universe: experiments on one end and abstract theory ideas on the other, both directed towards meeting in the middle.

CONTRIBUTIONS TO SCIENCE

Lithium Niobate single crystals and photo-functional devices, K. Kitamura, N. Furukawa, V. Gopalan, T. E. Mitchell, 2001, US and Japan Patent # 6195197. & Lithium Tantalate single crystals and Photofunctional devices K. Kitamura, N. Furukawa, V. Gopalan, T. E. Mitchell, 2001, US and Japan patent # 6211999. These foundational patents based on the above-mentioned work on these crystals led to the founding of *Oxide Corp.*, one of the leading single crystal growth companies in the world today, by my collaborator, Y. Furukawa (Founder and CEO). It is based in Yamanashi, Japan. See link here: <https://www.opt-oxide.com/en/>. I was awarded the *Richard M. Fulrath award* by the American Ceramics Society in 2009 for this collaborative achievement.

Relativistic Spacetime Crystals, V. Gopalan, *Acta Crystallographica*, A77, 242-256 (2021) DOI: 10.13140/RG.2.2.31083.57126, cover page. Accompanying commentary article by Bojowald and Saxena at 10.1107/S2053273321005234; In this paper, I introduce a new transformation of space-time called renormalized blended spacetime (RBS) that transforms the hyperbolic geometry of flat Minkowski spacetime into a Euclidean RBS spacetime.

Spatio-Temporal Symmetry – Crystallographic Point Groups with Time Translations and Time Inversion, Vincent V. Liu, Brian K. VanLeeuwen, Haricharan Padmanabhan, Jason Munro, Ismaila Dabo, Venkatraman Gopalan and Daniel B. Litvin, *Acta Crystallographica* A74, 1-4 (2018). <https://doi.org/10.1107/S2053273318004667>; Double antisymmetry and rotation reversal space groups, B. K. VanLeeuwen, V. Gopalan, D. B. Litvin, *Acta Crystallographica* A, 70, 24-38 (2014). Doi: 10.1107/S2053273313023176; Crystallographic data of double antisymmetry space groups, M. Huang, B. K. VanLeeuwen, D. B. Litvin, V. Gopalan, *Acta Crystallographica* A, A70, 373-381 (2014). doi:10.1107/S2053273314006871; These papers represent examples of group theory contributions from our group in being the first to list all spatio-temporal symmetry groups, and all 17,803 groups with two antisymmetries, so called double antisymmetry groups.

Antisymmetry: Fundamentals and Applications, H. Padmanabhan, J. Munro, I. Dabo, V. Gopalan, *Annual Reviews of Materials Research*, 50, 255, (2020). In addition to an overview of known antisymmetries, this review article summarizes our group's introduction of two new antisymmetries, namely *distortion reversal antisymmetry* and *wedge reversion antisymmetry*.

Antisymmetry of Distortions, Brian K. VanLeeuwen, V. Gopalan, *Nature Communications*, 6, 8818 (2015) doi:10.1038/ncomms9818; Implementation of Distortion Symmetry for the Nudged Elastic Band Method with DiSPy, arXiv:1810.01911v1 [cond-mat.mtrl-sci]. Jason M. Munro, Vincent S. Liu, Venkatraman Gopalan, and Ismaila Dabo, *npj Computational Materials*. 5, 52 (2019). <https://doi.org/10.1038/s41524-019-0188-x> ; Discovering minimum energy pathways via distortion symmetry groups, Jason M. Munro, Hirofumi Akamatsu, Haricharan Padmanabhan, Vincent S. Liu, Yin Shi, Long-Qing Chen, Brian K. VanLeeuwen, Ismaila Dabo, and Venkatraman Gopalan, *Phys. Rev. B*, 98, 085107 (2018). DOI: 10.1103/PhysRevB.98.085107. arXiv:1804.06798 [cond-mat.mtrl-sci]. We conceived and applied distortion reversal antisymmetry, a symmetry capturing a change in the configuration of a system, to a variety of physical phenomena ranging from atomic diffusion to molecular vibrations, and domain wall switching in ferromagnets and ferroelectrics to find the minimum energy pathways that the physical system

would take in making the change. We developed a software code called DisPy to apply this symmetry in computations.

Wedge Reversion Antisymmetry and Forty-One Types of Physical Quantities in Arbitrary Dimensions, Venkatraman Gopalan, arXiv:1910.09286 [physics.gen-ph] *Acta Crystallographica*, **A26**, 318-327 (2020).

Doi:10.1107/S205327332000217X. This work classifies all physical properties in any spatial dimension into one of 41 types, using three antisymmetries: spatial inversion, time reversal, and a new one I introduce here, namely, wedge reversion.

Subterahertz collective dynamics of polar vortices, Qian Li, Vladimir A Stoica, Marek Paściak, Yi Zhu, Yakun Yuan, Tiannan Yang, Margaret R McCarter, Sujit Das, Ajay K Yadav, Suji Park, Cheng Dai, Hyeon Jun Lee, Youngjun Ahn, Samuel D Marks, Shukai Yu, Christelle Kadlec, Takahiro Sato, Matthias C Hoffmann, Matthieu Chollet, Michael E Kozina, Silke Nelson, Diling Zhu, Donald A Walko, Aaron M Lindenberg, Paul G Evans, Long-Qing Chen, Ramamoorthy Ramesh, Lane W Martin, Venkatraman Gopalan, John W Freeland, Jirka Hlinka, Haidan Wen, arXiv:2102.05746, *Nature* (2021). doi.org/10.1038/s41586-021-03342-4, *News and Views*: doi.org/10.1038/d41586-021-00887-2.; Optical creation of an oxide supercrystal with three-dimensional nanoscale periodicity, V. A. Stoica, N. Laanait, C. Dai, Z. Hong, Z. Zhang, S. Lei, M. R. McCarter, A. Yadav, A. R. Damodaran, S. Das, G. A. Stone, J. Karapetrova, D. A. Walko, X. Zhang, L. W. Martin, R. Ramesh, L-Q. Chen, H. Wen, V. Gopalan, J. W. Freeland, *Nature Materials*, **18**, 377 (2019). doi.org/10.1038/s41563-019-0311-x ; I lead this team of many institutions and PIs funded by the department of energy to discover new emergent topological phases of matter using ultrafast laser light. Above are two recent examples of such discoveries.

Probing Ferroelectrics using Optical Second Harmonic Generation, S. A. Denev, T. T. A. Lummen, E. Vlahos, V. Gopalan, *J. Amer. Cer. Soc.* 94[9], 2699-2727 (2011). doi.org/10.1111/j.1551-2916.2011.04740.x; Thermotropic phase boundaries in classic ferroelectrics, T. T.A. Lummen, Yijia Gu, Jianjun Wang, Shiming Lei, Amit Kumar, Andrew T. Barnes, Eftihia Barnes, Sava Denev, Alex Belianinov, Martin Holt, Anna N. Morozovska, Sergei V. Kalinin, Long-Qing Chen and Venkatraman Gopalan, *Nat. Commun.* **5**, 3172 (2014). https://doi.org/10.1038/ncomms4172, Emergent Low-Symmetry Phases and Large Property Enhancements in Ferroelectric KNbO₃ Bulk Crystals, Tom TA Lummen, J Leung, Amit Kumar, X Wu, Y Ren, Brian K VanLeeuwen, Ryan C Haislmaier, Martin Holt, Keji Lai, Sergei V Kalinin, Venkatraman Gopalan, *Advanced Materials*, **29**, (2017); DOI: 10.1002/adma.201700530; We were one of the early groups to bring the tools of nonlinear optics, especially optical second harmonic generation to become mainstream materials science characterization tool of polar, ferroelectric and multiferroic materials. A few examples are given above.

Defect-domain wall interactions in trigonal ferroelectrics, V. Gopalan, V. Dierolf, D. Scrymgeour, *Annual Reviews of Materials Research*, **37**, pp. 449-489 (2007). This review article summarizes our group's discovery of dramatic effect of stoichiometry on the commercially important optical crystals LiNbO₃ and LiTaO₃, that power the internet today through electro-optic switches made from them. They are also used to generate the electromagnetic spectrum in the visible and in the THz.

Templated Chemically Deposited Semiconductor Optical Fiber Materials, Sparks, J.R., Sazio, P.J.A., Gopalan, V., Badding, J. V., *Annual Reviews of Materials Research*, **43**, 527-557 (2013). DOI: 10.1146/annurev-matsci-073012-125958. Chromium doped zinc selenide optical fiber lasers, J. R. Sparks, S. C. Aro, R. He, M. L. Goetz, J. P. Krug, S. A. McDaniel, P. A. Berry, G. Cook, K. L. Schepler, P. J. Sazio, V. Gopalan, J. V. Badding, *Optical Materials Express*, **10**, 1843 (2020). doi.org/10.1364/OME.397123; Continuous-Wave Fe²⁺:ZnSe mid-IR Optical Fiber Lasers, Michael G. Coco Jr., Stephen C. Aro, Sean A. McDaniel, Alexander Hendrickson, James P. Krug, Pier J. Sazio, Gary Cook, Venkatraman Gopalan and John V. Badding, *Optics Express*, **28** (20), 30263 (2020). https://doi.org/10.1364/OE.402197 Silicon p-i-n Junction Fibers, He, R., Day, T.D., Krishnamurthi, M., Sparks, J.R., Sazio, P.J.A., Gopalan, V., and

Badding, J. V., *Advanced Materials* 25, 1461-1467 (2013). Co-pioneered, along with John V. Badding, a new family of semiconductor optical fibers of silicon, germanium, ZnSe and their first-of-their-kind device applications. Some examples are given above.

Kolam tiles: My interest in bringing mathematics, and art together has resulted in studying the underlying mathematics of an ancient artform from south India, called Kolams. This publication (*A topological approach to creating any pulli kolam, an artform from southern India*, V. Gopalan, B. VanLeeuwen, *Forma* 30, 35-41 (2015). doi:10.5047/forma.2015.005) resulted recently in a mathematical tile game for kids available at kolamtiles.com.

PUBLICATIONS:

Google Scholar Citations (*h-Index: 75, citations: >22,000*):

<https://scholar.google.com/citations?user=l6gka1UAAAAJ&hl=en>

1. [Perspectives and progress on wurtzite ferroelectrics: Synthesis, characterization, theory, and device applications](#), Joseph Casamento, Steven M Baksa, Drew Behrendt, Sebastian Calderon, Devin Goodling, John Hayden, Fan He, Leonard Jacques, Seung Hoon Lee, Walter Smith, Albert Suceava, Quyen Tran, Xiaojun Zheng, Rui Zu, Thomas Beechem, Ismaila Dabo, Elizabeth C Dickey, Giovanni Esteves, Venkatraman Gopalan, Michael David Henry, Jon F. Ihlefeld, Thomas N Jackson, Sergei V Kalinin, Kyle P Kelley, Yongtao Liu, Andrew M Rappe, Joan Redwing, Susan Trolier-McKinstry, Jon-Paul Maria, *Appl. Phys. Lett.* 124, 080501 (2024).
2. [Non-equilibrium pathways to emergent polar supertextures](#), Vladimir A Stoica, Tiannan Yang, Sujit Das, Yue Cao, Huaiyu Wang, Yuya Kubota, Cheng Dai, Hari Padmanabhan, Yusuke Sato, Anudeep Mangu, Quynh L Nguyen, Zhan Zhang, Disha Talreja, Marc E Zajac, Donald A Walko, Anthony D DiChiara, Shigeki Owada, Kohei Miyanishi, Kenji Tamasaku, Takahiro Sato, James M Glowina, Vincent Esposito, Silke Nelson, Matthias C Hoffmann, Richard D Schaller, Aaron M Lindenberg, Lane W Martin, Ramamoorthy Ramesh, Iwao Matsuda, Diling Zhu, Long-Q Chen, Haidan Wen, Venkatraman Gopalan, John W Freeland, in review, (2024).
3. [Hidden non-equilibrium pathways towards crystalline perfection](#), A Mangu, VA Stoica, H Zheng, T Yang, M Zhang, H Wang, QL Nguyen, S Song, Sujit Das, Peter Meisenheimer, E Donoway, M Chollet, Y Sun, JJ Turner, JW Freeland, H Wen, LW Martin, L-Q Chen, V Gopalan, D Zhu, Y Cao, AM Lindenberg, in review, (2024).
4. [Stacking of Ferroelectric and Freestanding 3D SrTiO₃ and 2D MoS₂ Nanomembranes for Reconfigurable Neuromorphic Hardware](#), Dipanjan Sen, Harikrishnan Ravichandran, Mayukh Das, Pranavram Venkatram, Sooho Choo, Shivasheesh Varshney, Zhiyu Zhang, Yongwen Sun, Shiva Subbulakshmi Radhakrishnan, Akash Saha, Sankalpa Hazra, Venkatraman Gopalan, Yang Yang, Bharat Jalan & Saptarshi Das, *Nat. Commun.* Accepted (2024).
5. [In-Operando Spatiotemporal Imaging of Coupled Film-Substrate Elastodynamics during an Insulator-to-Metal Transition](#), Greg Stone, Yin Shi, Matthew Jerry, Vladimir Stoica, Hanjong Paik, Zhonghou Cai, Darrell G. Schlom, Roman Engel-Herbert, Suman Datta, Haidan Wen, Long-Qing Chen, and Venkatraman Gopalan, accepted, *Adv. Materials* (2024).
6. [Quantum fluctuations lead to glassy electron dynamics in a good metal](#), Shashank Kumar Ojha, Sankalpa Hazra, Surajit Bera, Sanat Kumar Gogoi, Prithwjit Mandal, Jyotirmay Maity, A Gloskovskii, C Schlueter, Smarajit Karmakar, Manish Jain, Sumilan Banerjee, Venkatraman Gopalan, Srimanta Middey, arXiv preprint arXiv:2306.14464 (2024).
7. [Optical Control of Nanoscale Domain Networks in Polar Superlattices](#), Marc Zajac, Tao Zhou, Tiannan Yang, Sujit Das, Yue Cao, Burak Guzel Turk, Vladimir Stoica, Mathew Cherukara, John W. Freeland, Venkatraman

- Gopalan, Ramamoorthy Ramesh, Lane W. Martin, Long-Qing Chen, Martin Holt, Stephan Hruszkewycz, Haidan Wen. Submitted (2024).
8. Computationally driven Discovery of Second Harmonic Generation in $\text{EuBa}_3(\text{B}_3\text{O}_6)_3$ Through Centrosymmetry Breaking, J. He, L. Alerts, Y. Wang, V. Trinquet, S. Yoshida, H. Yennawar, V. Sanni, R. Claes, R. Katzbaer, E. Krysko, S. Sarker, R. Schaak, G-M. Rignanese, G. Hautier, Z. Mao, V. Gopalan, *Optics Materials Express*, 13, 3416 (2023). <https://doi.org/10.1364/OME.497727>
 9. Light-Induced Transitions of Polar State and Domain Morphology of Photo-Ferroelectric Nanoparticles, Eugene A Eliseev, Anna N Morozovska, Yulian M Vysochanskii, Lesya P Yurchenko, Venkatraman Gopalan, Long-Qing Chen, in review, *Phys. Rev. B*, <https://doi.org/10.48550/arXiv.2303.04904>.
 10. SnP_2Se_6 : A Chiral 2D Semiconductor for High-Performance Electronics and Optoelectronics, Daniel G. Chica, Vinod K. Sangwan, Ting-Ching Chu, Matthew Cheng, Matthew A. Quintero, Shiqiang Hao, Hyeonseon Choi, Yukun Liu, Eric Qian, Jingyang He, Craig C. Laing, Venkatraman Gopalan, Chris Wolverton, Vinayak P. Dravid, Lincoln J. Lauhon, Mark C. Hersam, and Mercouri G. Kanatzidis. In review, *Nature Materials* (2022). <https://doi.org/10.21203/rs.3.rs-2143024/v1>
 11. Room temperature flash of single crystal titania: electronic and optical properties, Devinder Yadav, Yakun Yuan, Venkatraman Gopalan, Rishi Raj, Seohyeon Jo, <https://doi.org/10.1111/jace.18798>, *J. American Ceramics Society*, 106, 46-52 (2022).
 12. Phase-field model of coupled insulator-metal transitions and oxygen vacancy redox reactions, Yin Shi, Venkatraman Gopalan, Long-Qing Chen, *Physical Review B*, 107, L201110 (2023). DOI: 10.1103/PhysRevB.107.L201110
 13. Bipolaronic nature of the pseudogap in $(\text{TaSe}_4)_2\text{I}$ revealed via weak photoexcitation, Yingchao Zhang, Tika Kafle, Wenjing You, Xun Shi, Lujin Min, Na Li, Venkatraman Gopalan, Kai Rosnagel, Lexian Yang, Zhiqiang Mao, Rahul Nandkishore, Henry Kapteyn, Margaret Murnane, (2023) arXiv preprint arXiv:2203.05655; *Nano Letters*, 23, 18, 8392 (2023). DOI: 10.1021/acs.nanolett.3c01078
 14. Enhancement of second-order optical nonlinearities and UV second harmonic generation from periodically poled boron-substituted thin films, Albert Suceava, John Hayden, Kyle Kelley, Yihuang Xiaong, Ismaila Dabo, S. Trolier-McKinstry, Jon-Paul Maria, V. Gopalan, Proceedings volume PC12652, *UV and Higher Energy Photonics: From Materials to Applications 2023*; PC1265202 (2023); SPIE Nanoscience+Engineering, San Diego, CA (2023), <https://doi.org/10.1117/12.2677814>
 15. Generalized analytical and numerical modeling of optical second harmonic generation in anisotropic crystals and complex heterostructures using #SHAARP package, R. Zu, B. Wang, J. He, L. Weber, Jian-Jun Wang, L-Q. Chen, V. Gopalan, Proceedings volume 12681, *Ultrafast Nonlinear Imaging and Spectroscopy XI*; 1268106 (2023); SPIE Nanoscience+Engineering, San Diego, CA (2023); <https://doi.org/10.1117/12.2676223>
 16. Optical Second Harmonic Generation in Anisotropic Multilayers with Complete Multireflection Analysis of Linear and Nonlinear Waves using #SHAARP.ml Package, Rui Zu, Bo Wang, Jingyang He, Lincoln Weber, Akash Saha, Long-Qing Chen, V. Gopalan, arXiv:2307.01368v3, <https://doi.org/10.48550/arXiv.2307.01368>
 17. MgSiP_2 : An Infrared Nonlinear Optical Crystal with a Large Non-Resonant Phase-Matchable Second Harmonic Coefficient and High Laser Damage Threshold, Jingyang He, Yingdong Guan, Victor Trinquet, Guillaume Brunin, Ke Wang, Robert Robinson, Rui Zu, Suguru Yoshida, Seng Huat Lee, Yu Wang, Yanglin

- Zhu, Gian-Marco Rignanese, Zhiqiang Mao, and Venkatraman Gopalan, *Advanced Optical Materials*, 2301060 (2023). DOI: 10.1002/adom.202301060
18. Symmetry classification and enumeration of square-tile Sikku Kolams, Venkatraman Gopalan, arXiv:2304.14134 [math.HO] (2023).
 19. Strong Electron-Phonon Coupling driven Pseudogap Modulation and Density-Wave Fluctuations in a Correlated Polar Metal, Huaiyu(Hugo) Wang, Yihuang Xiong, Hari Padmanabhan, Yi Wang, Ziqi Wang, Romain Claes, Guillaume Brunin, Lujin Min, Rui Zu, Maxwell T. Wetherington, Yu Wang, Zhiqiang Mao, Geoffroy Hautier, Long-Qing Chen, Ismaila Dabo, Venkatraman Gopalan, *Nature Communications*, 14, 5769, (2023). <https://doi.org/10.1038/s41467-023-41460-x>
 20. Enhancement of second-order optical nonlinearities and nanoscale periodic domain patterning in ferroelectric boron-substituted aluminum nitride thin films, Albert Suceava, John Hayden, Kyle P. Kelley, Yihuang Xiong, Benazir Fazlioglu-Yalcin, Ismaila Dabo, Susan Trolier-McKinstry, Jon-Paul Maria, and Venkatraman Gopalan, *Optical Materials Express*, 13, pp. 1522-1534 (2023), <https://doi.org/10.1364/OME.488459>
 21. Phase-field model of coupled insulator-metal transitions and oxygen vacancy redox reactions. Yin Shi, Venkatraman Gopalan, and Long-Qing Chen, *Phys. Rev. B* 107, L201110 (2023), DOI: <https://doi.org/10.1103/PhysRevB.107.L201110>
 22. Landau-Ginzburg theory of charge density wave formation accompanying lattice and electronic long-range ordering, Anna N. Morozovska, Eugene A. Eliseev, Venkatraman Gopalan, and Long-Qing Chen, *Phys. Rev. B* 107, 174104 (2023); DOI: <https://doi.org/10.1103/PhysRevB.107.174104>
 23. Growth and phase transition of Sr₃Zr₂O₇ single crystals, Ikuya Fukasawa, Yuki Maruyama, Suguru Yoshida, Koji Fujita, Hidehiro Takahashi, Masataka Ohgaki, Masanori Nagao, Satoshi Watauchi, Venkatraman Gopalan, Katsuhisa Tanaka, Isao Tanaka, *J. Cryst. Growth*, 615, 127241 (2023). <https://doi.org/10.1016/j.jcrysgro.2023.127241>
 24. Large Enhancements in Optical and Piezoelectric Properties in Ferroelectric Zn_{1-x}Mg_xO Thin Films through Engineering Electronic and Ionic Anharmonicities, Rui Zu, Gyunghyun Ryu, Kyle P. Kelley, Steven M. Baksa, Leonard C Jacques, Bo Wang, Kevin Ferri, Jingyang He, Long-Qing Chen, Ismaila Dabo, Susan Trolier-McKinstry, Jon-Paul Maria, Venkatraman Gopalan. *Adv. Phys. Res.* 2300003 (2023), <https://doi.org/10.48550/arXiv.2304.14532>
 25. Time domain thermoreflectance measurements and phonon gas modeling of the thermal conductivity of silicon doped indium phosphide pertinent to quantum cascade lasers, C Perez, D Talreja, J Kirch, S Zhang, V Gopalan, D Botez, BM Foley, B Ramos-Alvarado, LJ Mawst, *APL Materials* 11, 4 (2023) <https://doi.org/10.1063/5.0141252>,
 26. Sn-modified BaTiO₃ thin film with enhanced polarization, William Nunn, Abinash Kumar, Rui Zu, Bailey Nebgen, Shukai Yu, Anusha Kamath Manjeshwar, Venkatraman Gopalan, James M LeBeau, Richard D James, Bharat Jalan, *J. Vacuum Sci. & Tech. A* 41, 022701 (2023). <https://doi.org/10.1116/6.0002208>
 27. Layered Semiconductor Cr_{0.32}Ga_{0.68}Te_{2.33} with Concurrent Broken Inversion Symmetry and Ferromagnetism: A Bulk Ferrovalley Material Candidate, Yingdong Guan, Leixin Miao, Jingyang He, Jinliang Ning, Yangyang Chen, Weiwei Xie, Jianwei Sun, Venkatraman Gopalan, Jun Zhu, Xiaoping Wang, Nasim Alem, Qiang Zhang, Zhiqiang Mao, *J. Am. Chem. Soc.* 145, 4683 (2023). <https://doi.org/10.1021/jacs.2c12848>.

28. Stabilization of the Polar Structure and Giant Second-Order Nonlinear Response of Single Crystal γ -NaAs_{0.95}Sb_{0.05}Se₂, Abishek K Iyer, Jingyang He, Hongyao Xie, Devin Goodling, Duck-Young Chung, Venkatraman Gopalan, Mercouri G Kanatzidis, *Advanced Functional Materials*, 33, 2211969, (2023). <https://doi.org/10.1002/adfm.202211969>.
29. Strong room-temperature bulk nonlinear Hall effect in a spin-valley locked Dirac material, Lujin Min, Hengxin Tan, Zhijian Xie, Leixin Miao, Ruoxi Zhang, Seng Huat Lee, Venkatraman Gopalan, Chao-Xing Liu, Nasim Alem, Binghai Yan, Zhiqiang Mao, *Nat. Commun.*, 14, 364 (2023). <https://doi.org/10.1038/s41467-023-35989-0>.
30. Thermodynamic and electron-transport properties of Ca₃Ru₂O₇ from first-principles phonon calculations and Boltzmann transport theory, Yi Wang, Yihuang Xiong, Tiannan Yang, Yakun Yuan, Shunli Shang, Zi-Kui Liu, Venkatraman Gopalan, Ismaila Dabo, and Long-Qing Chen, *Phys. Rev. B.* 107, 035118 (2023). <https://doi.org/10.1103/PhysRevB.107.035118> Arxiv.2210.08631
31. High-Throughput Screening Assisted Discovery of a Stable Layered Anti-Ferromagnetic Semiconductor: CdFeP₂Se₆, Manish Kothakonda, Yanglin Zhu, Yingdong Guan, Jingyang He, Jamin Kidd, Ruiqi Zhang, Jinliang Ning, Venkatraman Gopalan, Weiwei Xie, Zhiqiang Mao, Jianwei Sun, *Advanced Functional Materials*, 33, 2210965 (2023) <https://doi.org/10.1002/adfm.202210965>.
32. Stoichiometric Control and Optical Properties of BaTiO₃ Thin Films Grown by Hybrid MBE, Benazir Fazlioglu Yalcin, Albert Suceava, Tatiana Kuznetsova, Ke Wang, Venkatraman Gopalan, Roman Engel-Herbert, *Advanced Materials interfaces*, 10, 2300018, (2023); <https://doi.org/10.48550/arXiv.2212.11898>.
33. Room temperature flash of single crystal titania: Electronic and optical properties, Devinder Yadav, Yakun Yuan, Venkatraman Gopalan, Rishi Raj, Seohyeon Jo, *J. Am. Ceramics Society*, 106, 46-52 (2023). <https://doi.org/10.1111/jace.18798>.
34. Revealing the short and long-range structural distortions at Nb-doped KTaO₃, S. Salmani-Rezaie, T. Schwaigert, S. Hazra, V. Hopalan, D. G. Schlom, K. Ahadi, D. A. Muller, *Microscopy and Microanalysis*, 29, 1728-30 (2023). <https://doi.org/10.1093/micmic/ozad067.893>
35. Incoherent-to-coherent crossover in thermal transport through III-V alloy superlattices, C Perez, L Avazpour, MK Eryilmaz, T Earles, S Ruder, V Gopalan, D Botez, I Knezevic, B Ramos-Alvarado, BM Foley, LJ Mawst, *Appl. Phys. Lett.* 121, 232201 (2022) <https://doi.org/10.1063/5.0123711>.
36. Large Itinerant Electron Exchange Coupling between Itinerant Electrons and Topological Bands in MnBi₂Te₄, Hari Padmanabhan, Vladimir A. Stoica, Peter Kim, Maxwell Poore, Tiannan Yang, Xiaozhe Shen, Alexander H. Reid, Ming-Fu Lin, Suji Park, Jie Yang, Huaiyu Wang, Nathan Z. Koocher, Danilo Puggioni, Lujin Min, Seng-Huat Lee, Zhiqiang Mao, James M. Rondinelli, Aaron M. Lindenberg, Long-Qing Chen, Xijie Wang, Richard D. Averitt, John W. Freeland, and Venkatraman Gopalan, *Advanced Materials* (2022). <https://doi.org/10.1002/adma.202202841>
37. Atomic-Scale Observation of Stacking Domain Structures in a Semiconducting Van Der Waals Ferrovalley Material, VAgP₂Se₆, Leixin Miao, Seng Huat Lee, Jingyang He, Venkatraman Gopalan, Zhiqiang Mao, Nasim Alem, [Link](#)
38. Analysis and Modeling of Optical Second Harmonic Generation in Anisotropic Crystals using #SHAARP package, Rui Zu, Bo Wang, Jingyang He, Jian-Jun Wang, Lincoln Weber, Long-Qing Chen, Venkatraman

Gopalan, *npj Computational Materials* (2022). 8, Article number: 246 (2022). <https://doi.org/10.1038/s41524-022-00930-4>

39. Interlayer magnetophononic coupling in MnBi_2Te_4 , Hari Padmanabhan, Maxwell Poore, Peter Kim, Nathan Z. Koocher, Vladimir A. Stoica, Danilo Puggioni, Huaiyu Wang, Xiaozhe Shen, Alexander H. Reid, Mingqiang Gu, Maxwell Wetherington, Seng Huat Lee, Richard Schaller, Zhiqiang Mao, Aaron M. Lindenberg, Xijie Wang, James M. Rondinelli, Richard Averitt, Venkatraman Gopalan, *Nature Communications* **13**, 1929 (2022). <https://www.nature.com/articles/s41467-022-29545-5>
40. Ultrasensitive electrode-free and co-catalyst-free detection of nanomoles per hour hydrogen evolution for the discovery of new photocatalysts, H. Wang, R. Katz, J. Fanghanel, R. E. Schaak, and V. Gopalan, *Review of Scientific Instruments* **93**, 025002 (2022). <https://aip.scitation.org/doi/10.1063/5.0077650>
41. A Topological Kagome Magnet in High Entropy Form, L. Min, R. Zhu, V. Gopalan, T. Rost, X. Ke, Z. Mao, *Communications Physics* **5**, 63, (2022). <https://www.nature.com/articles/s42005-022-00842-1>
42. SnP_2S_6 : A Promising Infrared Nonlinear Optical Crystal with Strong Non-Resonant Second Harmonic Generation and Phase-matchability, Jingyang He, Seng Huat Lee, Francesco Naccarato, Guillaume Brunin, Rui Zu, Yuanxi Wang, Leixin Miao, Huaiyu Wang, Nasim Alem, Geoffroy Hautier, Gian-Marco Rignanese, Zhiqiang Mao, Venkatraman Gopalan, *ACS Photonics* (2022). <https://pubs.acs.org/doi/10.1021/acsp Photonics.2c00131>
43. Computing diffraction patterns of microstructures from phase-field simulations, Tiannan Yang, Cheng Dai; Vladimir A. Stoica, Fei Xue, Huaiyu Wang; Yanzhou Ji, Venkatraman Gopalan, Long-Qing Chen, *Acta Materialia*, **239**, 118258 (2022). doi.org/10.1016/j.actamat.2022.118258
44. $\text{Fe}_{3-x}\text{InSn}_x\text{O}_6$ ($x = 0, 0.25, 0.5$): A family of corundum derivatives with Sn-induced polarization and above room temperature antiferromagnetic ordering, Frank, Corey; McCabe, Emma; Orlandi, Fabio; Manuel, Pascal; Tan, Xiaoyan; Deng, Zheng; Jin, Changqing; Croft, Mark; Emge, Thomas; Yu, Shukai; Wang, Huaiyu; Gopalan, Venkatraman; Lapidus, Saul; Wu, MeiXia; Li, Man-Rong; Gross, Juliane; Burger, Paul; Mielewczyk-Gryn, Aleksandra; Klimczuk, Tomasz; Xie, Weiwei; Walker, David; Greenblatt, Martha, *Chemistry of Materials*, **34**, 11, 5020-29(2022). <https://doi.org/10.1021/acs.chemmater.2c00312>
45. Heteroanionic control of exemplary second harmonic generation and phase matchability in 1D $\text{LiAsS}_{2-x}\text{Se}_x$, Benjamin M. Oxley, Jeong Bin Cho, Abishek K. Iyer, Michael J. Waters, Jingyang He, Nathan C. Smith, Chris M. Wolverton, Venkatraman Gopalan, James M. Rondinelli, Joon I. Jang, Mercouri G. Kanatzidis, *J. Am. Chem. Soc.* **144**, 30, 13903 (2022). <https://doi.org/10.1021/jacs.2c05447>
46. Low-temperature processed beta-phase In_2Se_3 ferroelectric semiconductor thin film transistors, Sora Lee, Xiaotian Zhang, Thomas McKnight, Bhavesh Ramkorun, Joan M. Redwing, Venkatraman Gopalan, and Thomas N. Jackson, *2D Materials*, **9**, 025023 (2022). <https://iopscience.iop.org/article/10.1088/2053-1583/ac5b17>
47. Homogenization of Optical Field in Nanocrystal-Embedded Perovskite Composites, Yuchen Hou, Jun Zhang, Xianlin Zheng, Yiqing Lu, Alexej Pogrebnyakov, Haodong Wu, Jungjin Yoon, Dong Yang, Luyao Zheng, Venkatraman Gopalan, Thomas M. Brown, James A. Piper, Kai Wang, and Shashank Priya, *ACS Energy Letters*, **7**, 1657-1671 (2022) <https://doi.org/10.1021/acsenrgylett.2c00608>
48. Overcoming Shockley-Queisser limit using halide perovskite platform? Kai Wang, Luyao Zheng, Yuchen Hou, Amin Nozariasbmarz, Bed Poudel, Jungjin Yoon, Tao Ye, Dong Yang, Alexej V Pogrebnyakov, Venkatraman

49. Femtosecond laser induced surface damage and ablation of tungsten and tungsten carbide in high flux conditions, Minsuk Seo, Shukai Yu, Venkatraman Gopalan, A Leigh Winfrey, in review, *Applied Physics B*, DOI: <https://doi.org/10.21203/rs.3.rs-1479675/v1>
50. Interplay between oxygen octahedral rotation and deformation in acentric ARTiO_4 series toward negative thermal expansion, Yoshida, Suguru; Akamatsu, Hirofumi; Gibbs, Alexandra; Kawaguchi, Shogo; Gopalan, Venkatraman; Tanaka, Katsuhisa; Fujita, Koji, *Chemistry of Materials*, 34, 14, 6492 (2022). <https://doi.org/10.1021/acs.chemmater.2c01245>
51. Giant non-resonant Infrared Second Order Nonlinearity in $\gamma\text{-NaAsSe}_2$, Jingyang He, Abishek K. Iyer, Michael J. Waters, Sumanta Sarkar, Rui Zu, James M. Rondinelli, Mercouri G. Kanatzidis, Venkatraman Gopalan, *Advanced Optical Materials*, 2101729, (2022). DOI: 10.1002/adom.202101729
52. Relativistic spacetime crystals, V. Gopalan, *Acta Crystallographica*, A77, 242-256 (2021) DOI: 10.13140/RG.2.2.31083.57126, cover page. Accompanying commentary article by Bojowald and Saxena at 10.1107/S2053273321005234; Mathematica notebook: <https://notebookarchive.org/renormalized-blended-spacetime--2021-07-6zluq9u/>
53. Subterahertz collective dynamics of polar vortices, Qian Li, Vladimir A Stoica, Marek Paściak, Yi Zhu, Yakun Yuan, Tiannan Yang, Margaret R McCarter, Sujit Das, Ajay K Yadav, Suji Park, Cheng Dai, Hyeon Jun Lee, Youngjun Ahn, Samuel D Marks, Shukai Yu, Christelle Kadlec, Takahiro Sato, Matthias C Hoffmann, Matthieu Chollet, Michael E Kozina, Silke Nelson, Diling Zhu, Donald A Walko, Aaron M Lindenberg, Paul G Evans, Long-Qing Chen, Ramamoorthy Ramesh, Lane W Martin, Venkatraman Gopalan, John W Freeland, Jirka Hlinka, Haidan Wen, arXiv:2102.05746, *Nature* (2021). <https://doi.org/10.1038/s41586-021-03342-4>, *News and Views*: <https://doi.org/10.1038/d41586-021-00887-2>.
54. Tunable nanoscale evolution and topological phase transitions of a polar vortex supercrystal, C. Dai, V. A. Stoica, S. Das, Z. Hong, L. W. Martin, R. Ramesh, J. W. Freeland, H. Wen, V. Gopalan, L-Q. Chen, *Advanced Materials*, 2106401 (2021) <https://doi.org/10.1002/adma.202106401>
55. Spin valley locking and bulk quantum Hall effect in a noncentrosymmetric Dirac semimetal, BaMnSb_2 , JY Liu, J Yu, JL Ning, HM Yi, L Miao, LJ Min, YF Zhao, W Ning, KA Lopez, YL Zhu, T Pillsbury, YB Zhang, Y Wang, J Hu, HB Cao, BC Chakoumakos, F Balakirev, F Weickert, M Jaime, Y Lai, Kun Yang, JW Sun, N Alem, V Gopalan, CZ Chang, N Samarth, CX Liu, RD McDonald, ZQ Mao, *Nature Communications*, 12,1-10 (2021) doi: 10.1038/s41467-021-24369-1
56. Evidence for a Magnetic-Field-Induced Ideal Type-II Weyl State in Antiferromagnetic Topological Insulator $\text{Mn}(\text{Bi}_{1-x}\text{Sb}_x)_2\text{Te}_4$, Seng Huat Lee, David Graf, Lujin Min, Yanglin Zhu, Hemian Yi, Samuel Ciocys, Yuanxi Wang, Eun Sang Choi, Rabindra Basnet, Arash Fereidouni, Aaron Wegner, Yi-Fan Zhao, Katrina Verlinde, Jingyang He, Ronald Redwing, V Gopalan, Hugh OH Churchill, Alessandra Lanzara, Nitin Samarth, Cui-Zu Chang, Jin Hu, ZQ Mao, *Physical Review X*, 11, 031032 (2021). Doi: 10.1103/PhysRevX.11.031032
57. Comprehensive Anisotropic Linear Optical Properties of Weyl Semimetals, TaAs and NbAs, Rui Zu, Mingqiang Gu, Lujin Min, Chaowei Hu, Ni Ni, Zhiqiang Mao, James M Rondinelli, Venkatraman Gopalan, arXiv:2011.09036, *Phys. Rev. B*, 103, 165137, (2021). <https://doi.org/10.1103/PhysRevB.103.165137>

58. Nano-imaging of strain-tuned stripe textures in a Mott crystal, A. S. McLeod, A. Wieteska, G. Chiriac, B. Foutty, Y. Wang, Y. Yuan, F. Xue, V. Gopalan, L. Q. Chen, Z. Q. Mao, A. J. Millis, A. N. Pasupathy and D. N. Basov, *npj Quantum Materials*, 6:46 ; <https://doi.org/10.1038/s41535-021-00339-0> (2021).
59. Optimizing accuracy and efficacy in data-driven materials discovery for the solar production of hydrogen, Yihuang Xiong, Quinn T Campbell, Julian Fanghanel, Catherine K Badding, Huaiyu Wang, Nicole E Kirchner-Hall, Monica J Theibault, Iurii Timrov, Jared S Mondschein, Kriti Seth, Rebecca Katz, Andres Molina Villarino, Betül Pamuk, Megan E Penrod, Mohammed M Khan, Tiffany Rivera, Nathan C Smith, Xavier Quintana, Paul Orbe, Craig J Fennie, Senorpe Asem-Hiablie, James L Young, Todd G Deutsch, Matteo Cococcioni, Venkatraman Gopalan, Hector D Abruña, Raymond E Schaak, Ismaila Dabo, *Energy and Environmental Science*, (2021). <https://doi.org/10.1039/D0EE02984J>
60. Structure Tuning, Strong Second Harmonic Generation Response, and High Optical Stability of the Polar Semiconductors $\text{Na}_{1-x}\text{K}_x\text{AsQ}_2$, Abishek K. Iyer, Jeong Bin Cho, Hye Ryung Byun, Shiqiang Waters, Michael J., Hao, Benjamin M. Oxley, Venkat Gopalan, Christopher Wolverton, James M. Rondinelli, Joon I. Jang, Mercouri G. Kanatzidis, *J. American Chem. Soc.* **143**, 43, 18204-18215 (2021). <https://doi.org/10.1021/jacs.1c07993>
61. Synchrotron x-ray metrology of dopant distribution and oxidation state in high pressure CVD grown $\text{TM}^{2+}:\text{ZnSe}$ optical fibers, Michael G Coco, Stephen C Aro, Alexander Hendrickson, James P Krug, Barry Lai, Zhonghou Cai, Pier J Sazio, Sean A McDaniel, Gary Cook, Venkatraman Gopalan, John V Badding, *Optical Materials Express*, 11(2) 289-298(2021)
62. Aluminosilicate glasses for zinc selenide tunable fiber laser cladding, C. Mathewson, I. Urbina, J. C. Mauro, V. Gopalan, J. V. Badding, *J. American Ceramics Society*, **104**, 691-696 (2021). <https://doi.org/10.1111/jace.17471>
63. Extreme ultraviolet second harmonic generation spectroscopy in a polar metal, Emma Berger, Sasawat Jamnuch, Can B. Uzundal, Clarisse Woodahl, Hari Padmanabhan, Angélique Amado, Paul Manset, Yasuyuki Hirata, Yuya Kubota, Shigeki Owada, Kensuke Tono, Makina Yabashi, Cuixiang Wang, Youguo Shi, Venkatraman Gopalan, Craig P. Schwartz, Walter S. Drisdell, Iwao Matsuda, John W. Freeland, Tod A. Pascal, Michael Zuerch, *Nano Letters*, 21, 6095-6101 (2021). Doi: 10.1021/acs.nanolett.1c01502
64. Electric field-induced polarization responses of noncentrosymmetric crystalline biopolymers in different frequency regimes – a case study on unidirectionally aligned β –chitin crystals, I. Chae, R. Zu, A. B. Meddeb, Y. Ogawa, Z. Chen, V. Gopalan, Z. Ouanaies, S. H. Kim, *Biomolecules*, 22, 1901-1909 (2021). <https://doi.org/10.1021/acs.biomac.0c01799>
65. In-plane quasi-single-domain BaTiO_3 via interfacial symmetry engineering, J. W. Lee, JW Lee, K Eom, TR Paudel, B Wang, H Lu, H Huyan, S Lindemann, S Ryu, H Lee, TH Kim, Y Yuan, JA Zorn, S Lei, W Gao, T Tybell, V Gopalan, X Pan, A Gruverman, LQ Chen, EY Tsymbal, CB Eom, *Nature Communications*, **12**, 6784 (2021) arXiv:2109.08296 (2021); doi: 10.1038/s41467-021-26660-7
66. A polar magnetic and insulating double corundum oxide: $\text{Mn}_2\text{MnSbO}_6$ with ordered Mn(II) and Mn(III) ions, Hai L Feng, Chang-Jong Kang, Bongjae Kim, Kyoo Kim, Mark Croft, Sizhan Liu, Trevor A Tyson, Eli Stavitski, Rui Zu, Venkatraman Gopalan, Saul H Lapidus, Corey E Frank, Youguo Shi, David Walker, Martha Greenblatt, *Chemistry of Materials*, 33, 16, 6522-6529 (2021). doi.org/10.1021/acs.chemmater.1c02046
67. Dynamics of voltage-driven oscillating insulator-metal transitions, Yin Shi, Amy E Duwel, Dennis M Callahan, Yifei Sun, F Anika Hong, Hari Padmanabhan, Venkatraman Gopalan, Roman Engel-Herbert, Shriram Ramanathan, Long-Qing Chen, *Physical Review B*, 104, 064308 (2021). Doi: 10.1103/PhysRevB.104.064308

68. Co-crystalline polymer films exhibiting second-order nonlinear optical properties, Yifan Xu, Rui Zu, Neela H. Yennawar, Venkatraman Gopalan, Robert J. Hickey, *ACS Macro Lett.* **10**, 1216-1222 (2021). Doi: <https://doi.org/10.1021/acsmacrolett.1c00345>
69. Shear-induced unidirectional deposition of bacterial cellulose microfibrils using rising bubble stream cultivation, I. Chae, S. M. Q. Bokhari, X. Chen, R. Zu, K. Liu, A. Borhan, V. Gopalan, J. M. Catchmark, S. H. Kim, *Carbohydrate polymers*, **255**, 117328 (2021). <https://doi.org/10.1016/j.carbpol.2020.117328>
70. HPCVD of ZnS_xSe_{1-x} claddings for ZnSe Optical Fibers, Michael G. Coco, Justin R. Sparks, Stephen C. Aro, Alexander Hendrickson, James P. Krug, Sean A. McDaniel, Gary Cook, Pier J. Sazio, Venkatraman Gopalan, and John V. Badding, *OSA Advanced Photonics, Novel Optical Materials and Applications 2021*, Washington, DC United States, 26–29 July 2021, ISBN: 978-1-943580-94-1, <https://opg.optica.org/abstract.cfm?uri=NOMA-2021-NoTu3C.7>
71. Wedge Reversion Antisymmetry and Forty-One Types of Physical Quantities in Arbitrary Dimensions, Venkatraman Gopalan, arXiv:1910.09286 [physics.gen-ph] *Acta Crystallographica*, **A26**, 318-327 (2020). Doi:10.1107/S205327332000217X
72. Antisymmetry: Fundamentals and Applications, Hari Padmanabhan, Jason Munro, Ismaila Dabo, Venkatraman Gopalan, *Annual Reviews of Materials Research*, **50**, 255, (2020).
73. Continuous-Wave Fe²⁺:ZnSe mid-IR Optical Fiber Lasers, Michael G. Coco Jr., Stephen C. Aro, Sean A. McDaniel, Alexander Hendrickson, James P. Krug, Pier J. Sazio, Gary Cook, Venkatraman Gopalan and John V. Badding, *Optics Express*, **28** (20), 30263 (2020). <https://doi.org/10.1364/OE.402197>
74. Making EuO multiferroic by epitaxial strain engineering, Veronica Goian, Rainer Held, Eric Bousquet, Yakun Yuan, Alexander Melville, Hua Zhou, Venkatraman Gopalan, Phillipe Ghosez, Nicola A Spaldin, Darrell G Schlom, Stanislav Kamba, *Communications Materials*, **1** (1), 1-10 (2020). <https://doi.org/10.1038/s43246-020-00075-1>
75. Post-processing ZnSe optical fibers with a micro-chemical vapor transport technique, Alex T Hendrickson, Stephen C Aro, Justin R Sparks, Michael G Coco, James P Krug, Carly J Mathewson, Sean A McDaniel, Pier J Sazio, Gary Cook, Venkatraman Gopalan, John V Badding, *Optical Materials Express*, **10** (12), 3125-36 (2020). <https://doi.org/10.1364/OME.404700>
76. Chirality-dependent second harmonic generation of MoS₂ nanoscroll with enhanced efficiency, Q. Qian, R. Zhu, Q. Ji, G. S. Jung, K. Zhang, Y. Zhang, M. J. Buehler, J. Kong, V. Gopalan, S. Huang, *ACS Nano*, doi.org/10.1021/acsnano.0c05189
77. Searching for new ferroelectric materials using high-throughput databases: An experimental perspective on BiAlO₃ and BiInO₃, M. Acharya, S. Mack, A. Fernandez, J. Kim, H. Wang, K. Eriguchi, D. Meyers, V. Gopalan, J. Neaton, L. W. Martin, *Chemistry of Materials*, **17**, 7274-7283 (2020). doi.org/10.1021/acs.chemmater.0c01770
78. Chromium doped zinc selenide optical fiber lasers, J. R. Sparks, S. C. Aro, R. He, M. L. Goetz, J. P. Krug, S. A. McDaniel, P. A. Berry, G. Cook, K. L. Schepler, P. J. Sazio, V. Gopalan, J. V. Badding, *Optical Materials Express*, **10**, 1843 (2020). doi.org/10.1364/OME.397123
79. Relativistic spacetimeprime crystals: A Euclidean spacetime perspective of blended inertial observers, V. Gopalan, DOI: 10.13140/RG.2.2.31680.56322

80. SrNbO₃ as a transparent conductor in the visible and ultraviolet spectra, Y. Park, J. Roth, D. Oka, Y. Hirose, T. Hasegawa, A. Paul, A. Pogrebnikov, V. Gopalan, T. Birol, R. Engel-Herbert, *Communications Physics*, **3**, 102 (2020). doi.org/10.1038/s42005-020-0372-9.
81. Achieving Minimal Heat Conductivity by Ballistic Confinement in Phononic Metalattices, Chen, Weinan; Talreja, Disha; Goodling, Devon; Mahale, Pratibha; Nova, Nabila Nabi; Cheng, Hiu; Russell, Jennifer; Yu, Shih-Ying; Poilvert, Nicolas; Mahan, Gerald; Mohny, Suzanne; Crespi, Vincent; Mallouk, Thomas; Badding, John; Foley, Brian; Gopalan, Venkatraman; Dabo, Ismaila, *ACS Nano* **14**, 4235-4243 (2020). <https://doi.org/10.1021/acsnano.9b09487>
82. Nondestructive measurements of the mechanical and structural properties of nanostructured metalattices, B. Abad et. al. *Nano Lett.*, **20**, 5, 3306-3312 (2020). doi.org/10.1021/acs.nanolett.0c00167
83. Ir₆In₃₂S₂₁: A polar, metal-rich semiconducting subchalcogenide, Jason F. Khoury, Jiangang He, Jonathan E. Pfluger, Ido Hadar, Mahalingam Balasubramanian, Constantinos C. Stoumpos, Rui Zu, Venkatraman Gopalan, Chris Wolverton, and Mercouri G. Kanatzidis, *Chem. Sci.* (2020). DOI: 10.1039/C9SC05609B
84. Nanoengineering giant room temperature ferroelectricity into orthorhombic SmMnO₃ films, Eun-Mi Choi, Tuhin Maity, Ahmed Kursumovic, Ping Lu, Oon Jew Lee, Zenxing Bi, Yoonsang Park, Bonan Zhu, Rui Wu, Venkatraman Gopalan, Haiyan Wang, and Judith L. MacManus-Driscoll, *Nature Communications*, **11**, 2207 (2020). doi.org/10.1038/s41467-020-16101-2
85. High-Pressure, High-Temperature Synthesis and Characterization of Polar and Magnetic LuCrWO₆, S. W. Kim, et. al. *Inorganic Chemistry*, **59**, 6, 3579 (2020) doi.org/10.1021/acs.inorgchem.9b02900
86. Optical creation of an oxide supercrystal with three-dimensional nanoscale periodicity, V. A. Stoica, N. Laanait, C. Dai, Z. Hong, Z. Zhang, S. Lei, M. R. McCarter, A. Yadav, A. R. Damodaran, S. Das, G. A. Stone, J. Karapetrova, D. A. Walko, X. Zhang, L. W. Martin, R. Ramesh, L-Q. Chen, H. Wen, V. Gopalan, J. W. Freeland, *Nature Materials*, **18**, 377 (2019). <https://doi.org/10.1038/s41563-019-0311-x>
87. Designing optimal perovskite structure for high ionic conduction, R. Gao, A. Jain, S. Pandya, Y. Dong, Y. Yuan, H. Zhou, L. R. Dedon, V. Thoreton, S. Saremi, R. Xu, A. Luo, T. Chen, V. Gopalan, E. Ertekin, T. Ishihara, N. H. Perry, D. R. Trinkle, L. W. Martin, *Advanced Materials*, 1905178 (2019).
88. Surface Chiral Metals in a bulk half-integer quantum Hall insulator, JY Liu, J Yu, JL Ning, L Miao, LJ Min, KA Lopez, YL Zhu, HM Yi, T Pillsbury, YB Zhang, Y Wang, J Hu, HB Cao, F Balakirev, F Weickert, M Jaime, Kun Yang, JW Sun, N Alem, V Gopalan, CZ Chang, N Samarth, CX Liu, RD Mcdonald, ZQ Mao, arXiv:1907.06318 (2019).
89. Probing thermal and acoustic dynamics of inverse silicon metallattices, C. Bevis, B. Abad, J. Knobloch, T. Frazer, A. Adak, J. Hernández-Charpak, H. Cheng, A. Grede, N. Giebink, N. Nova, T. Mallouk, P. Mahale, W. Chen, Y. Xiong, I. Dabo, V. Crespi, D. Talreja, H. Kapteyn, V. Gopalan, J. Badding, M. Murnane, *Microsc. Microanal.* 25 (Suppl 2), (2019); doi:10.1017/S1431927619011607.
90. Multidimensional thermal analysis of an ultrawide bandgap AlGa_N channel high electron mobility transistor, James Spencer Lundh, Bikramjit Chatterjee, Yiwen Song, Albert G. Baca, Robert J. Kaplar, Thomas E. Beechem, Andrew A. Allerman, Andrew M. Armstrong, Brianna A. Klein, Anushka Bansal, Disha Talreja, Alexej Pogrebnikov, Eric Heller, Venkatraman Gopalan, Joan M. Redwing, Brian M. Foley, and Sukwon Choi, *Appl. Phys. Lett.* **115**, 153503 (2019); <https://doi.org/10.1063/1.5115013>.

91. High-Pressure Synthesis and Ferrimagnetism of Ni₃TeO₆-Type Mn₂ScMO₆ (M = Nb, Ta), Hai L. Feng, Zheng Deng, Mark Croft, Saul H. Lapidus, Rui Zu, Venkatraman Gopalan, Christoph P. Grams, Joachim Hemberger, Sizhan Liu, Trevor A. Tyson, Corey E. Frank, Changqing Jin, David Walker, Martha Greenblatt, *Inorg. Chem.* **58**, 23, 15953-15961 (2019); <https://doi.org/10.1021/acs.inorgchem.9b02468>
92. Atomic scale measurement of polar entropy, Debangshu Mukherjee, Sergei Prokhorenko, Leixin Miao, Ke Wang, Eric Bousquet, Venkatraman Gopalan, Nasim Alem, *Physical Review B*, **100** (10) 104102; arXiv preprint arXiv:1807.06525, (2019).
93. Comprehensive magnetic phase diagrams of the polar metal Ca₃(Ru_{0.95}Fe_{0.05})₂O₇, S. Lei, S. Chikara, D. Puggioni, J. Peng, M. Zhu, M. Gu, W. Zhao, Y. Wang, Y. Yuan, H. Akamatsu, M. H. W. Chan, X. Ke, Z. Mao, J. M. Rondinelli, M. Jaime, J. Singleton, F. Weickert, V. S. Zapf, and V. Gopalan, *Physical Review B*, **99**, 224411 (2019). DOI: 10.1103/PhysRevB.99.224411
94. Competing polar and antipolar structures in the Ruddlesden-Popper layered perovskite Li₂SrNb₂O₇, R. Uppuluri, H. Akamatsu, A. Sen Gupta, H. Wang, C. M. Brown, K. E. Agueda Lopez, N. Alem, V. Gopalan, T. E. Mallouk, *Chemistry of Materials*, **31**, 12 4418-4425 (2019). <https://doi-org.ezaccess.libraries.psu.edu/10.1021/acs.chemmater.9b00786>
95. A-site cation size effect on oxygen octahedral rotations in acentric Ruddlesden-Popper alkali rare earth titanates, H. Akamatsu, K. Fujita, T. Kuge, A. Sen Gupta, J. M. Rondinelli, I. Tanaka, K. Tanaka, V. Gopalan, *Physics Review Materials* **3**, 065001 (2019). DOI: 10.1103/PhysRevMaterials.3.065001
96. Large Tetragonality and Room Temperature Ferroelectricity in Compressively Strained CaTiO₃ Thin Films, Ryan C. Haislmaier, Yanfu Lu, Jason Lapano, Hua Zhou, Nasim Alem, Susan B. Sinnott, Roman Engel-Herbert, and Venkatraman Gopalan, *APL Materials*, **7**, 051104 (2019). <https://doi.org/10.1063/1.5090798>
97. Implementation of Distortion Symmetry for the Nudged Elastic Band Method with DiSPy, arXiv:1810.01911v1 [cond-mat.mtrl-sci]. Jason M. Munro, Vincent S. Liu, Venkatraman Gopalan, and Ismaila Dabo, *npj Computational Materials*. **5**, 52 (2019). <https://doi.org/10.1038/s41524-019-0188-x>
98. Ultrafast quasiparticle dynamics in correlated semimetal Ca₃Ru₂O₇, Yakun Yuan, Peter Kissin, Danilo Puggioni, Kevin Cremin, Shiming Lei, Yu Wang, Zhiqiang Mao, James M Rondinelli, Richard D Averitt, Venkatraman Gopalan, arXiv preprint arXiv:1901.02512, *Physical Review B*, **99**, 155111(2019). <https://doi.org/10.1103/PhysRevB.99.155111>
99. Ultrafast quasiparticle dynamics in correlated semimetals (Conference Presentation), Venkatraman Gopalan, Yakun Yuan, Peter Kissin, Danilo Puggioni, Kevin Cremin, Zhiqiang Mao, James M. Rondinelli, Richard D. Averitt, and Haricharan Padmanabhan ", *Proc. SPIE 11122*, Ultrafast Nonlinear Imaging and Spectroscopy VII, 1112208 (9 September 2019); <https://doi.org/10.1117/12.2532022>
100. Relaxor behavior in ordered lead magnesium niobite (PbMn_{1/3}Nb_{2/3}O₃) thin films, S. Shetty, A. Damodaran, K. Wang, Y. Yuan, V. Gopalan, L. Martin, S. Trolier-McKinstry, *Advanced Functional Materials*, **29** (5), 1804358 (2018). <https://doi.org/10.1002/adfm.201804258>
101. Structural dynamics of LaVO₃ on the nanosecond time scale, Matthew Brahlek, Vladimir A. Stoica, Jason Lapano, Lei Zhang, Hirofumi Akamatsu, I-Cheng Tung, Venkatraman Gopalan, Donald A. Walko, Haidan Wen, John W. Freeland, and Roman Engel-Herbert, *Structural Dynamics*, **6**, 014502 (2019). <https://doi.org/10.1063/1.5045704>

102. Atomic scale electronic structure of domain walls in a polar metal, Greg Stone, Danilo Puggioni, Shiming Lei, Mingqiang Gu, Ke Wang, Yu Wang, Jianjian Ge, Xue-Zeng Lu, Zhiqiang Mao, James M Rondinelli, Venkatraman Gopalan, *Physical Review B*, **99**, 014105 (2019). <https://doi.org/10.1103/PhysRevB.99.014105>
103. Emergent room temperature phase in CaTiO₃ nanoparticles and single crystals, Mariola O Ramirez, Tom TA Lummen, Irene Carrasco, Eftihia Barnes, Ulrich Aschauer, Dagmara Stefanska, Arnab Sen Gupta, Carmen de las Heras, Hirofumi Akamatsu, Martin Holt, Pablo Molina, Andrew Barnes, Ryan C Haislmaier, Przemyslaw J Deren, Carlos Prieto, Luisa E Bausá, Nicola A Spaldin, Venkatraman Gopalan, *APL Materials*, **7**, 011103 (2019). Doi: 10.1063/1.5078706
104. MnFe_{0.5}Ru_{0.5}O₃: an above-room-temperature antiferromagnetic semiconductor, Xiaoyan Tan, Emma E McCabe, Fabio Orlandi, Pascal Manuel, Maria Batuk, Joke Hadermann, Zheng Deng, Changqing Jin, Israel Nowik, Rolfe Herber, Carlo U Segre, Sizhan Liu, Mark Croft, Chang-Jong Kang, Saul Lapidus, Corey E Frank, Haricharan Padmanabhan, Venkatraman Gopalan, Meixia Wu, Man-Rong Li, Gabriel Kotliar, David Walker, Martha Greenblatt, *J. Mater. Chem. C*, **7**, 509-522 (2019). Doi: 10.1039/C8TC05059G
105. Interdependence of Electronic and Thermal Transport in Al_xGa_{1-x}N Channel HEMTs, B. Chatterjee *et al.* *IEEE Electron Device Letters*, vol. 41, no. 3, pp. 461-464, March 2020, doi: 10.1109/LED.2020.2969515.
106. Three-dimensional atomic scale electron density reconstruction of octahedral tilt epitaxy in functional perovskites, Yakun Yuan, Yanfu Lu, Greg Stone, Ke Wang, Charles M Brooks, Darrell G Schlom, Susan B Sinnott, Hua Zhou, Venkatraman Gopalan, *Nature Communications*, **9**, 5220 (2018). DOI: 10.1038/s41467-018-07665
107. Discovering minimum energy pathways via distortion symmetry groups, Jason M. Munro, Hirofumi Akamatsu, Haricharan Padmanabhan, Vincent S. Liu, Yin Shi, Long-Qing Chen, Brian K. VanLeeuwen, Ismaila Dabo, and Venkatraman Gopalan, *Phys. Rev. B*, **98**, 085107 (2018). DOI: 10.1103/PhysRevB.98.085107. arXiv:1804.06798 [cond-mat.mtrl-sci].
108. Linear and nonlinear optical probe of the ferroelectric-like phase transition in a polar metal LiOsO₃, Haricharan Padmanabhan, Yoonsang Park, Danilo Puggioni, Yakun Yuan, Yanwei Cao, Lev Gasparov, Youguo Shi, Jak Chakhalian, James M. Rondinelli, and Venkatraman Gopalan, *Appl. Phys. Lett.* **113**, 122906 (2018). doi: 10.1063/1.5042769
109. Strain-induced ferroelectricity and spin-lattice coupling in SrMnO₃ thin films, JW Guo, PS Wang, Y Yuan, Q He, JL Lu, TZ Chen, SZ Yang, YJ Wang, R Erni, MD Rossell, V Gopalan, HJ Xiang, Y Tokura, P Yu, *Physical Review B*, **97**, 235135 (2018). DOI: <https://doi.org/10.1103/PhysRevB.97.235135>
110. Hybrid Improper Ferroelectricity in (Sr,Ca)₃Sn₂O₇ and Beyond: Universal Relationship between Ferroelectric Transition Temperature and Tolerance Factor in n = 2 Ruddlesden-Popper Phases, Suguru Yoshida, Hirofumi Akamatsu, Ryosuke Tsuji, Olivier Hernandez, Haricharan Padmanabhan, Arnab Sen Gupta, Alexandra S. Gibbs, Ko Mibu, Shunsuke Murai, James M. Rondinelli, Venkatraman Gopalan, Katsuhisa Tanaka, and Koji Fujita, *J. Am. Chem. Soc.* **140**, 15690–15700 (2018). DOI: 10.1021/jacs.8b07998.
111. Theory-Guided Synthesizability of Metastable Lead-Free Piezoelectric Polymorphs, Lauren M. Garten, Shyam Dwaraknath, Julian Walker, John Magnum, Paul F. Ndione, Yoonsang Park, Dan Beaton, Venkataraman Gopalan, Brian Gorman, Laura Schelhas, Sanjini Nanayakkara, Mike Toney, Susan Trolier-McKinstry, Kristin Persson, David S. Ginley, *Advanced Materials* **30**, 1800159 (2018). doi: 10.1002/adma.201800559

112. Ferroelectric $\text{Sr}_3\text{Zr}_2\text{O}_7$: Competition between Hybrid Improper Ferroelectric and Antiferroelectric Mechanisms, Suguru Yoshida, Koji Fujita, Hirofumi Akamatsu, Olivier Hernandez, Arnab Sen Gupta, Forrest G. Brown, Haricharan Padmanabhan, Alexandra S. Gibbs, Toshihiro Kuge, Ryosuke Tsuji, Shunsuke Murai, James M. Rondinelli, Venkatraman Gopalan, and Katsuhisa Tanaka, *Adv. Funct. Mater.* (2018), 28, 1801856, doi: 10.1002/adfm.201801856
113. Artificial two-dimensional polar metal at room temperature, Yanwei Cao, Zhen Wang, Se Young Park, Yakun Yuan, Xiaoran Liu, Sergey M Nikitin, Hirofumi Akamatsu, Mikhail Kareev, Srimanta Middey, Derek Meyers, P Thompson, PJ Ryan, Padraic Shafer, A N'Diaye, E Arenholz, Venkatraman Gopalan, Yimei Zhu, Karin M Rabe, J Chakhalian, *Nature communications*, 9, 1547 (2018). doi: 10.1038/s41467-018-03964-9
114. Rotomagnetic coupling in fine-grained multiferroic BiFeO_3 : theory and experiment, Anna N. Morozovska, Eugene A. Eliseev, Maya D. Glinchuk, Olena M. Fesenko, Vladimir V. Shvartsman, Venkatraman Gopalan, Maxim V. Silibin, and Dmitry V. Karpinsky, *Phys. Rev. B.* (2018). doi: 10.1103/PhysRevB.97.134115
115. Observation of Quasi-two-dimensional Polar Domains and Ferroelastic Switching in a Metal, Shiming Lei, Mingqiang Gu, Danilo Puggioni, Greg Stone, Jin Peng, Jianjian Ge, Yu Wang, Baoming Wang, Yakun Yuan, Ke Wang, Zhiqiang Mao, James M. Rondinelli, Venkatraman Gopalan, *Nano Letters* (2018). doi: 10.1021/acs.nanolett.8b00633, DOI: 10.1021/acs.nanolett.8b00633
116. Conformal coating of amorphous silicon and germanium by high pressure chemical vapor deposition for photovoltaic fabrics, Xiaoyu Ji, Hui Yan Cheng, Alex J Grede, Alex Molina, Disha Talreja, Suzanne E Mohney, Noel C Giebink, John V Badding, Venkatraman Gopalan, *APL Materials*, 6, 046105 (2018). <https://doi.org/10.1063/1.5020814>
117. Spatio-Temporal Symmetry – Crystallographic Point Groups with Time Translations and Time Inversion, Vincent V. Liu, Brian K. VanLeeuwen, Haricharan Padmanabhan, Jason Munro, Ismaila Dabo, Venkatraman Gopalan and Daniel B. Litvin, *Acta Crystallographica A* 74, 1-4 (2018). <https://doi.org/10.1107/S2053273318004667>
118. Terahertz Emission from Hybrid Perovskites Driven by Ultrafast Charge Separation and Strong Electron–Phonon Coupling, Burak Guzelturk, Rebecca A. Belisle, Matthew D. Smith, Karsten Bruening, Rohit Prasanna, Yakun Yuan, Venkatraman Gopalan, Christopher J. Tassone, Hemamala I. Karunadasa, Michael D. McGehee, and Aaron M. Lindenberg, *Adv. Mater.* 30, 1704737, (2018). DOI: 10.1002/adma.201704737
119. Light-Activated Gigahertz Ferroelectric Domain Dynamics, Hirofumi Akamatsu, Yakun Yuan, Vladimir A. Stoica, Greg Stone, Tiannan Yang, Zijian Hong, Shiming Lei, Yi Zhu, Ryan C. Haislmaier, John W. Freeland, Long-Qing Chen, Haidan Wen, and Venkatraman Gopalan, *Physical Review Letters* 120, 096101 (2018), DOI: <https://doi.org/10.1103/PhysRevLett.120.096101>,
120. Continuously Tuning Epitaxial Strains by Thermal Mismatch, Lei Zhang, Yakun Yuan, Jason Lapano, Matthew Brahlek, Shiming Lei, Bernd Kabius, Venkatraman Gopalan, and Roman Engel-Herbert, *ACS Nano* 12, 1306–1312, (2018). DOI: 10.1021/acsnano.7b07539.
121. YCrWO_6 : Polar and Magnetic Oxide with CaTa_2O_6 -Related Structure, Sun Woo Kim, Thomas J. Emge, Zheng Deng, Ritesh Uppuluri, Liam Collins, Saul H. Lapidus, Carlo U. Segre, Mark Croft, Changqing Jin, Venkatraman Gopalan, Sergei V. Kalinin and Martha Greenblatt, *Chem. Mater.* 30, 1045–1054 (2018). DOI: 10.1021/acs.chemmater.7b04941

122. Random anion distribution in MS_xSe_{2-x} ($M = Mo, W$) crystals and nanosheets, Minh An T. Nguyen, Arnab Sen Gupta, Jacob Shevrin, Hirofumi Akamatsu, Pengtao Xu, Zhong Lin, Ke Wang, Jun Zhu, Venkatraman Gopalan, Mauricio Terrones and Thomas E. Mallouk, *RSC Adv.*, **8**, 9871, (2018). DOI: 10.1039/c8ra01497c
123. Spatio-Temporal Symmetry –Point Groups with time Translations, Haricharan Padmanabhan, Maggie L Kingsland, Jason M Munro, Daniel B Litvin, Venkatraman Gopalan, *Symmetry*, **9**, 187 (2017).
124. Emergent Low-Symmetry Phases and Large Property Enhancements in Ferroelectric $KNbO_3$ Bulk Crystals, Tom TA Lummen, J Leung, Amit Kumar, X Wu, Y Ren, Brian K VanLeeuwen, Ryan C Haislmaier, Martin Holt, Keji Lai, Sergei V Kalinin, Venkatraman Gopalan, *Advanced Materials*, **29**, (2017); DOI: 10.1002/adma.201700530
125. A (II) $GeTeO_6$ ($A = Mn, Cd, Pb$): Non-Centrosymmetric Layered Tellurates with $PbSb_2O_6$ -Related Structure, Sun Woo Kim, Zheng Deng, Shuang Yu, Haricharan Padmanabhan, Weiguo Zhang, Venkatraman Gopalan, Changqing Jin, Martha Greenblatt, *Inorganic Chemistry*, **56**, (2017), DOI: 10.1021/acs.inorgchem.7b01013
126. A Comprehensive Thermodynamic Potential and Phase Diagram for Multiferroic Bismuth Ferrite, D.V. Karpinsky, I.O. Troyanchuk, S.A. Gavrilov, M.V. Silibin, Dr. E.A. Eliseev, Prof. M.D. Glinchuk, Dr. Fei Xue, Prof. V. Gopalan, Prof. L.-Q. Chen, Dr. A. Franz, Dr. A. N. Morozovska, *npj Computational Materials* **3**, 1(2017). doi:10.1038/s41524-017-0021-3
127. Magnetostriction-Polarization Coupling in Multiferroic Mn_2MnWO_6 , Man-Rong Li, Emma McCabe, Peter W. Stephens, Mark Croft, Liam F. Collins, Sergei V. Kalinin, Zheng Deng, Maria Retuerto, Arnab Sen Gupta, Haricharan Padmanabhan, Venkatraman Gopalan, Christoph P. Grams, Joachim Hemberger, Fabio Orlandi, Pascal Manuel, Wen-Min Li, Chang-Qing Jin, Dave Walker, Martha Greenblatt, Magnetostriction-Polarization Coupling in Multiferroic Mn_2MnWO_6 , *Nature Communications*, (2017). 8: 2037 | DOI: 10.1038/s41467-017-02003-3
128. Sub-wavelength modulation of $\chi^{(2)}$ optical nonlinearity in organic thin films, Y. Yan, Y. Yuan, B. Wang, V. Gopalan, N. C. Giebink, *Nature Communications*, doi: 10.1038/ncomms14269 (2017).
129. High-Quality $LaVO_3$ Films as Solar Energy Conversion Material, Hai-Tian Zhang, Matthew J Brahlek, Xiaoyu Ji, Shiming Lei, Jason Lapano, John W Freeland, Venkatraman Gopalan, Roman Engel-Herbert, *ACS Applied Materials & Interfaces*, **9** (14), pp 12556–12562 DOI: 10.1021/acsami.6b16007 (2017).
130. A silicon microwire under a three-dimensional anisotropic tensile stress, Xiaoyu Ji, Nicolas Poilvert, Wenjun Liu, Yihuang Xiong, Hui Yan Cheng, John V Badding, Ismaila Dabo, Venkatraman Gopalan, *Appl. Phys. Lett.* **110**, 091911 (2017); doi: <http://dx.doi.org/10.1063/1.4977852>
131. Polar Oxides without Inversion Symmetry through Vacancy and Chemical Order, Joshua Young, Eun Ju Moon, Debangshu Mukherjee, Greg Stone, Venkatraman Gopalan, Nasim Alem, Steven J May, James M Rondinelli, *J. Am. Chem. Soc.*, **139** (7), pp 2833–2841 (2017). DOI: 10.1021/jacs.6b10697
132. A Listing of Crystallographic Point Groups in Space and Time, Maggie L Kingsland, Haricharan Padmanabhan, Jason M Munro, Daniel B Litvin, Venkatraman Gopalan, arXiv preprint arXiv:1701.04088
133. Design of next generation mid-infrared multimaterial fiber optics, X. Ji, R. L. Page, V. Gopalan, *Proceedings of the COMSOL conference*, Boston, October (2016).

134. [Complex Oxides: Creative Tension in Layered Crystals](#), V. Gopalan, R. Engel-Herbert, *Nature Materials*, News and Views, (2016). doi:10.1038/nmat4662
135. [Single crystal germanium core optoelectronic fibers](#), X. Ji, R. L. Page, S. Chaudhuri, W. Liu, S-Y. Yu, S. E. Mohney, J. V. Badding, V. Gopalan, *Advanced Optical Materials*, (2016). <http://onlinelibrary.wiley.com/doi/10.1002/adom.201600592/full>
136. [Competing structural instabilities in the Ruddlesden-Popper derivatives \$\text{HRTiO}_4\$ \(R=Rare earths\): Oxygen Octahedral rotations inducing noncentrosymmetry and layer sliding retaining centrosymmetry](#), A. SenGupta, H. Akamatsu, F. G. Brown, Minh An T. Nguyen, M. E. Strayer, S. Lapidus, S. Yoshida, K. Fujita, K. Tanaka, I. Tanaka, T. E. Mallouk, V. Gopalan, *ACS Chemistry of Materials*, (2016). DOI: 10.1021/acs.chemmater.6b04103
137. [Single crystal silicon optical fiber by direct laser crystallization](#), X. Ji, S. Lei, S-Y. Yu, H. Y. Cheng, W. Liu, N. Poilvert, Y-H. Xiong, I. Dabo, S. Mohney, J. V. Badding, V. Gopalan, *ACS Photonics* (2016). DOI: 10.1021/acsp Photonics.6b00584 (2016).
138. [Unleashing strain induced ferroelectricity in complex oxide thin films via precise stoichiometry control](#), R. C. Haislmaier, E. D. Grimley, M. D. Biegalski, J. M. Lebeau, S. Trolier-McKinstry, V. Gopalan, R. E. Herbert, *Advanced Functional Materials*, (2016). DOI: 10.1002/adfm.201602767
139. [Low-temperature cationic rearrangement in a bulk metal oxide](#), Man-Rong Li, Maria Retuerto, Peter W. Stephens, Mark Croft, Santu Baidya, Tanusri Saha-Dasgupta, Denis Sheptyakov, Vladimir Pomjakushin, Zheng Deng, Hirofumi Akamatsu, Venkatraman Gopalan, Javier Sánchez-Benítez, Felix O. Saouma, Joon I. Jang, David Walker, Martha Greenblatt, *Angewandte Chemie*, **128**, 10016-10021 (2016). 10.1002/ange.201511360
140. [Fast Magnetic Domain-Wall Motion in a Ring-Shaped Nanowire Driven by a Voltage](#), Jia-Mian Hu, Tiannan Yang, Kasra Momeni, Xiaoxing Cheng, Lei Chen, Shiming Lei, Shujun Zhang, Susan Trolier-McKinstry, Venkatraman Gopalan, Gregory P Carman, Cewen Nan, Long-Qing Chen, *Nano Letters* (2016) DOI: 10.1021/acs.nanolett.5b05046
141. [Imprinting of Local Metallic States into \$\text{VO}_2\$ with Ultraviolet Light](#), Hai-Tian Zhang, Lu Guo, Greg Stone, Lei Zhang, Yuan-Xia Zheng, Eugene Freeman, Derek W. Keefer, Subhasis Chaudhuri, Hanjong Paik, Jarrett A. Moyer, Michael Barth, Darrell G. Schlom, John V. Badding, Suman Datta, Venkatraman Gopalan, Roman Engel-Herbert, *Advanced Functional Materials*, (2016) 10.1002/adfm.201601890.
142. [\$\text{PbMn\(IV\)TeO}_6\$: A new noncentrosymmetric layered honeycomb magnetic oxide](#), S.W. Kim, Z. Deng, M-R. Li, M. Croft, A. Sen Gupta, H. Akamatsu, V. Gopalan, M. Greenblatt, *Inorganic Chemistry*, **55**, 1333-1338, (2016). DOI: 10.1021/acs.inorgchem.5b02677
143. [Atomic-scale imaging of competing polar states in a Ruddlesden-Popper layered oxide](#), G. Stone, C. Ophus, T. Birol, J. Ciston, C-H. Lee, K. Wang, C. J. Fennie, D. G. Schlom, N. Alem, V. Gopalan, *Nature Communications* doi:10.1038/ncomms12572 (2016).
144. [Improper inversion symmetry breaking and piezoelectricity through oxygen octahedral rotations in layered perovskite family, \$\text{LiRTiO}_4\$ \(R= rare earths\)](#), A. Sen Gupta, H. Akamatsu, M. E. Strayer, S. Lei, T. Kuge, K. Fujita, C. dela Cruz, A. Togo, I. Tanaka, K. Tanaka, T. E. Mallouk, and V. Gopalan, *Advanced Electronic Materials*, 10.1002/aelm.201500196
145. [Polar Metals by Geometric Design](#), T. H. Kim, D. Puggioni, Y. Yuan, L. Xie, H. Zhou, N. Campbell, P. J. Ryan,

- Y. Choi, J.-W. Kim, J. R. Patzner, S. Rzechowski, X. Q. Pan, V. Gopalan, J. M. Rondinelli, C.-B. Eom, doi:10.1038/nature17628, *Nature* **533**, 68-72 (2016).
146. Emergent non-centrosymmetry and piezoelectricity driven by oxygen octahedral rotations in $n = 2$ Dion-Jacobson phase layer perovskites, M. E. Strayer, A. Sen Gupta, H. Akamatsu, S. Lei, N. A. Benedek, V. Gopalan, and T. E. Mallouk, *Advanced Functional Materials*, **26**, 1930-1937 (2016). DOI: 10.1002/adfm.201504046 (primary support, IRG1)
147. Interfacial Octahedral Rotation Mismatch Control of the Symmetry and Properties of SrRuO_3 , Ran Gao, Yongqi Dong, Han Xu, Hua Zhou, Yakun Yuan, Venkatraman Gopalan, Chen Gao, Dillon D Fong, Zuhuang Chen, Zhenlin Luo, Lane W Martin, *ACS Appl. Mater. Interfaces*, **2016**, *8* (23), pp 14871–14878 DOI: 10.1021/acsami.6b02864
148. Crystalline Silicon Optical Fibers with Low Optical Loss, Subhasis Chaudhuri, Justin R Sparks, Xiaoyu Ji, Mahesh Krishnamurthi, Li Shen, Noel Healy, Anna C Peacock, Venkatraman Gopalan, John V Badding, *ACS Photonics*, **2016**, *3* (3), 378–384, DOI: 10.1021/acsp Photonics.5b00434
149. Stoichiometry as key to strain-enabled ferroelectricity in compressively strained SrTiO_3 thin films, Ryan C. Haislmaier, Everett Grimley, Mike Biegalski, James LeBeau, Venkatraman Gopalan & Roman Engel-Herbert, *Appl. Phys. Lett.* **109**, 032901 (2016). <http://dx.doi.org/10.1063/1.4959077>
150. Chemistry, growth kinetics, and epitaxial stabilization of Sn^{2+} in Sn-doped SrTiO_3 using $(\text{CH}_3)_6\text{Sn}_2$ tin precursor, Tianqi Wang, Krishna Chaitanya Pitike, Yakun Yuan, Serge M. Nakhmanson, Venkatraman Gopalan, and Bharat Jalan, *APL Materials*, **4**, 126111 (2016) <http://aip.scitation.org/doi/full/10.1063/1.4972995>
151. Depinning of the ferroelectric domain wall in congruent LiNbO_3 , D. Lee, V. Gopalan, S. R. Phillpot, *Appl. Phys. Lett.* **109**, 082905 (2016)
152. Relaxor Ferroelectric Behavior in Barium Strontium Titanate, L. M. Garten, M. Burch, A. Sen Gupta, R. Haislmaier, P. Lam, D. Harris, V. Gopalan, E.C. Dickey, J.-P. Maria, and S. Trolier-McKinstry, *Journal of the American Ceramic Society* (2016). DOI: 10.1111/jace.14109
153. Quantitative lateral and vertical piezoresponse force microscopy on a PbTiO_3 single crystal, S. Lei, Tae-Yeong Koo, Wenwu Cao, Eugene A Eliseev, Anna N Morozovska, S-W Cheong, Venkatraman Gopalan, *J. Appl. Phys.* **120**, 124106 (2016); <http://dx.doi.org/10.1063/1.4963750>
154. Aberration corrected STEM imaging of domains walls in LiNbO_3 , D. Mukherjee, G. Stone, K. Wang, V. Gopalan, N. Alem, *Proceedings of Microscopy and Microanalysis*, **22**, Supplement S3, 914-915 (2016). <http://dx.doi.org/10.1017/S1431927616005419>
155. Cr^{2+} : ZnSe fiber lasers, S. C. Aro, J. R. Sparks, S. A. McDaniel, M. G. Coco, A. T. Hendrickson, V. Gopalan, G. Cook, J. V. Badding, Lasers Congress 2016 (ASSL, LSC, LAC) *OSA Technical Digest* (online) (Optical Society of America, 2016), paper AW3A.4 <https://doi.org/10.1364/ASSL.2016.AW3A.4>
156. Ultrafast spatio-temporal mapping of gigahertz lattice distortion in a ferroelectric crystal, V. Gopalan, Y. Yuan, *Proc. SPIE 9956, Ultrafast Nonlinear Imaging and Spectroscopy IV*, 99560S (November 2, 2016); doi:10.1117/12.2238307. <http://dx.doi.org/10.1117/12.2238307>

157. X-ray diffraction and spectroscopy of photoinduced ferroic superstructures, Vladimir A. Stoica, Haidan Wen, Xiaoyi Zhang, Zhan Zhang, John W. Freeland, L. W. Martin, R. Ramesh, V. Gopalan *Proc. SPIE* 9956, Ultrafast Nonlinear Imaging and Spectroscopy IV, 99560W (November 2, 2016); doi:10.1117/12.2238708;
158. Influence of interface coherency on ferroelectric switching of superlattice BaTiO₃/SrTiO₃, P. Wu, X. Ma, Y. Li, C-B. Eom, D. G. Schlom, V. Gopalan, L-Q. Chen, *Appl. Phys. Lett.* **107**, 122906 (2015).
159. Antisymmetry of Distortions, Brian K. VanLeeuwen, V. Gopalan, *Nature Communications*, **6**, 8818 (2015) doi:10.1038/ncomms9818
160. A labile hydride strategy to synthesize heavily nitrated BaTiO₃, Takeshi Yajima, Fumitaka Takeiri, Kohei Aidzu, Hirofumi Akamatsu, Koji Fujita, Masatoshi Ohkura, Wataru Yoshimune, Shiming Lei, Venkatraman Gopalan, Katsuhisa Tanaka, C. M. Brown, Mark A. Green, Takafumi Yamamoto, Yoji Kobayashi, and Hiroshi Kageyama, *Nature Chemistry*, **7**, 1017-1023 (2015). doi:10.1038/nchem.2370
161. Rotomagnetic coupling influence on the magnetic properties of antiferrodistortive antiferromagnets, E. A. Eliseev, M. D. Glinchuk, V. Gopalan, A. N. Morozovska, *Journal of Applied Physics*, **118**, 144101 (2015). <http://dx.doi.org/10.1063/1.4932211>
162. Correlated metals as transparent conductors, Lei Zhang, Yuanjun Zhou, Lu Guo, Weiwei Zhao, Anna Barnes, Haitian Zhang, Craig Eaton, Hamna F. Haneef, Nikolas J. Podraza, Moses H. W. Chan, Venkatraman Gopalan, Karin M. Rabe, Roman Engel-Herbert, *Nature Materials*, doi:10.1038/nmat4493 (2015).
163. A topological approach to creating any pulli kolam, an artform from southern India, V. Gopalan, B. VanLeeuwen, *Forma* **30**, 35-41 (2015). doi:10.5047/forma.2015.005, <http://arxiv.org/abs/1503.02130>, <https://forma.katachi-jp.com/pdf/3001/30010035.pdf>
164. The Affine and Euclidean normalizers of the subperiodic groups, B. K. VanLeeuwen, P. V. De Jesus, D. B. Litvin, and V. Gopalan, *Acta Cryst.* **A71**, 150-160 (2015). doi: 10.1107/S2053273314024395
165. Linear antidistortive-antiferromagnetic effect in multiferroics: physical manifestations, A. N. Morozovska, V. V. Khist, M. D. Glinchuk, V. Gopalan, E. A. Eliseev, *Phys. Rev. B.* **92**, 054421 (2015). 10.1103/PhysRevB.92.054421
166. Mn₂FeWO₆: a new Ni₃TeO₆-type polar and magnetic oxide, M-R. Li, M. Croft, P. W. Stephens, M. Ye, D. Vanderbilt, M. Retuerto, Z. Deng, C. P. Grams, J. Hemberger, J. Hadermann, W-M. Li, C-Q. Jin, F. O. Saouma, J. I. Jang, H. Akamatsu, V. Gopalan, D. Walker, M. Greenblatt, *Advanced Materials*, **28**, 2098, (2015). doi: 10.1002/adma.201405244
167. Mid-infrared spectroscopic imaging enabled by an array of Ge-filled waveguides in a microstructured optical fiber probe, X. Ji, B.G. Zhang, M. Krishnamurthi, J. Badding, V. Gopalan, *Optics Express*, **22**, 28459-28466 (2014). Doi: 10.1364/OE.22.028459
168. Piezoelectric enhancement of (PbTiO₃)_m/(BaTiO₃)_n ferroelectric superlattices through domain engineering, L. Hong, P. P. Wu, Y. L. Li, V. Gopalan, C. B. Eom, D. G. Schlom, L. Q. Chen, *Phys. Rev. B.* **19**, 174111 (2014). Doi: 10.1103/PhysRevB.90.174111

169. Monoclinic phase arising across thermal inter-ferroelectric phase transitions, Yijia Gu, Fei Xue, Shiming Lei, Tom T. A. Lummen, Jianjun Wang, Venkatraman Gopalan, and Long-Qing Chen, *Phys. Rev. B.*, **90**, 024104 (2014).
170. Inversion symmetry breaking by oxygen octahedral rotations in Ruddlesden-Popper NaRTiO_4 family, H. Akamatsu, K. Fujita, T. Kuge, A. S. Gupta, A. Togo, S. Lei, F. Xue, G. Stone, J. M. Rondinelli, L. Q. Chen, I. Tanaka, V. Gopalan, K. Tanaka, *Phys. Rev. Lett.* **112**, 187602 (2014).
171. Crystallographic data of double antisymmetry space groups, M. Huang, B. K. VanLeeuwen, D. B. Litvin, V. Gopalan, *Acta Crystallographica A*, **A70**, 373-381 (2014). doi:10.1107/S2053273314006871
172. Flexoelectricity and ferroelectric domain wall structures: Phase-field modeling and DFT calculations, Yijia Gu, Menglei Li, Anna N. Morozovska, Yi Wang, Eugene A. Eliseev, V. Gopalan, and Long-Qing Chen, *Phys. Rev. B.* **89**, 174111 (2014). Doi: 10.1103/PhysRevB.89.174111
173. Thermotropic phase boundaries in classic ferroelectrics, T. T.A. Lummen, Yijia Gu, Jianjun Wang, Shiming Lei, Amit Kumar, Andrew T. Barnes, Eftihia Barnes, Sava Denev, Alex Belianinov, Martin Holt, Anna N. Morozovska, Sergei V. Kalinin, Long-Qing Chen and Venkatraman Gopalan, *Nat. Commun.* **5**, 3172 (2014). <https://doi.org/10.1038/ncomms4172>
174. Electric-field induced ferromagnetic phase in paraelectric antiferromagnets, M. D. Glinchuk, E. A. Eliseev, L-Q. Chen, V. Gopalan, and A. N. Morozovska, *Phys. Rev. B*, **89**, 014112 (2014). arXiv:1307.7402 [cond-mat.mtrl-sci].
175. Elastic strain engineering of ferroic oxides, D. G. Schlom, L-Q. Chen, C. J. Fennie, V. Gopalan, D. A. Muller, X. Pan, R. Ramesh, R. Uecker, *MRS Bulletin*, **39**, 118-130 (2014).
176. Double antisymmetry and rotation reversal space groups, B. K. VanLeeuwen, V. Gopalan, D. B. Litvin, *Acta Crystallographica A*, **70**, 24-38 (2014). Doi: 10.1107/S2053273313023176
177. Reinvestigation of Electric Field Induced Optical Activity in alpha-Quartz: Application of a Polarimeter with Four Photoelastic Modulators, A. SenGupta, Oriol Arteaga, Ryan Haislmaier, Bart Kahr, Venkatraman Gopalan, *Chirality* **26**, 430-433 (2014) DOI: 10.1002/chir.22262.
178. Synchronized charged oscillations in correlated electron systems, N. Shukla, A. Parihar, E. Freeman, H. Paik, G. Stone, V. Narayanan, H. Wen, Z. Cai, R. Engel-Herbert, D.G. Schlom, A. K. Raychowdhury, S. Datta, *Scientific Reports*, **4**, 4964 (2014) doi:10.1038/srep04964
179. Reply to "Comment on 'Origin of piezoelectric response under a biased scanning probe microscopy tip across a 180 degree ferroelectric domain wall", S. Lei, E. A. Eliseev, A. N. Morozovska, R. C. Haislmaier, T. T. A. Lummen, W. Cao, S. V. Kalinin, V. Gopalan, *Phys. Rev. B*, **89**, 226102 (2014). Doi: 10.1103/PhysRevB.89.226102
180. Universal emergence of spatially modulated structures induced by flexoantiferrodistortive coupling in multiferroics, E. A. Eliseev, S. V. Kalinin, Y. Gu, M. D. Glinchuk, V. Khist, A. Borisevich, V. Gopalan, L. Q. Chen, A. N. Morozovska, *Phys. Rev. B.* **88**, 224105 (2013).
181. Characterization of full set of material constants of piezoelectric materials based on ultrasonic method and inverse impedance spectroscopy using only one sample, S. Li, L. Zheng, W. Jiang, R. Sahul, V. Gopalan, W. Cao, *J. Appl. Phys.*, **114**, 104505 (2013).

182. Nanoscale structural evolution of electrically driven insulator to metal transition in vanadium dioxide, Eugene Freeman, Greg Stone, Nikhil Shukla, Hanjong Paik, Jarrett Moyer, Zhonghou Cai, Haidan Wen, Roman Engel-Herbert, Darrell G. Schlom, Venkatraman Gopalan and Suman Datta, *Appl. Phys. Lett.* **103**, 263109 (2013).
183. Low-symmetry monoclinic ferroelectric phase stabilized by oxygen octahedra rotations in strained $\text{Eu}_x\text{Sr}_{1-x}\text{TiO}_3$ thin films, A.N. Morozovska, Y.J. Gu, V.V. Khist, M.D. Glinchuk, L.Q. Chen, V. Gopalan, and E.A. Eliseev, *Physical Review B*, **87**(13), 232904 (2013).
184. Structural and Electronic Recovery Pathways of Photoexcited Ultrathin VO_2 Film, Haidan Wen, Lu Guo, Eftihia Barnes, June-Hyuk Lee, Donald A. Walko, Richard D. Schaller, Jarrett Moyer, Rajiv Misra, Yuelin Li, Eric M. Dufresne, Peter Schiffer, Darrell G. Schlom, Venkatraman Gopalan, John. W. Freeland, *Phys. Rev. B.*, **88**, 165424 (2013).
185. Exploiting Dimensionality and Defect Mitigation to Create Tunable Microwave Dielectrics, Che-Hui Lee, Nathan D. Orloff, Turan Birol, Ye Zhu, Veronica Goian, Ryan Haislmaier, Eftihia Vlahos, Julia A. Mundy, Yuefeng Nie, Michael D. Biegalski, Jingshu Zhang, Margitta Bernhagen, Nicole A. Benedek, Yongsam Kim, Joel D. Brock, Reinhard Uecker, Xiaoxing Xi, Venkatraman Gopalan, Dmitry Nuzhnyy, Stanislav Kamba, David A. Muller, Ichiro Takeuchi, James C. Booth, Craig J. Fennie & Darrell G. Schlom, *Nature*, **502**, 532-536 (2013). (DOI:10.1038/nature12582)
186. Templated Chemically Deposited Semiconductor Optical Fiber Materials, Sparks, J.R., Sazio, P.J.A., Gopalan, V., Badding, J. V., *Annual Reviews of Materials Research*, **43**, 527-557 (2013). DOI: 10.1146/annurev-matsci-073012-125958.
187. Quantification of octahedral rotations in strained LaAlO_3 films via synchrotron x-ray diffraction, R.L. Johnson-Wilke, D. Marincel, R. Engel-Herbert, V. Gopalan, S. Zhu, D.G. Schlom, M.P. Warusawithana, A. Hatt, J. Sayre, K.T. Delaney, N.A. Spaldin, C. M. Schlepütz, J.-W. Kim, P. Ryan, and S. Trolier-McKinstry *Phys. Rev. B*, **88**, 174101 (2013)
188. Large nonlinear optical coefficients in pseudo-tetragonal BiFeO_3 thin films, R. C. Haislmaier, N. J. Podraza, S. Denev, A. Melville, D. G. Schlom, V. Gopalan, *Appl. Phys. Lett.* **103**, 031906 (2013). <https://doi.org/10.1063/1.4812978>
189. Silicon p-i-n Junction Fibers, He, R., Day, T.D., Krishnamurthi, M., Sparks, J.R., Sazio, P.J.A., Gopalan, V., and Badding, J. V., *Advanced Materials*, **25**, 1461-1467 (2013). (Most accessed in December 2012.) (News Perspectives.) (Frontispiece.)
190. Effect of stoichiometry on the dielectric properties and soft mode behavior of strained epitaxial SrTiO_3 thin films on DyScO_3 substrates, C-H. Lee, V. Skoromets, S. Lei, M. D. Biegalski, M. Bernhagen, R. Uecker, X.X. Xi, V. Gopalan, X. Martí, S. Kamba, P. Kužel, and D. G. Schlom, *Applied Physics Letters*, **102**, 082905 (2013).
191. Polarization and pyroelectricity in antiferrodistortive structures and surfaces induced by a flexoelectric effect: Impact of free charges, A. Morozovska, E. A. Eliseev, M. D. Glinchuk, L-Q. Chen, S. V. Kalinin, V. Gopalan, *Ferroelectrics*, **438**, 32-44 (2012).
192. Integration of GHz Bandwidth Semiconductor Devices inside Microstructured Optical Fibers, R. He, P. J. A. Sazio, N. Healy, A. C. Peacock, M. Krishnamurthi, V. Gopalan, J. V. Badding, *Nature Photonics*, **6**, 174-179 (2012).

193. Conductivity of twin walls-surface junctions in ferroelastics-Interplay of deformation potential, octahedral rotations, improper ferroelectricity, and flexoelectric coupling, E. A. Eliseev, A. N. Morozovska, Y. Gu, A. Borisevich, L-Q. Chen, V. Gopalan, S. V. Kalinin, *Phys. Rev. B*, **86**, 085416 (2012).
194. Orthorhombic BiFeO₃ Multiferroic Thin Films, J. C. Yang, Q. He, S. J. Suresha, C. Y. Kuo, R. Haislmaier, G. Sheng, C. Adamo, H. J. Liu, C. W. Liang, C. Y. Peng, H. J. Lin, Z. Hu, L. Chang, C. T. Chen, L. H. Tjeng, E. Arenholz, D. G. Schlom, V. Gopalan, L. Q. Chen, Y. H. Chu, and R. Ramesh, *Phys. Rev. Lett.*, **109**, 247606 (2012).
195. A magnifying fiberscope for infrared imaging with sub-wavelength Ge/ZnSe pixel waveguides, Mahesh Krishnamurthi, Eftihia Barnes, Justin Sparks, Rongrui He, Neil Baril, Pier Sazio, John Badding, and V. Gopalan, *Applied Physics Lett.* **101**, 021108 (2012).
196. Origin of piezoelectric response under a biased scanning probe microscopy tip across a 180° ferroelectric domain wall, S. Lei, E. A. Eliseev, A. N. Morozovska, R. C. Haislmaier, T. T. A. Lummen, W. Cao, S. V. Kalinin and V. Gopalan, *Phys. Rev. B*, **86**, 134115, (2012); Erratum: *Phys. Rev. B*, **87**, 179904(E) (2013).
197. Surface polar states and pyroelectricity in ferroelastics induced by flexo-rotational field, A. N. Morozovska, E. A. Eliseev, S. V. Kalinin, L-Q. Chen, V. Gopalan, *Appl. Phys. Lett.* **100**, 142902 (2012).
198. Dipole spring ferroelectrics in superlattice SrTiO₃/BaTiO₃ thin films exhibiting constricted hysteresis loops, P. Wu, X. Ma, Y. Li, V. Gopalan, L-Q. Chen, *Appl. Phys. Lett.* **100**, 092905 (2012).
199. Array of tapered semiconductor waveguides in a fiber for infrared image transfer and magnification, M. Krishnamurthi, J. Sparks, R. He, I. A. Temnykh, N. Baril, Z. Liu, P. A. Sazio, J. V. Badding, V. Gopalan, *Optics Express*, **20**, 4168-4175 (2012).
200. Investigating electric field control of magnetism, M. B. Holcomb, S. Polisetty, A. Fraile-Rodriguez, V. Gopalan, R. Ramesh, *review article International J. Modern Physics B* **26**, 1230004-1/12 (2012).
201. A Phenomenological Thermodynamic Potential for CaTiO₃ Single Crystal, Yijia Gu, Karin Rabe, Eric Bousquet, Venkatraman Gopalan, and Long-Qing Chen, *Phys. Rev. B*, **85**, 064117 (2012).
202. Interfacial Polarization and pyroelectricity in antiferrodistortive structures induced by a flexoelectric effect and rotostriction, A. Morozovska, E. A. Eliseev, M. D. Glinchuk, V. Gopalan, *Phys. Rev. B*, **85**, 094107 (2012).
203. Frequency shift of Raman modes due to an applied electric field and domain inversion in LiNbO₃, G. Stone, B. Knorr, V. Gopalan, V. Dierolf, *Physical Rev. B* **84**, 134303 (2011).
204. Rotation-reversal symmetries in crystals and handed structures, V. Gopalan, D. B. Litvin, *Nature Materials*, **10**, 376 (2011).
205. Thick lead-free ferroelectric films with high Curie temperatures through nanocomposite-induced strain, S. Harrington, J. Zhai, S. A. Denev, V. Gopalan, H. Wang, Z. Bi, S. A. T. Redfern, S-H. Baek, C.W. Bark, C-B. Eom, Q. X. Jia, M. E. Vickers, J. L. MacManus-Driscoll, *Nature Nanotechnology* **6**, 491-495 (2011).
206. Probing Ferroelectrics using Optical Second Harmonic Generation, S. A. Denev, T. T. A. Lummen, E. Vlahos, V. Gopalan, *J. Amer. Cer. Soc.* **94**[9], 2699-2727 (2011).
207. Confined High Pressure Chemical Deposition of Amorphous Hydrogenated Silicon, Neil F. Baril, Rongrui

- He, Todd D. Day, Justin R. Sparks, Banafsheh Keshavarzi, Mahesh Krishnamurthi, Ali Borhan, Venkatraman Gopalan, Anna C. Peacock, Noel Healy, Pier J.A. Sazio, John V. Badding, *J. Am. Chem. Soc.* **134**, 19-22 (2012).
208. Structure and energetics of 180° domain walls in PbTiO₃ by density functional theory, R. K. Behera, C-W. Lee, D. Lee, A. N. Morozovska, S. B. Sinnott, A. Asthagiri, V. Gopalan, and S. R. Phillpot, *J. Phys. Condensed Matter*, **23**, 175902-1/12 (2011).
209. High conductivity of charged domain walls in *n*-type uniaxial ferroelectric semiconductors, E. Eliseev, A. M. Morozovska, S. V. Svechnikov, V. Gopalan, V. Ya. Shur, *Phys. Rev. B*, **83**, 235313-1/8 (2011).
210. Low loss ZnSe Optical Fiber Waveguides, J. R. Sparks, R. He, Noel Healy, M. Krishnamurthi, A. C. Peacock, P. J.A. Sazio, V. Gopalan, and J. V. Badding, *Advanced Materials*, **23**, 1647-1651 (2011).
211. Characterization of the second-harmonic response of second-order nonlinear probes, H. Li, P. Edwards, Z. Zhang, Y. Xu, V. Gopalan, Z. Liu, *J. Opt. Soc. Am. B*, **28**, 2844-2847(2011).
212. Interactions of Defects and Domain Walls in LiNbO₃ – Insights from Simulation, H. Xu, D. W. Lee, S. B. Sinnott, V. Gopalan, V. Dierolf and S. R. Phillpot, *IOP Conf. Ser.: Mater. Sci. Eng.* **15** 012003 (2010).
213. Chromatic second harmonic generation, C. Yang, K. Shi, H. Li, Q. Xu, V. Gopalan, Z. Liu, *Optics Express*, **18**, 23837-23843 (2010).
214. Shape of domains in LiNbO₃ and LiTaO₃ from defect/domain wall interactions, Donghwa Lee (이동화), Haixuan Xu (徐海讚), Volkmar Dierolf, Venkatraman Gopalan, and Simon R. Phillpot, *Appl. Phys. Lett.* **98**, 092903 (2010).
215. Mid-infrared transmission properties of amorphous germanium optical fibers, P. Mehta, M. Krishnamurthi, N. Healy, N. F. Baril, J. Sparks, P. J. A. Sazio, V. Gopalan, J. V. Badding, A. C. Peacock, *Applied Physics Lett.* **97**, 071117 (2010).
216. Stability and charge transfer levels of extrinsic defects in LiNbO₃, H. Xu (徐海讚), A. Chernatynskiy, D. Lee (이동화), S. B. Sinnott, V. Gopalan, V. Dierolf, and S. R. Phillpot, *Phys. Rev. B* (2010), **82** 184109 (2010).
217. Phase diagram and domain splitting in thin ferroelectric films with incommensurate phase, A.N. Morozovska, E.A. Eliseev, JianJun Wang, G.S. Svechnikov, Yu. M. Vysochanskii, V. Gopalan, and Long-Qing Chen, *Phys. Rev. B*, **81**, 195437, (2010).
218. Correlated polarization switching in the proximity of a 180 degree domain wall, A. Vasudevarao, A. N. Morozovska, I. Grinberg, S. Bhattacharya, Y. Li, S. Jesse, P. Wu, K. Seal, S. Choudhury, E.A. Eliseev, S. Svechnikov, D. Lee, S. Phillpot, L.Q. Chen, A. M. Rappe, V. Gopalan and S.V. Kalinin, *Phys. Rev. B*, **82**, 024111 (2010).
219. Optical Properties of quasi-tetragonal BiFeO₃ thin films, P. Chen, N. J. Podraza, X. S. Xu, A. Melville, E. Vlahos, V. Gopalan, R. Ramesh, D. G. Schlom, and J. L. Musfeldt, *Appl. Phys. Lett.* **96**, 131907 (2010).
220. Laser improved protein crystallization screening, N. Yennawar, S. Denev, V. Gopalan, H. Yennawar, *Acta Crystallographica F*, **66**, 969-972 (2010).

221. Phase-field simulations of phase transitions and domain stabilities in biaxially strained (001) SrTiO₃ epitaxial thin films, G. Sheng, Y. L. Li, J. X. Zhang, S. Choudhury, Q. X. Jia, V. Gopalan, D. G. Schlom, Z. K. Liu, L. Q. Chen, *J. Appl. Phys.* **108**, 084113-1/6 (2010).
222. Structure and Energetics of ferroelectric domain walls in LiNbO₃ from atomic-level simulation, Donghwa Lee (이동화)¹, Haixuan Xu (徐海譔)¹, Venkatraman Gopalan², Volkmar Dierolf, V. Gopalan and Simon R. Phillpot, *Phys. Rev. B.* **82**, 014104-1/13, (2010).
223. Creating a Strong Ferroelectric Ferromagnet via Spin-Phonon Coupling, J. H. Lee, L. Fang, E. Vlahos, X. Ke, Y. W. Jung, L. Fitting Kourkoutis, J.W. Kim, P. Ryan, T. Heeg, M. Roeckerath, V. Goian, M. Bernhagen, R. Uecker, P. C. Hammel, K. M. Rabe, S. Kamba, J. Schubert, J. W. Freeland, D. A. Muller, C. J. Fennie, P. Schiffer, V. Gopalan, E. Johnston-Halperin & D. G. Schlom, *Nature* **466**, 954 (2010).
224. Optical multistability in a silicon-core silica-cladding fiber, I. A. Temnykh, N. F. Baril, Z. Liu, J. V. Badding, V. Gopalan, *Optics Express*, **18**, 5305-5313 (2010).
225. Probing mixed phases and monoclinic distortion in strained bismuth ferrite films by optical second harmonic generation, A. Kumar, R. Zeches, S. Denev, N. Podraza, A. Melville, D. G. Schlom, R. Ramesh, V. Gopalan, *Appl. Phys. Lett.* **97**, 112903 (2010).
226. A modified Landau-Devonshire thermodynamic potential for strontium titanate, G. Sheng, Y. L. Li, J. X. Zhang, S. Choudhury, Q. X. Jia, V. Gopalan, D. G. Schlom, Z. K. Liu and L. Q. Chen, *Appl. Phys. Lett.* **96**, 232902(2010).
227. Tunable band gap in Bi(FeMn)O₃ films, X.S. Xu, J. F. Ihlefeld, J. H. Lee, O.K. Ezekoye, E. Vlahos, R. Ramesh, V. Gopalan, X.Q. Pan, D. G. Schlom, and J.L. Musfeldt, *Appl. Phys. Lett.* **96**, 192901 (2010).
228. Ferroelectricity in strain-free SrTiO₃ films, H. W. Jang, A. Kumar, S. Denev, M. D. Biegalski, P. Maksymovych, C. T. Nelson, C. M. Folkman, S. H. Baek, N. Balke, D.A. Tenne, D. G. Schlom, L. Q. Chen, X. Q. Pan, S. V. Kalinin, V. Gopalan, and C. B. Eom, *Phys. Rev. Lett.* **104**, 197601(2010).
229. High Pressure chemical deposition for void free filling of extreme aspect ratio templates, N. F. Baril, B. Keshavarzi, J. R. Sparks, Mahesh Krishnamurthi, I. Temnykh, P.J.A. Sazio, Ali Borhan, V. Gopalan, and J. V. Badding, *Advanced Materials*, **22**, 4605-4611(2010).
230. Structure and diffusion of intrinsic defect complexes in LiNbO₃ from density functional theory calculations, H. Xu, D. Lee, J. He, S. B. Sinnott, V. Dierolf, V. Gopalan, S. R. Phillpot, *Journal of physics, Condensed Matter* **22**, 135002-1/7 (2010).
231. Optical properties of tetragonal BiFeO₃ thin films, P. Chen, N. J. Podraza, X. S. Xu, A. Melville, E. Vlahos, V. Gopalan, R. Ramesh, D. G. Schlom, and J. L. Musfeldt, *Appl. Phys. Lett.* **96**, 131907-1/4 (2010).
232. Co-Casting and Optical Characteristics of Transparent Segmented Composite Er:YAG Laser Ceramics, E. R. Kupp, G. L. Messing, J. M. Anderson, V. Gopalan, J. Q. Dumm, C. Kraisinger, N. Ter-Gabrielyan, L. D. Merkle, M. Dubinskii, V. K. Castillo-Simonaitis, G. J. Quarles, *J. Materials Research* **25**, 476-483 (2010).
233. Thermodynamics of nanodomain formation and breakdown in Scanning Probe Microscopy: Landau-Ginzburg-Devonshire approach, A. N. Morozovska, Eugene A. Eliseev, Yulan Li, S. V. Svechnikov, P. Maksymovych, V. Gopalan, L-Q. Chen and S. V. Kalinin, *Phys. Rev. B*, **80**, 214110 (2009).

234. Electro-Optic Laser Beam Shaping by Patterned Ferroelectric domains, Mahesh Krishnamurthi, Peng Li, Aseem Singh, J. G. Thomas, T. M. Lehecka, Z. Liu and V. Gopalan, *Appl. Phys. Lett.* **95**, 202902 (2009).
235. A strain-driven morphotropic phase boundary in BiFeO₃, R. J. Zeches, M. D. Rossell, J. X. Zhang, A. J. Hatt, C. H. Yang, A. Kumar, A. Melville, J. H. Ihlefeld, R. Erni, C. Ederer, V. Gopalan, D. G. Schlom, N. A. Spaldin, L. W. Martin, R. Ramesh, *Science* **326**, 977 (2009).
236. Phase Transition in Weberite-type Gd₃NbO₇, L. Cai, S. Denev, V. Gopalan, and J. C. Nino, *J. Amer. Cer. Soc.* **93**, 875-880 (2009).
237. Structure and Energetics of Er defects in LiNbO₃ from first principles and thermodynamic calculations, H. Xu, D. Lee, S. B. Sinnott, V. Gopalan, V. Dierolf, S. R. Phillpot, *Phys. Rev. B*, **80**, 144104-1/9 (2009).
238. Spin-Charge-Lattice Coupling through Multi-Magnon Excitations in Multiferroic BiFeO₃, M. O. Ramirez, A. Kumar, S. A. Denev, Y. H. Chu, J. Seidel, L. Martin, S-Y. Yang, R. C. Rai, X. Xu, J. F. Ihlefeld, N. Podraza, E. Saiz, S. Lee, J. Klug, S. W. Cheong, M.J. Bedzyk, O. Auciello, J. L. Musfeldt, D. G. Schlom, R. Ramesh, J. Orenstein and V. Gopalan, *Appl. Phys. Lett.* **94**, 161905-1/3 (2009).
239. Mixed Bloch-Néel-Ising Character of 180° Ferroelectric Domain Walls, Donghwa Lee (이동화), Rakesh K. Behera, Pingping Wu, Haixuan Xu (徐海讚), Y. L. Li, Simon R. Phillpot, Susan B. Sinnott, L. Q. Chen, V. Gopalan, *Phys. Rev. B. Rapid Communications*, **80**, 060102(R)(2009).
240. Coexistence of weak ferromagnetism and ferroelectricity in the high pressure LiNbO₃-type phase of FeTiO₃, T. Varga, A. Kumar, E. Vlahos, S. Denev, M. Park, S. Hong, T. Sanehira, Y. Wang, C. J. Fennie, S. K. Streiffer, X. Ke, P. Schiffer, V. Gopalan, J. F. Mitchell, *Phys. Rev. Lett.* **103**, 047601 (2009).
241. Temperature dependent blue second harmonic generation in Ba₅Li₂Ti₂Nb₈O₃₀ microcrystals embedded in TeO₂ glass-matrix, N. A Madhar, A. Vasudevarao; V. Gopalan; H.Jain; K.B.R. Varma, *Journal of non-crystalline solids*, **355**, 1517-1520 (2009).
242. Magnon Sidebands in Bismuth Ferrite Probed by Nonlinear Optical Spectroscopy, M. O. Ramirez, A. Kumar, S. Denev, N. Podraza, X. S. Xu, R. C. Rai, Y. H. Chu, J. Seidel, L. Martin, S-Y. Yang, E. Saiz, J. F. Ihlefeld, S. Lee, S. W. Cheong, D. G. Schlom, R. Ramesh, J. Orenstein, J. L. Musfeldt, and V. Gopalan, *Phys. Rev. B*, **76**, 224106 (2009).
243. Optical Properties and magnetochromism in multiferroic BiFeO₃, X. S. Xu, T. V. Brinzari, S. Lee, Y. H. Chu, L. W. Martin, A. Kumar, S. McGill, R. C. Rai, R. Ramesh, V. Gopalan, S. W. Cheong, J. L. Musfeldt, *Phys. Rev. B*, **79**, 134425-1/4 (2009).
244. Anisotropic ferroelectric properties of SrTiO₃ thin films on DyScO₃ substrates, M. D. Biegalski, E. Vlahos, Y. L. Li, L. Q. Chen, V. Gopalan, S. Trolier-Mckinstry, D. G. Schlom, S. K. Streiffer, M. Bernhagen, P. Reiche and R. Uecker, *Phys. Rev. B*, **79**, 224117-1/11(2009).
245. Stripe vertical domain walls of epitaxial (001) BiFeO₃ thin films on orthorhombic TbScO₃ substrate, C. M. Folkman, S.H. Baek, H.W. Jang, C. B. Eom, C. T. Nelson, X.Q. Pan, A. Kumar and V. Gopalan, *Appl. Phys. Lett.* **94**, 254911-1/3(2009).

246. Surface Effect on Domain Wall Width in Ferroelectrics, E. A. Eliseev, Anna N. Morozovska, Sergei V. Kalinin, Yulan L. Li, Jie Shen, Maya D. Glinchuk, Long-qing Chen, Venkatraman Gopalan, *J. Appl. Phys.* **106**, 084102 (2009).
247. The interaction of a 180° ferroelectric domain wall with a biased scanning probe microscopy tip: Geometry and thermodynamics in Ginzburg-Landau-Devonshire theory, A. N. Morozovska, S. V. Kalinin, E. A. Eliseev, V. Gopalan, S. V. Svechnikov, *Phys. Rev. B* **78**, 124407-1/11(2008).
248. Stability of defects and defect clusters in LiNbO₃ from density functional theory calculations, H. Xu, D. Lee, J. He, S. B. Sinnott, V. Gopalan, V. Dierolf, S. R. Phillpot, *Physical Review B* **78**, 174103-1/12 (2008).
249. Solitons and critical breakup fields in lithium niobate type uniaxial ferroelectrics, A. Bandyopadhyay, P. C. Ray, V. Gopalan, *European Physical Journal B*, **65**, 525–531 (2008).
250. The Influence of 180 degree ferroelectric domain wall width on the threshold field for wall motion, S. Choudhury, Y. Li, N. Odagawa, Aravind Vasudevarao, L. Tian, P. Capek, V. Dierolf, A. N. Morozovska, Eugene A. Eliseev, Sergei Kalinin, Long-qing Chen, Venkatraman Gopalan, *J. Appl. Phys.* **104**, 084107-1/7, (2008).
251. Magnetic color symmetry of lattice rotations in a diamagnetic material, S. Denev, A. Kumar, M. Biegalski, H. W. Wang, C. M. Folkman, A. Vasudevarao, Y. Han, I. M. Reaney, S. T. Mckinstry, C. B.- Eom, D. G. Schlom, V. Gopalan, *Phys. Rev. Lett.*, **100**, 257601-1/4 (2008).
252. Nanoscale polarization profile across a 180° ferroelectric domain wall extracted by quantitative piezoelectric force microscopy, L. Tian, A. Vasudevarao, A. N. Morozovska, E. A. Eliseev, S. Kalinin, V. Gopalan, **104**, 074110-1/10 *J. Appl. Phys.* (2008).
253. Effect of the intrinsic width on the piezoelectric force microscopy of a single ferroelectric domain wall, A. N. Morozovska, E. A. Eliseev, G. S. Svechnikov, V. Gopalan, S. Kalinin, *J. Appl. Phys.* **103**, 124110 (2008).
254. Linear and Nonlinear Optical Properties of multifunctional PbVO₃, A. Kumar, S. Denev, L. W. Martin, R. Ramesh, and V. Gopalan, *Appl. Phys. Lett.* **92**, 231915 (2008).
255. Design and simulation of planar electro-optic switches in ferroelectrics, M. Krishnamurthi, L. Tian and V. Gopalan, **93**, 052912, *Appl. Phys. Lett.* (2008).
256. Linear and Nonlinear Optical Properties of BiFeO₃, A. Kumar, R. C. Rai, N. J. Podraza, S. Denev, M. Ramirez, Y.-H. Chu, L. W. Martin, J. Ihlefeld, T. Heeg, J. Schubert, D. G. Schlom, J. Orenstein, R. Ramesh, R. W. Collins, J. L. Musfeldt, and V. Gopalan, *Appl. Phys. Lett.* **92**, 121915-1/3 (2008).
257. Polarization rotation transitions in anisotropically strained SrTiO₃ thin films, A. Vasudevarao, Sava Denev, Michael D. Biegalski, Yulan Li, Long-Qing Chen, Susan Trolier-McKinstry, Darrell G. Schlom, and Venkatraman Gopalan *Appl. Phys. Lett.* **92**, 12195-1/3 (2008).
258. Sintering and Grain Growth in SiO₂ doped Nd:YAG, S. Kochawattana, A. Stevenson, E. Kupp, Sang-Ho Lee, M. Ramirez, V. Gopalan, and G. L. Messing, *J. Eur. Cer. Soc.* **28**, 1527–1534 (2008).
259. Three-dimensional grain boundary spectroscopy in transparent high power ceramic laser materials, M. O. Ramirez, J. Wisdom, Z. Liu, R. L. Byer, G. L. Messing, V. Gopalan, *Optics Express*, **16**, 5965-5973 (2008).

260. Two-phonon coupling to the antiferromagnetic phase transition in multiferroic BiFeO_3 , M. O. Ramirez, M. Krishnamurthy, S. Denev, A. Kumar, S.-Y. Yang, Y. H. Chu, E. Saiz, A. P. Pyatakov, A. Bush, D. Viehland, J. Orenstein, R. Ramesh, V. Gopalan, *Appl. Phys. Lett.* **92**, 022511-3 (2008).
261. Development of optical nonlinearity, high dielectric constant, and ferromagnetic behavior in a silicate glass nanocomposite by suitable heat treatment, S. Basu, V. Gopalan, H. Jain, D. Chakravorty, *J. Non-Crystalline Solids*, **354**, 3278-3283 (2008).
262. Natural focusing of rays from ferroelectric lithium niobate wafers, S. Durbin, T. Jach, S. Kim, V. Gopalan, *Appl. Phys. Lett.* **91**, 142909 (2007).
263. Amorphous silicon-filled microstructures optical fibers for in-fiber light modulation, D. Won, M. O. Ramirez, V. Gopalan, H. Kang, N. F. Baril, J. Calkins, P. J. A. Sazio, J. V. Badding, V. Gopalan, *Appl. Phys. Lett.* **91**, 161112-1/3(2007).
264. Raman studies of ferroelectric domain walls in lithium tantalate and niobate, P. Capek, G. Stone, V. Dierolf, C. Althouse, V. Gopalan, *Phys. Stat. Sol.* **4**, 830-833 (2007).
265. Adsorption-controlled molecular-beam epitaxial growth of BiFeO_3 , J. F. Ihlefeld, A. Kumar, V. Gopalan, D. G. Schlom, Y. B. Chen, X. Q. Pan, T. Heeg, J. Schubert, X. Ke, P. Schiffer, J. Orenstein, L. W. Martin, Y. H. Chu, and R. Ramesh, *Appl. Phys. Lett.* **91**, 071922 (2007).
266. Quantitative determination of the tip parameters in piezoresponse force microscopy, S. V. Kalinin, S. Jesse, B. J. Rodriguez, E. A. Eliseev, V. Gopalan, A. N. Morozovska, *Appl. Phys. Lett.* **90**, 212905 (2007).
267. 2-D dynamic focusing of laser light by ferroelectrics based electro-optic domain lenses, M. Krishnamurthi, S. Denev, L. Tian, T. Lehecka, J. Thomas, V. Gopalan, *Appl. Phys. Lett.* **90**, 201106-1/3 (2007).
268. Integrated Optoelectronics in an Optical Fiber, J.V. Badding, A. Amezcua Correa, T.J. Scheidemantel, C.E. Finlayson, N.F. Baril, D.J. Won, H. Fang, B. Jackson, A. Borhan and V. Gopalan, Proceedings of SPIE-The International Society for Optical Engineering, volume 6475, 64750N (2007)
269. Microstructured Optical Fibers as New Nanotemplates for High Pressure CVD, N.F. Baril, J.V. Badding, V. Gopalan, P.J. Sazio, T.J. Scheidemantel, B.R. Jackson, D.-J. Won, A. Amezcua Correa and C. Finlayson, Materials Research Society Symposium Proceedings, in press.(2007)
270. Polar and Magnetic properties of PbVO_3 Thin Films, Amit Kumar, Lane W. Martin, Sava Denev, Qian Zhan, Miaofang Chi, Teruyasu Mizoguchi, Jeffery B. Kortright, Jens Kreisel, Nigel Browning, R. Ramesh, Yuri Suzuki, and Venkatraman Gopalan, *Physical Review B- Rapid Communications* **75**, 060101-4(R)(2007).
271. Multiferroic Domain Dynamics in strained SrTiO_3 , A. Vasudevarao, A. Kumar, L. Tian, J. H. Haeni, Y.L. Li, C. Fennie, C-J Eklund, Q.X. Jia, R. Uecker, P. Reiche, K. Rabe, L.Q. Chen, D.G. Schlom and V. Gopalan, *Phys. Rev Lett.* **97**, 257602 (2006). (cond-mat/0609585)
272. Microstructured optical fibers as high-pressure microfluidic reactors, P. J.A. Sazio, A. Amezcua-Correa, C. E. Finlayson, J. R. Hayes, T. J. Scheidemantel, N. F. Baril, B. R. Jackson, D-J. Won, F. Zhang, R. Margine, V. Gopalan, V. H. Crespi, and J. V. Badding, *Science*, **311**, 1583, (2006).

273. Dynamical systems analysis for polarization in ferroelectrics, A. K. Bandhyopadhyay, P. C. Ray, V. Gopalan, *Journal of Applied Physics*, **100**, 114106-1 to 11410-9 (2006).
274. An approach to the Klein–Gordon equation for a dynamic study in ferroelectric materials, A. K. Bandhyopadhyay, P. C. Ray, V. Gopalan, *Journal of Physics Condensed Matter*, **18**, 4093-4099 (2006).
275. *c*-axis oriented epitaxial BaTiO₃ films on (001) Si, V. Vaithyanathan, J. Lettieri, W. Tian, A. Kochhar, H. Ma, A. Sharan, A. Vasudevarao, V. Gopalan, Y. Li, L. Q. Chen, P. Zschack, J. C. Woicik, J. Levy, and D. G. Schlom, *J. Appl. Phys.* **100**, 024108-1/9 (2006).
276. Phase transitions and domain structures in strained pseudocubic (001) SrTiO₃ thin films, Y. L. Li, S. Choudhury, J.H. Haeni, M.D. Biegalski, A. Vasudevarao, A. Sharan, H. Z. Ma, J. Levy, V. Gopalan, S. Trolier-McKinstry, D. G. Schlom, Q. X. Jia, and L. Q. Chen, *Physical Review B*, **73**, 184112-1-to-13 (2006).
277. Building semiconductor structures in optical fiber, J. V. Badding, V. Gopalan, P. J. A. Sazio, *Photonics Spectra*, **40**, n 8, p 80-8, Aug. (2006).
278. Fabrication of semiconductor-metal optical fiber metamaterials for electromagnetic devices, J. V. Badding, P. J. A. Sazio, A. Amezcua Correa, T. J. Scheidemantel, C. E. Finlayson, N. F. Baril, D.-J. Won, H. Fang, B. Jackson, V. Gopalan, D. H. Werner, L. Li, Proceedings, IEEE Antennas and Propagation Society International Symposium (IEEE Cat. No. 06CH37758C), p 768 (2006)
279. Spatial mapping of Fluorescence and Raman spectra across grain boundaries in transparent Nd-YAG ceramic laser materials, S-J. Lee, J. Stitt, W. White, G. Messing, V. Gopalan, Proceedings of the SPIE, Solid State Lasers XV: Technology and Devices, Editors: Hanna J. Hoffman, Ramesh K. Shori, V 6100, page 610011-1/11-8, San Jose CA, Jan (2006).
280. Xray synchrotron imaging of ferroelectric domain walls, T. Jach, V. Gopalan, *Ceramic Transactions* 196, 119-123 (2006).
281. Hybrid Electro-optic and Piezoelectric Laser Beam Steering in Two Dimensions, D. A. Scrymgeour, B. Koc, L. Tian, M. W. Gentzel, K. Uchino and V. Gopalan, *IEEE Journal of Lightwave Technology*, **23**, 2772-2777 (2005).
282. Tunable microphotonic devices in ferroelectrics, D. A. Scrymgeour, V. Gopalan, K. Gahagan, *American Ceramic Society Bulletin* **84** (5), 14-17 (2005).
283. Numerical study of the light-beam propagation and superprism effect inside two-dimensional hexagonal photonic crystals, N. Malkova, D. Scrymgeour, and V. Gopalan, *Physical Review B*, **72**, 045144 (2005).
284. Nanoscale Piezoelectric response at a single ferroelectric Domain wall, D. Scrymgeour, V. Gopalan, *Phys. Rev. B* **72**, 024103 (2005).
285. Real-time study of domain dynamics in Sr_{0.61}Ba_{0.39}Nb₂O₆, L. Tian, D. A. Scrymgeour, V. Gopalan, *J. Appl. Physics*, **97**, 114111-1(2005).
286. Phased-Array Electro-Optic Steering of Large Aperture Laser Beams using Ferroelectrics, D. A. Scrymgeour, L. Tian, V. Gopalan, D. Chauvin, K. A. Schepler, *Applied Physics Letters*, **86**, 211113 (2005).

287. Phenomenological theory of a Single Domain Wall in Uniaxial Trigonal Ferroelectrics: Lithium Niobate and Lithium Tantalate, D. Scrymgeour, V. Gopalan, A. Itagi, A. Saxena, P. Swart, *Phys. Rev. B* **71**, 184110-1/13 (2005).
288. Optical index profile at an antiparallel ferroelectric domain wall in lithium niobate, S. Kim, V. Gopalan, *Materials Science and Engineering, B Solid State Materials for Advanced Technologies*, **120**, 91-94 (2005).
289. Ultraviolet laser-induced sub-micron periodic domain formation in congruent undoped lithium niobate crystals, C.L. Sones, C.E. Valdivia, J.G. Scott, S. Mailis, R.W. Eason, D.A. Scrymgeour, V. Gopalan (4), T. Jungk, E. Soergel, *Applied Physics B*, **80**, 341(2005).
290. Nanoscale surface domain formation on the + z face of lithium niobate by pulsed UV laser illumination, C.E. Valdivia, C.L. Sones, J.G. Scott, S. Mailis, R.W. Eason, D.A. Scrymgeour, V. Gopalan, T. Jungk, E. Soergel, *Applied Physics Letters*, **86**, 022906 (2005).
291. Fabrication of extreme aspect ratio wires within photonic crystal fibers. Badding, J. V., P. J. A. Sazio, A. Amezcua Correa, T. J. Scheidemantel, C. E. Finlayson, N. F. Baril, D. J. Won, H. Fang, B. Jackson, A. Borhan and V. Gopalan (4). Proceedings of SPIE-The International Society for Optical Engineering 6005: 111-119 (2005).
292. Comparison of the domain reversal and electro-optic properties of congruent and stoichiometric lithium tantalate, L. Tian, V. Gopalan, Proceedings of the SPIE, Integrated Optics: Devices, Materials, and Technologies IX, Y. Sidorkin, C. A. Wächter, Eds. Vol. 5728, p. 278-282, San Jose CA, Jan (2005).
293. Domain reversal in stoichiometric lithium tantalate prepared by vapor transport equilibration, L. Tian, V. Gopalan, *Applied Physics Letters*, **85**, 4445-4447 (2004).
294. Enhancement of ferroelectricity in strained BaTiO₃ thin films, K. J. Choi, M. Biegalski, Y. L. Li, A. Sharan, J. Schubert, R. Uecker, P. Reiche, Y. B. Chen, X. Q. Pan, V. Gopalan, L.-Q. Chen, D. G. Schlom, C. B. Eom, *Science* **306**, 1005 (2004).
295. Electro-optic Coefficients of Lithium Tantalate at Near-IR Wavelengths, J. L. Casson, K. T. Gahagan, D. A. Scrymgeour, R. K. Jain, J. M. Robinson, V. Gopalan, R. K. Sander, *Journal of the Optical Society of America, B*, **21**, 1948-1952 (2004).
296. Local electromechanical response at a single ferroelectric domain wall, D. Scrymgeour, V. Gopalan, *Metallurgical and Materials Transactions*, **35A**, 2287-90 (2004).
297. Bismuth Manganite: a multiferroic with a large nonlinear optical response, A. Sharan, J. Lettieri, Y. Jia, W. Tian, X. Pan, D. Schlom, V. Gopalan, *Physical Review B*, **60**, 214109/1-7 (2004).
298. Coupled displacive and order-disorder dynamics in LiNbO₃ by molecular dynamics simulation, S. Phillpot, V. Gopalan, *Applied Physics Letters*, **84**, 1916-18 (2004).
299. Long range strains and the effects of applied fields at 180° ferroelectric domain walls in lithium niobate, T. Jach, S. Kim, V. Gopalan, S. Durbin, D. Bright, *Physical Review B*, **69**, 064113-1/9 (2004).
300. Processing and properties of high aspect ratio ferroelectric structures, S. S. N. Bharadwaja, D. J. Won, H. Fang, V. Gopalan, S. Trolier-Mckinstry, L. Saldanha, T. Mayer, Proceedings, IEEE International Ultrasonics,

- Ferroelectrics, and Frequency Control, Joint 50th anniversary conference , Montreal, August (2004) pp. 189-192.
301. Tunable electro-optic microphotonic devices in ferroelectrics, D. A. Scrymgeour, V. Gopalan, K. T. Gahagan, Proceedings of the SPIE, Active and Passive Optical Components for WDM Communications IV; Achyut K. Dutta, Abdul Ahad S. Awwal, Niloy K. Dutta, Yasutake Ohishi; Eds. Vol. 5595, p. 310-317, October (2004).
 302. Tunable microphotonic devices on ferroelectrics, D. A. Scrymgeour, K. T. Gahagan, V. Gopalan, Proceedings, American Ceramics Society Annual Meeting, Indianapolis, IN, Photonic Materials and Devices symposium, April (2004).
 303. Domain reversal in single crystal strontium barium niobate ($\text{Sr}_{0.61}\text{Ba}_{0.39}\text{Nb}_2\text{O}_6$), L. Tian, D. Scrymgeour, V. Gopalan, Conference on Lasers and Electro-Optics (CLEO), pt. 1, p 2 pp. vol.1 (2004).
 304. Numerical study of the light-beam propagation inside two-dimensional crystals, Malkova, N., Scrymgeour, D., Gopalan, V., 2004 Digest of the LEOS Summer Topical Meetings: Biophotonics/Optical Interconnects & VLSI Photonics/WGM Microcavities (IEEE Cat. No.04TH8728), p 2 (2004).
 305. Strain-tunable optical valves at T-junction waveguides in photonic crystals, N. Malkova, V. Gopalan, *Physical Review B*, **68**, 245115-1/6 (2003).
 306. Large optical nonlinearities in BiMnO_3 thin films, A. Sharan, I. Ahn, C. Chen, R. W. Collins, J. Lettieri, D. Schlom, V. Gopalan, *Applied Physics Letters* **83**, 5169-71 (2003).
 307. Anomalous electro-optic effect in $\text{Sr}_{0.6}\text{Ba}_{0.4}\text{Nb}_2\text{O}_6$ single crystals and its application in 2-dimensional laser scanning, L. Tian, A. Sharan, V. Gopalan, *Applied Physics Letters*, **83**, 4375-77 (2003).
 308. Strain-tunable light transmission through a 90° bend waveguide in a two-dimensional photonic crystal, N. Malkova, S. Kim, and V. Gopalan, *Applied Physics Letters*, **83**, 1509-11 (2003).
 309. Electro-optic control of superprism effect in photonic crystals, D. Scrymgeour, N. Malkova, S. Kim, and V. Gopalan, *Applied Physics Letters*, **82**, 3176-78 (2003);
 310. Symmetrical analysis of complex two-dimensional hexagonal photonic crystals, N. Malkova, S. Kim, T. Dilazaro, V. Gopalan, *Physical Review B*, **67**, 125203-11 (2003).
 311. Jahn-Teller effect in two-dimensional photonic crystals, N. Malkova, S. Kim, V. Gopalan, *Physical Review B*, **68**, 045105-10 (2003).
 312. Ferroelectric domain imaging by defect luminescence microscopy, V. Dierolf, S. Sandman, S. Kim, V. Gopalan, K. Polgar, *J. Appl. Physics*, **93**, 2295-97(2003).
 313. Complex dynamical behavior in oxide ferroelectrics by molecular-dynamics simulation, S. R. Phillpot, M. Sepiarsky, M. G. Stachiotti, V. Gopalan, S. K. Streiffer and R. L. Migoni, *Proceedings, Electrochemical Society Meeting, Orlando, FL, August (2003)*.
 314. Jahn-Teller effect in photonic crystals, N. Malkova, V. Gopalan, Proceedings, Materials Research Society Annual Meeting, Boston, MA, Manuscript: 47164, W3.3, December (2003).

315. Symmetrical analysis of complex photonic bandgap crystals, N. Malkova, S. Kim, V. Gopalan, *Physical Review B*, **66**, 115113-23 (2002).
316. Cascaded electro-optic scanning of laser light over large angles using domain microengineered ferroelectrics, D. A. Scrymgeour, V. Gopalan, K. T. Gahagan, R. Sander, J. M. Robinson, F. Muhammad, P. Chandramani, F. Kiamilev, *Applied Physics Letters*, **81**, 3140-42 (2002).
317. Multi-channel ± 1.1 kV arbitrary waveform generator for beam steering using ferroelectric device, F. Muhammad, P. Chandramani, J. Ekman, F. Kiamilev, D. Scrymgeour, V. Gopalan, E. Moore, M. Weiler, *IEEE Photonics Technology Lett.* **14**, 1605-07 (2002).
318. Near-IR tunable laser using an integrated LiTaO₃ electro-optic deflector, J. L. Casson, L. Wang, N. J.C. Libatique, R. K. Jain, D. A. Scrymgeour, V. Gopalan, Kevin T. Gahagan, *Applied Optics*, **41** 6416-19 (2002).
319. Coercive fields in ferroelectrics: A case study in lithium niobate and lithium tantalate, S. Kim, V. Gopalan, A. Gruverman, *Appl. Phys. Lett.*, **80**, 2740-42 (2002).
320. On domain wall broadening in ferroelectric lithium niobate and tantalate, S. Kim, B. Steiner, A. Gruverman, V. Gopalan, *Fundamental Physics of Ferroelectrics 2002*, Washington DC, Editor: R. E. Cohen, American Institute of Physics, pp. 277-84 (2002).
321. In-situ probing of domain poling in Bi₄Ti₃O₁₂ thin films by optical second harmonic generation, Y. Barad, J. Lettieri, C. D. Theis, D. G. Schlom, V. Gopalan, *Integrated Ferroelectrics*, 19-24, **44** (2002).
322. Real-time studies of strains at ferroelectric domain walls under an applied field, T. Jach, S. Kim, S. Durbin, V. Gopalan, D. Bright, *Fundamental Physics of Ferroelectrics 2002*, Washington DC, Editor: R. E. Cohen, American Institute of Physics, 260-65(2002).
323. Tunable nonlinear liquid crystal-based photonic crystals, I. C. Khoo, Yana Zhang, A. Diaz, J. Ding, I. B. Divliansky, K. Holliday, T. S. Mayer, V. Crespi, D. Scrymgeour, V. Gopalan, *Proceedings of Liquid Crystals VI – SPIE International Symposium on Optical Science and Technology*, Vol. 4799 pp. 381-82 (2002).
324. Domain switching and electromechanical properties of pulse poled Pb(Zn_{1/3}Nb_{2/3})O₃-PbTiO₃ crystals, H. Yu, V. Gopalan, J. Sindel, C. A. Randall, *J. Appl. Phys.* **89**, 561-67 (2001).
325. Probing domain microstructure in ferroelectric Bi₄Ti₃O₁₂ thin films by optical second harmonic generation, Y. Barad, V. Gopalan, C. D. Theis, J. A. Lettieri, J. C. Jiang, X. Q. Pan, Darrell G. Schlom, *J. Appl. Phys.* **89**, 1387-92 (2001).
326. Piezoelectric strain-tunable photonic crystals, S. Kim, V. Gopalan, *Appl. Phys. Lett.* **78**, 3015-17 (2001).
327. Integrated high power electro-optic lens and large-angle deflector, K. T. Gahagan, David A. Scrymgeour, Joanna L. Casson, J. M. Robinson, V. Gopalan, *Appl. Opt.* **31**, 5638-42 (2001).
328. A large angle electro-optic scanner on LiTaO₃ fabricated by in-situ monitoring of ferroelectric domain microengineering, D. A. Scrymgeour, Y. Barad, V. Gopalan, K. T. Gahagan, J. M. Robinson, Q. X. Jia, T. E. Mitchell, *Appl. Optics*. Vol. **40**, 6236-41, (2001).

329. Domain reversal and non-stoichiometry in LiTaO_3 , S. Kim, V. Gopalan, K. Kitamura, Y. Furukawa, *J. Appl. Phys.*, **90**, 2949 (2001).
330. Domain rearrangement in $\text{Bi}_4\text{Ti}_3\text{O}_{12}$ thin films studied by in-situ optical second harmonic generation, Y. Barad, J. Lettieri, C. D. Theis, D. G. Schlom, V. Gopalan, *J. Appl. Phys.* **90**, 3497-03 (2001).
331. Ultrathin slices of domain-patterned lithium niobate by crystal ion slicing, D. A. Scrymgeour, T. Haynes, M. Levy, V. Gopalan, Materials Research Society Proceeding, Vol 681E, I6.3, Spring (2001).
332. Crystal ion slicing of domain micro-engineered electro-optic devices on lithium niobate, D. A. Scrymgeour, V. Gopalan, T. E. Haynes, *Integrated Ferroelectrics*, **41**, 35[1687]-42[1674] (2001).
333. Compact multi-channel 2kV arbitrary waveform generator for ferroelectric device arrays, F. Muhammad, P. Chandramani, J. Ekman, F. Kiamilev, V. Gopalan, E. Moore, M. Weiler, in 2001 IEEE/LEOS Annual Meeting Conf. Proc., vol. 2, pp. 818-19, (2001).
334. Compact multi-channel 2kV arbitrary waveform generator for ferroelectric device arrays, F. Muhammad, P. Chandramani, J. Ekman, F. Kiamilev, V. Gopalan, E. Moore, M. Weiler, in 2001 IEEE/LEOS Annual Meeting Conf. Proc., vol. 2, pp. 818-19, (2001).
335. Ferroelectric domain reversal in congruent LiTaO_3 at elevated temperatures, C. C. Battle, S. Kim, V. Gopalan, K. Borkacy, M. C. Gupta, *Appl. Phys Lett.*, **76**, 2436-38 (2000).
336. T. J. Yang, V. Gopalan, P. J. Swart, P; U. Mohideen, "Experimental study of internal fields and movement of single ferroelectric domain walls " *Journal of the Physics and Chemistry of Solids*, **61**, 275-82 (2000).
337. Direct X-ray synchrotron imaging of strains at 180° domain walls in congruent LiNbO_3 and LiTaO_3 crystals, S. Kim, B. Steiner, V. Gopalan, *Appl. Phys. Lett.*, **77**, 2051-53 (2000).
338. Domain reversal and wall structure of 180° ferroelectric domains in LiTaO_3 crystals, V. Gopalan, K. Kitamura, Y. Furukawa, *Fundamental Physics of Ferroelectrics 2000*, Aspen Center for Physics, Winter Workshop, Editor: R. E. Cohen, p 183-190, American Institute of Physics Iss. no.535, pp. 183-90; (2000).
339. Real-time video study of domain microengineering in ferroelectric LiNbO_3 and LiTaO_3 for integrated optics, V. Gopalan, S. Kim, K. Kitamura, Y. Furukawa, *Optical Society of America, Technical Digest Series, Conference on Lasers and Electro-Optics*, p. 210-12 (2000).
340. Domain switching performance of stoichiometric LiTaO_3 for bulk quasi-phase matching devices, K. Kitamura, Y. Furukawa, S. Takekawa, T. Hatanaka, H. Ito, V. Gopalan(4), H. Injeyan, U. Keller, C. Marshall, *OSA Trends in Optics and Photonics. Advanced Solid State Lasers. Vol. 34, Proceedings. Opt. Soc. America, Washington, DC, USA. pp. 321-23; (2000).*
341. Integrated high power electro-optic lens/scanner for space-based platforms, K. T. Gahagan, J. L. Casson, V. Gopalan, D. A. Scrymgeour, and J. M. Robinson, *SPIE - Proceeding of the 45th Annual Meeting. : Photonics for Space Env.*, 4134, 133-37(2000), San Diego, CA (Aug 2000).
342. Observation of mobility study of single 180° domain wall in LiTaO_3 , T. J. Yang, U. Mohideen, V. Gopalan, P. J. Swart, *Ferroelectrics*, **222** (1-4), 609-13 (1999).

343. In-situ video observation of 180° domain kinetics in congruent LiNbO₃ crystals, V. Gopalan, Q. X. Jia, T. E. Mitchell, *Appl. Phys. Lett.*, **75**, 16-18 (1999).
344. Mobility of 180° domain walls in congruent LiTaO₃ measured using in-situ electro-optic imaging microscopy, V. Gopalan, S. S. A. Gerstl, A. Itagi, Q. X. Jia, T. E. Mitchell, T. E. Schlesinger, D. D. Stancil, *J. Appl. Phys.* **86**, 1638-46 (1999).
345. In-situ video observation of kinetics of 180° domains in congruent LiTaO₃ crystals, V. Gopalan, T. E. Mitchell, *J. Appl. Phys.*, **85**, 2304-11 (1999).
346. Switching kinetics of 180° domains in congruent LiNbO₃ and LiTaO₃ crystals, V. Gopalan, T. E. Mitchell, K. E. Sickafus, *Solid State Communications*, **109**, 111-17 (1999).
347. Direct observation of pinning and bowing of a single ferroelectric domain wall, T. J. Yang, U. Mohideen, V. Gopalan, P. Swart, *Phys. Rev. Lett.* **82**, 4106-09 (1999).
348. Integrated Electro-optic lens/scanner in LiTaO₃ single crystal, K. T. Gahagan, V. Gopalan, J. M. Robinson, Q. X. Jia, T. E. Mitchell, *Applied Optics*, **38**, 1186-90 (1999).
349. Shape-optimized electro-optic beam scanners: Experiment, J. C. Fang, M. J. Kawas, J. Zou, V. Gopalan, T. E. Schlesinger, D. D. Stancil, *IEEE Photonic Technol. Lett.* **11**, 66-8 (1999).
350. Integrated optical device with second-harmonic generator, electrooptic lens, and electrooptic scanner in LiTaO₃, Y. Chiu, V. Gopalan, M. J. Kawas, T. E. Schlesinger, D. D. Stancil, W. P. Risk, *J. Lightwave Technol.* **17**, 462-65 (1999).
351. Integration of electro-optic lenses and scanners on ferroelectric LiTaO₃, V. Gopalan, K. T. Gahagan, M. Kawas, Q. X. Jia, J. M. Robinson, T. E. Mitchell, T. E. Schlesinger, D. D. Stancil, *Integrated Ferroelectrics*, **25**, 31-6 (1999).
352. Ferroelectric domain kinetics in congruent LiTaO₃, V. Gopalan, S. Gerstl, A. Itagi, P. Swart, Q. X. Jia, T. E. Mitchell, T. E. Schlesinger, D. D. Stancil, *Integrated Ferroelectrics*, **27**, 137-46 (1999).
353. Radiation damage effects in ferroelectric LiTaO₃ single crystals, C. J. Wetteland, K. E. Sickafus, V. Gopalan, J. N. Mitchell, T. Hartmann, M. Nastasi, C. J. Maggiore, J. R. Tesmer, T. E. Mitchell, J. C. Barbour, S. Roorda, D. Ila, M. Tsujioka, *Atomistic Mechanisms in Beam Synthesis and Irradiation of Materials*. Mater. Res. Soc, Warrendale, PA, USA. pp. 159-64; (1999).
354. Stoichiometric LiNbO₃ as a new nonlinear material for bulk quasi-phase matching, Y. Furukawa, K. Kitamura, V. Gopalan, T. E. Mitchell, G. Foulton, A. Alexandrovski, R. K. Route(4), and M. M. Fejer, *Optical Society of America, Technical Digest Series, Conference on Lasers and Electro-Optics*, p. 167-68 (1999).
355. Fabrication and characterization of high-speed integrated electro-optic lens and scanner devices, K. T. Gahagan, V. Gopalan, J. M. Robinson, Q. X. Jia, T. E. Mitchell, M. J. Kawas, T. E. Schlesinger, and D. D. Stancil, *1999 Proceedings of SPIE*, vol. 3620, 374-79 (1999).
356. The role of stoichiometry in 180° domain switching in LiNbO₃ crystals, V. Gopalan, T. E. Mitchell, K. Kitamura, N. Furukawa, *Appl. Phys. Lett.* **72**, 1981-83 (1998).

357. Wall velocities, switching times and stabilization mechanism of 180° domains in congruent LiTaO₃ crystals, V. Gopalan, T. E. Mitchell, *J. Appl. Phys.* **83**, 941-54 (1998).
358. Crystal growth and low coercive field 180° domain switching characteristics of stoichiometric LiTaO₃, K. Kitamura, Y. Furukawa, K. Niwa, V. Gopalan, T. E. Mitchell, *Appl. Phys. Lett.*, **73**, 3073-75 (1998).
359. Radiation effects in corundum structure derivatives, J. N. Mitchell, R. Devanathan, N. Yu, K. E. Sickafus, C. J. Wetteland, V. Gopalan, M. A. Nastasi, K. J. McClellan, *Nuclear Instruments and Methods in Physics Res. B* **141**, 461-66 (1998).
360. Real-time study of kinetics of 180° domains in congruent LiTaO₃ under an external field, V. Gopalan, T. E. Mitchell, K. E. Sickafus, Q. X. Jia, *Integrated Ferroelectrics*, **22**, 405-9 (1998).
361. Ferroelectrics as a versatile solid state platform for integrated optics, V. Gopalan, T. E. Mitchell, Q. X. Jia, J. M. Robinson, M. J. Kwas, T. E. Schlesinger, D. D. Stancil, *Integrated Ferroelectrics*, **22**, 465-71 (1998).
362. Electro-optic lens stack on LiTaO₃ crystals, M. Kwas, V. Gopalan, T. E. Schlesinger, D. D. Stancil, *J. Lightwave Technol.* **15**, 1716-19 (1997).
363. In-situ X-ray diffraction study of phase transitions in epitaxial KNbO₃ thin films, V. Gopalan, R. Raj, *Ferroelectrics* **200**, Numbers 1-4 pp. 343-51 (1997).
364. Origin and characteristics of internal fields in LiNbO₃ crystals, V. Gopalan, and M. C. Gupta, *Ferroelectrics* **198**, 1-4 pp. 49-59 (1997);.
365. Electric field induced domain rearrangement in potassium niobate thin films studied by *in-situ* second harmonic generation, V. Gopalan and R. Raj, *J. Appl. Phys.*, **81**, 865-75 (1997).
366. Domain wall pinning by grain boundaries in epitaxial KNbO₃ thin films studied by *in-situ* second harmonic generation, V. Gopalan and R. Raj, *Ferroelectric Thin Films VI*, Proceedings, Materials Research Society, Boston, **493**, p. 75-9, December (1997).
367. Observation of internal fields in Z-cut LiTaO₃ crystals: origin and time-temperature dependence, V. Gopalan and M. C. Gupta, *Appl. Phys. Lett.*, **68**, 888-90 (1996).
368. Domain structure and phase transitions in KNbO₃ thin films observed by *in-situ* second harmonic generation, V. Gopalan and R. Raj, *Appl. Phys. Lett.*, **68**, 1323-25 (1996).
369. Integrated solid state second harmonic generator with an electro-optic scanner on a LiTaO₃ crystal. V. Gopalan, M. Kwas, T. E. Schlesinger, M. C. Gupta, and D. D. Stancil, *IEEE Photonics Technology Letters*, **8**, 1704-06 (1996).
370. Origin of internal fields and visualization of 180° domains in congruent LiTaO₃ crystals, V. Gopalan, and M. C. Gupta, *J. Appl. Phys.* **80**, 6099-106 (1996).
371. Domain structure-second harmonic generation correlation in potassium niobate thin films on strontium titanate substrates, V. Gopalan and R. Raj, *J. Am. Cer. Soc.*, **79**, 3289-96 (1996).

372. Internal fields in LiTaO₃ single crystals, V. Gopalan and M. C. Gupta, SPIE Proceedings, Vol. 2700, 28-33 (1996).
373. Integrated second harmonic generator and high speed optical beam scanner for data storage, D. D. Stancil, V. Gopalan, M. Kawas, M. C. Gupta, J. Li, Idema Insight, vol. 9, (5) 4-6 (1996).
374. Periodic domain inversion in Z-cut LiTaO₃ by electron-beam scanning assisted by internal field within the crystal, V. Gopalan and M. C. Gupta, SPIE Proceedings, vol. 2700, 196-202 (1996).
375. Structure-optical property correlation of KNbO₃ thin films deposited on MgO (100) using SrTiO₃ transition layers, V. Gopalan and R. Raj, *J. Am. Cer. Soc.*, **78**, 1825-33 (1995).
376. Orientation control of KNbO₃ thin films deposited by laser ablation on single crystal MgO substrates using SrTiO₃ transition layers, V. Gopalan, H. Xie, W-Y. Hsu and R. Raj, *Ferroelectrics*, **152**, 55-60 (1994).
377. Correlation between structural and optical properties in proton-exchanged LiNbO₃, W. Y. Hsu, G. Braunstein, V. Gopalan, C. S. Willand and M. C. Gupta, *Appl. Phys. Lett.* **61**, 3083-85 (1992).
378. Effect of proton exchange on the non-linear optical properties of LiNbO₃ and LiTaO₃, W-Y. Hsu, C. S. Willand, V. Gopalan, and M. C. Gupta, *Appl. Phys. Lett.* **61**, 2263-65 (1992).
379. Domain inversion in LiNbO₃ using direct electron-beam writing, A. C. G. Nutt, V. Gopalan and M. C. Gupta, *Appl. Phys. Lett.* **60**, 2828-30 (1992).

PATENTS

(Patents 3 and 4 were the founding patents for the company, **Oxide Inc.**, (<http://www.opt-oxide.com/en/>) started by my collaborator, Dr. Yasunori Furukawa, the current CEO. It is now a leading supplier of highest quality optical crystals worldwide.)

- (1) "Domain inverted grating in Ferroelectric crystals with polarization in the crystal plane," V. Gopalan and Mool C. Gupta, Awarded March. 1998. US patent # 5734772
- (2) "Domain inverted grating in ferroelectric crystals by electron-beam scanning", Mool C. Gupta, Alan C. G. Nutt and V. Gopalan, Awarded May. 1998. US patent # 5748361
- (3) "Lithium Niobate single crystals and Photo-functional devices" K. Kitamura, N. Furukawa, V. Gopalan, T. E. Mitchell, Awarded Feb 27, 2001, US and Japan Patent # 6195197.
- (4) "Lithium Tantalate single crystals and Photofunctional devices" K. Kitamura, N. Furukawa, V. Gopalan, T. E. Mitchell, Awarded April 4, 2001, US and Japan patent # 6211999.
- (5) "Strain-tunable Photonic Bandgap crystals," S. Kim, V. Gopalan, patent disclosure # 2001-2416, April 20, 2001.
- (6) "Device architectures for High-speed electro-optic switches and modulators," V. Gopalan, D. Scrymgeour. Sept 25, 2002. Patent Disclosure, #2002-2682,
- (7) "Strain-engineered BaTiO₃ thin films for ferroelectric memory, electro-optic modulators, and related applications," D. Schlom, L. -Q. Chen, C. -B. Eom, V. Gopalan, PSU Invention Number 2004-2964.

(8) "Phased Array beam Steering," V. Gopalan, K. Schepler, D. Scrymgeour, L. Tian, Patent Disclosure, #2004-2991; PST-17018/36 March (2004).

(9) "Hybrid 2-dimensional beam steering," V. Gopalan, K. Uchino, D. Scrymgeour, B. Koc, Patent Disclosure filed May (2005).

(10) "Fiber-optic Phased Array with Low Voltage and Wide Angle Steering," V. Gopalan, J. Badding, Ali Jazairy, J. Douglas, Silai V. Krishnaswamy, Penn State and Northrop Grumman, Patent disclosure (2006-3211) filed June (2006)

(11) "Glass compositions, glass articles and methods of making the same," Carly Mathewson, John Mauro, Venkatraman Gopalan, John V. Badding, US Patent 17/549,213 Granted 2022.

(12) "Nonlinear optical Mg-IV-V₂ crystals, methods of making the same and devices comprising the same". Patent disclosure, U.S. Application No. 63/398,993, August 18, 2022.

MEMBER

International Union of Crystallography (IUCr), Materials Research Society (MRS), IEEE Ultrasonics, Ferroelectrics, and Frequency Control, American Physical Society (APS), Society of Photonics and Instrumentation Engineers (SPIE), American Ceramics Society (ACerS)

SYMPOSIUM ORGANIZER

1. Co-Organizer of CLEO-Europe, focused topic on optical materials, fabrication and characterization, organized by the *Optical Society of America* (2017).
2. Co-organized the Focused Topic Group on "Dielectrics and Ferroics," for the *American Physical Society* annual meeting (2014).
3. Optical materials subcommittee, CLEO (Conference on Lasers and Electro-Optics, Annual Meeting of the *Optical Society of America*, (2008).
4. Symposium Organizer, "Ferroelectrics, Multiferroics, and Magnetolectrics" *Materials Research Society* annual meeting, Fall (2007).
5. Optical materials subcommittee, CLEO (Conference on Lasers and Electro-Optics, Annual Meeting of the *Optical Society of America*, (2007).
6. Symposium co-organizer, "Integrated Photonics" Opto East, *SPIE annual meeting*, October (2007).
7. Lead Symposium Organizer, "Ferroelectric and Multiferroics," *Materials Research Society* annual meeting, Fall (2006).
8. Symposium co-organizer, "Photonic bandgap crystals and photonic crystal fibers for sensing applications," Opto East, *SPIE annual meeting*, October (2005).
9. *Conceived* and organizing a symposium on 'Infrared Materials and Technologies,' at Penn State, November 21/22 (2005).
10. Symposium Organizer, "Emerging Advances in Electronic, Optical, Magnetic, and Elastic Ferroics," Pacific Rim Meeting, *The American Ceramics Society*, (2005) Hawaii, September 11-16, (2005).
11. *Conceived* and organized a symposium on 'Infrared Materials and Technologies,' at Penn State, October 4/5 (2004).
12. Symposium Chair, "Novel oxides" *American Physical Society*, Austin, TX, March (2003).
13. Symposium co-organizer and session chair, "Optoelectronic materials and technology in the information age," *American Ceramic Society annual meeting*, St-Louis, MO (2002).

14. Symposium Co-organizer, "Polarization dynamics in ferroelectrics and ferroelastics," *Materials Research Society annual meeting*, Boston, MA Dec (2001).
15. Session chair, "Novel characterization techniques," International Symposium on Integrated Ferroelectrics, Colorado Springs, CO, March (2001).
16. Session Chair, "fundamental physics of ferroelectrics," *American Physical Society annual meeting*, Seattle, WA (2001).
17. Symposium co-organizer, "Optoelectronic materials and technology in the information age," *American Ceramic Society annual meeting*, Indianapolis, IN (2001).

SELECT INVITED AND CONTRIBUTED TALKS

Of the **nearly 400 talks total** given by Gopalan or his group/ collaborators, 133 were invited talks and 2 were plenary talks. Only **select invited** and **plenary** talks are listed below:

PLENARY TALKS:

1. Fluctuations, Emergence and Dynamics of Non-equilibrium Phases, Linac Coherent Light Source, Stanford University, November (2021).
2. Multifunctional complex oxides by design, *International conference on Advances in Functional Materials*, Anna University, India, January (2017).
3. The secret life of ferroic domain walls, *International Conference on Defects in Inorganic Materials (ICDIM)*, Aracaju, Brazil, August 28, (2008).

SELECT INVITED

1. Exchange pathways in a Magnetic Topological Insulator, *NIST QMMS workshop on quantum materials*. Jan (2023).
2. Magneto-phononic coupling in MnBi_2Te_4 topological insulator, *MRS Spring meeting*, Boston, MA, Spring (2022).
3. Band-resolved phonon-mediated ultrafast demagnetization in MnBi_2Te_4 , *Photo-induced Phase Transitions (PIPT) symposium*, November (2021).
4. Creation and dynamics of complex polar supertextures by Design, *Ferroelectrics*, Carnegie Institute in Washington, November (2021).
5. Nonlinear Optical Crystals Design, FERRO 2021, remote by zoom February (2021).
6. Optical Creation of a supercrystal, *American Physical Society*, March (2021).
7. Probing Emergent Phenomena in Complex Oxides through Nonlinear Optics and Coherent X-rays, *Rutgers University*, by zoom, October (2020)
8. Probing Emergent Phenomena in Complex Oxides through Nonlinear Optics and Coherent X-rays, *University of Delaware*, by zoom, October (2020)
9. Antisymmetry: Fundamentals and Applications, *U. Pittsburgh*, by zoom, September (2020).
10. Wedge reversion antisymmetry, and 41 types of properties, *U. C. Berkeley*, by zoom, May (2020)
11. Distortion Symmetry and its applications, *U. C. Berkeley*, by zoom, May (2020)
12. Probing Emergent Phenomena in Complex Oxides through Nonlinear Optics and Coherent X-rays, *Society for Photonics and Instrumentation Engineers, SPIE chapter at Penn State*, on zoom, April (2020).
13. Probing Emergent Phenomena in Complex Oxides through Nonlinear Optics and Coherent X-rays, *Oxides seminar, Penn State University*, May (2020)
14. Probing Emergent Phenomena in Complex Oxides through Nonlinear Optics and Coherent X-rays *University of Michigan, Ann Arbor*, February (2020)
15. Materials metrology on nm-pm scale using electrons and photons, *University of Colorado Boulder*, July (2019).

16. Materials metrology on nm-pm scale with electrons and photons, *American Ceramics Society*, Daytona Beach, FL (Feb 2019).
17. Ultrafast probing of correlated polar metals, *Carnegie Mellon University*, November (2018).
18. A distortion-symmetry based approach to minimum energy pathways, *Rutgers University*, Physics, December (2018).
19. Ultrafast Light Activated Emergent Phenomena in Polar Oxides, *West Virginia University*, April (2018).
20. Ultrafast Light Activated Emergent Phenomena in Polar Oxides, *U. Texas Austin*, April (2018).
21. Polar Metals, *Gordon Conference on Multiferroics and Magnetoelectrics*, August (2018), Bates College, ME.
22. Ultrafast Light Activated Emergent Phenomena in Polar Oxides, *Penn State University*, Physics, March (2018).
23. Imaging complex oxides with electrons and photons on the nm-pm length scales, *MRS Spring meeting*, Boston, MA, November (2017).
24. Domain dynamics in Polar Metals, Workshop on Oxide Electronics, *Northwestern University*, September (2017).
25. UED studies for complex oxides, SLAC THz-URD workshop. *Stanford Linear Accelerator Center*. March (2017).
26. Hidden phases and symmetries in Nature, *Tokyo Institute of Technology*, August (2016)
27. Hidden phases and symmetries in Nature, Engineering Science and Mechanics, *Pennsylvania State University*, February (2016).
28. Hidden symmetries of motion, *MRS annual meeting*, Boston, MA, November (2016).
29. Designing multifunctionality into layered ferroics, *PRICM meeting organized by the TMS*, Kyoto, Japan, August (2016).
30. Designing multifunctionality into layered ferroics, Topo 2016: The international workshop on topological structures in ferroic materials, *Technische Universität Dresden*, Germany, August (2016).
31. Ultrafast spatio-temporal mapping of gigahertz acoustic waves in a ferroelectric, *SPIE Photonics*, San Diego, (2016).
32. X-ray diffraction and spectroscopy of photoinduced ferroic superstructures, *SPIE Photonics*, San Diego, (2016).
33. Hidden phases and symmetries in Nature, *University of Pittsburgh*, November (2015).
34. Multifunctionality in Complex Oxides, Materials Day, *Pennsylvania State University*, September (2015).
35. Hidden phases and symmetries in nature, *POSTECH*, South Korea, July (2015).
36. Hidden symmetries in Nature and Art, Colloquium, *Physics department, Pennsylvania State University*, February (2015).
37. Hidden phases and symmetries in Nature, *University of New South Wales*, May (2015).
38. Hidden Metastable phases in ferroelectrics, *University of Buffalo*, May (2014).
39. Strain-enabled Multiferroics, MRSEC seminar, *Pennsylvania State University*, May (2014).
40. Hidden symmetries and phases in Ferroics, *Los Alamos National Laboratory Theory Division*, Los Alamos, NM, August (2014).
41. Hidden Metastable phases in ferroelectrics, *Argonne National Labs*, Center for Nanophase Materials, May (2014).
42. Optical probing of ferroelectrics and multiferroics, CIMTEC, Montecatini, Italy, June (2014).
43. Hidden Metastable phases in ferroelectrics, *International Symposium on Integrated Ferroelectrics*, Penn State University, May (2014).
44. Probing metastable ferroelectric states with large property enhancements, *SPIE Photonics west*, August (2014).
45. Metastable phases in ferroelectrics, *Indian Institute of Science*, Bangalore, India, June (2013).
46. Hidden phases, structures and symmetries in ferroelectrics, *Cornell University*, Ithaca, NY, April (2013).
47. Metastable states in ferroelectrics imaged by nanoscale x-ray diffraction imaging, *Argonne National Labs*, Argonne, IL, August (2013).
48. SHG microscopy, Ultrafast Imaging and Spectroscopy conference in the 2013 *SPIE Optics and Photonics*, San Diego, (2013).

49. Hidden structures and symmetries in ferroelectrics, *University of West Virginia*, Morgantown, WVA, Nov. (2012).
50. Enhanced Properties through domain wall stabilized intermediate phases in ferroelectrics, *Materials Research Society Annual Meeting*, Boston, MA November (2012).
51. High-pressure enabled metamaterials, *Stanford University*, Sept (2012).
52. Strain-enabled multiferroics, MRSEC seminar, *Penn State University*, January (2012).
53. Scanning Probe Microscopy of Ferroelectrics, *American Ceramics Society*, Pittsburgh PA October (2012).
54. Metastable states in ferroelectrics with enhanced properties, *International Materials Research Society (IMRC)*, Cancun, Mexico, August (2012).
55. Metastable states in ferroelectrics with enhanced properties, Oxide Interfaces by Design, *Army workshop*, Salve Regina University, Newport, Rhode Island, July (2012).
56. Hidden roto symmetries in crystals and handed structures, MRSEC seminar, *Penn State University*, January (2011).
57. Domain Walls in lithium Niobate and Lithium Tantalate: Local Structure and Properties, Conference on Lasers and Electro-Optics- Europe, *Optical Society of America*, Munich, Germany, May (2011).
58. Imaging local domains symmetries – the BaTiO₃ and CaTiO₃ perovskites, MRSEC Seminar, *Penn State University* December (2010).
59. The secret life of ferroics, *International Symposium on Ferroelectric Devices*, Prague, Czech republic, September (2010).
60. The secret life of ferroics, *International Materials Research Conference*, Cancun Mexico August, (2010).
61. Strain Enabled Multiferroics, MRL ferroelectrics seminar, *Pennsylvania State University*, March (2010).
62. Secret life of ferroic domain walls, *Zhejiang university*, China, June 16 (2009).
63. Secret life of ferroic domain walls, MRL ferroelectrics seminar, *Pennsylvania State University*, April 16 (2009).
64. Nonlinear Optics in Materials Science, *Nelson W. Taylor Award speaker*, *Pennsylvania State University* September (2009).
65. Strain-enabled multiferroics, Materials Science and Engineering, *Pennsylvania State University*, University Park, PA January 19 (2009).
66. The secret life of ferroic domain walls, *Richard M. Fulrath award speaker*, *MS&T*, Pittsburgh, PA, October 26 (2009).
67. The secret life of multifunctional ferroics, Workshop on scanning probe microscopy, *National Institute for Materials Science (NIMS)*, Japan, August 17 (2009).
68. Spin-Charge-Lattice coupling in Ferroic Oxides, *American Chemical Society (ACS) National meeting*, New Orleans, April (2008).
69. Spin-Charge-Lattice coupling in Ferroic Oxides, *American Ceramic Society*, Daytona Beach, Jan 27 (2008).
70. Strain-enabled multiferroics, Materials Science and Engineering, *Pennsylvania State University*, University Park, PA September 15 (2008).
71. The Secret Life of Ferroic Domain Walls, *Max Planck Institute for Metallforschung*, September (2008).
72. The Secret Life of Ferroic Domain Walls, *University of Bonn*, Germany, Sept (2008).
73. The Secret Life of Ferroic Domain Walls, *Tohoku University*, Sendai, Japan, July 14, (2008).
74. The Secret Life of Ferroic Domain Walls, *Indian Institute of Science*, Bangalore, India, July 7, (2008).
75. Spin-charge-lattice coupling in Ferroic oxides, Materials Science and Engineering, *Rensselaer Polytechnic Institute*, Troy, NY March 27, (2008).
76. Spin-charge-lattice coupling in Ferroic oxides, Materials Science and Engineering, *University of Wisconsin*, Madison, March 6 (2008).
77. Spin-charge-lattice coupling in Ferroic oxides, Physics Department, *Lehigh University*, Bethlehem, PA, February 28, (2008)
78. Electro-optic beam steering devices, *Wright Patterson Air-Force base*, Air Force Research Laboratory, Dayton, OH, July (2008).

79. LiNbO₃ based devices, *RF Micro*, North Carolina, October (2008).
80. Electro-optic devices for laser beam steering, shaping, and dynamic focusing, *Electro-Optic Center*, Freeport, PA January (2008).
81. Spin-charge-lattice coupling in Ferroic oxides, Materials Science and Engineering, *Pennsylvania State University*, University Park, PA September 6 (2007).
82. Spin-charge-lattice coupling in Ferroic oxides, *Indian Institute of Science*, Bangalore, India, CA, June 18, (2007).
83. Spin-charge-lattice coupling in complex oxides, *University of Santa Barbara*, Santa Barbara, CA, May 18 (2007).
84. Spin-charge-lattice coupling in complex oxides, Dept of Materials Science and Engr., *Northwestern University*, Evanston, IL January 22 (2007).
85. Spin-charge-lattice coupling in ferroic oxides, workshop on Multifunctional Oxides, *University of California, Berkeley*, CA, March 12 (2007).
86. Nanoscale structure of a single ferroelectric domain wall, *Materials Research Society*, Annual meeting, November (2007).
87. Tunable Photonic Crystals, *Stanford University*, September (2006).
88. Dramatic changes in ferroelectricity with strain tuning and point defects, Dept of Physics, *University of California, Berkeley*, CA, Sept 11 (2006).
89. Local structure and dynamics of ferroelectric domain walls, Dept of Materials science and Engineering, *University of California, Berkeley*, CA, Oct 19 (2006).
90. Local structure and dynamics of ferroelectric domain walls, *American Physical Society*, March (2006).
91. Local structure and dynamics of ferroelectric domain walls, *Oak Ridge National Laboratory*, Oak Ridge, TN, July 22 (2006).
92. A Study of Waveguide QPM Device Technology, *Corning Research Inc*, (2006).
93. Quantitative Piezoelectric Force Microscopy of Ferroelectric Domain Walls, Ferroelectrics and Multiferroics Symposium, *Materials Research Society Annual Meeting*, Nov (2006).
94. Engineered ferroelectrics and hybrid semiconductor-silica fiber structures for tunable optical devices, *Proceedings of the SPIE, Solid State Lasers*, San Jose, CA Jan, (2006).
95. Semiconductor Electronics Inside an Optical Fiber, *Gordon Research Conference on Nanostructure Fabrication*, July (2006).
96. Tunable Photonics Crystals, Department of Electrical Engineering, *Pennsylvania State University*, October (2005).
97. Local structure and dynamics of ferroelectric domain walls for photonics, Department of Physics, *University of Paderborn*, Germany, May (2005).
98. Local structure and dynamics of ferroelectric domain walls, Department of applied and engineering sciences, *Harvard university*, April (2005).
99. Local structure and dynamics of ferroelectric domain walls, Dept. of Physics, *Rutgers University*, March 1 (2005).
100. High-pressure fabrication of extreme aspect ratio semiconductor micro and nanostructures, *Materials Research Society Annual Meeting*, Fall Symposium, Boston, MA (2005).
101. Local structure and dynamics of ferroelectric domain walls, *Los Alamos National Laboratory*, Los Alamos, NM, March 8 (2005).
102. Tunable photonic devices, *Northrop Grumman*, Nov (2005).
103. Tunable photonic devices, *Lockheed Martin*, Miami, Florida, June (2005).
104. The role of extrinsic defects in ferroelectric domain inversion of lithium niobate, Emerging Advances in Electronic, Magnetic, Optical and Elastic Ferroics, Pacific Rim Meeting, *American Ceramics Society*, Maui, September (2005).
105. The science and technology of domain engineering, *SPIE Photonics West, Integrated Optics: Devices, Materials, and Technologies IX*, San Hose, CA, January 22 (2005).

106. Engineered Microstructures for Infrared Technologies, *Air Force Research Labs/Electro-Optic Center workshop*, VA, May (2005).
107. Microphotonics and Nanophotonics, Electrical Engineering, *Pennsylvania state University*, University Park, PA, October 11 (2004).
108. Tunable Photonic Crystal Structures, *Stevens Institute of Technology*, Chemical, Biomedical and Materials Engineering, NJ, June 30 (2004).
109. Tunable Photonics: Ferroelectrics, Electro-Optics and Photonic Crystal devices, *Wright Patterson Air-Force base*, Air Force Research Laboratory, Dayton, OH, June (2004).
110. Ferroelectric domain walls: Phenomenology, Local structure, and Probing Methods, Department of Applied Physics, *Waseda University*, Tokyo, Japan, August 23 (2004).
111. Local structure and shaping of ferroelectric domain walls for photonic applications, *Northwestern University* April 21 (2004).
112. Local structure and shaping of ferroelectric domain walls for photonic applications, Optoelectronic Research Center, *University of Southampton*, United Kingdom, March 31 (2004).
113. Tunable Photonics, *Northrop Grumman visit to Penn State*, September 9 (2004).
114. Nonlinear optical probing of ferroic and multiferroic thin films, *Materials Research Society Annual Meeting, Fall Symposium*, Boston, MA (2004).
115. Infrared Electro-optic beam steering, Symposium on Infrared Materials and Technologies, Pennsylvania State University, University Park, PA, October 5 (2004).
116. Ferroelectrics for micro- and nanophotonics, *Cornell University*, Electrical Engineering, Oct 1 (2003).
117. Shaping ferroelectric domains for electro-optic devices, *Wright Patterson Air-Force base*, Air Force Research Laboratory, Dayton, OH, Oct (2003).
118. Shaping ferroelectric domains for tunable electro-optic devices, Glass and Optical Materials Division, *The American Ceramic Society*, Oct. (2003).
119. Local structure and shaping of ferroelectric domains for electro-optics, Stanford Photonics Research Center, *Annual Review meeting, Stanford University*, Palo Alto, CA, September 17, (2003).
120. Defect-domain wall interactions in ferroelectrics, International Conference on Electroceramics, *Massachusetts Institute of Technology*, August (2003).
121. Ferroelectrics based Tunable photonics, International Conference on Intelligent Materials, *Pennsylvania State University*, University Park, PA, June (2003).
122. Tunable photonic crystals on silicon, Integrated Photonics Research, *Optical Society of America*, June (2003).
123. Nanoscale probing of ferroelectric domain wall structure and dynamics, *Transactions of Metallurgical Society annual meeting*, San Diego, CA, March (2003).
124. Probing ferroelectricity in BiMnO₃ ferroelectromagnets using nonlinear optics, *American Physical Society annual meeting*, Austin, TX, March (2003).
125. Integrated optical devices by ferroelectric domain micropatterning, *Materials Solutions for Photonics, 1st NIMS International Conference*, Tsukuba, Japan, March (2003).
126. Ferroelectrics for microphotonic devices, *Army Research Laboratory*, Adelphi, MD, August (2002).
127. Large angle electro-optic beam steering in the infrared, *International Symposium on Integrated Ferroelectrics*, Colorado Springs, CO, March (2001).
128. Structure and dynamics of ferroelectric domains, *Northwestern University*, IL June 25-26 (2001).
129. Local structure and shaping of ferroelectric domains, *Oak Ridge National Laboratory*, TN, (2000).
130. Structure and Real-time dynamics of ferroelectric domains, *National Institute for Standards and Technology*, Gaithersburg, MD May (2000).
131. Real-time dynamics of ferroelectric domains, Bell Laboratories, *Lucent Technologies*, Murray Hill, NJ, May 22 (2000).
132. Integrated high power electrooptic lens/scanner for space-based platforms, presentation at the International Symposium on Optical Science and Technology, San Diego, CA, Aug. (2000).

133. Local structure and dynamics of ferroelectric domains, *Indiana University of Pennsylvania*, Department of Physics, Oct (1999).
134. Structure and Real-time dynamics of ferroelectric domains, *National Institute For Research in Inorganic Materials, Tsukuba Japan*, Nov 9 (1999).
135. Real-time dynamics of ferroelectric domains, *National Panasonic Company, Moriaguchi, Japan*, Nov. 11 (1999).
136. Ferroelectric domain structure and dynamics, *Yale University*, Department of Applied Physics, Feb. (1998)
137. Ferroelectric domain structure and dynamics, *Carnegie Mellon University*, Dept. of Materials Science and Engineering, March (1998).
138. Ferroelectric domain structure and dynamics, *Washington University*, St. Louis, Dept. of Electrical Engineering, March (1998).
139. Ferroelectric domain structure and dynamics, *Penn State University*, Dept. Materials Science Engr., May (1998).
140. Ferroelectric domain structure and dynamics, *University of Michigan, Ann Arbor*, Dept. Materials Science Engr., May (1997).
141. Ferroelectric domain structure and dynamics, *Clemson University*, Dept. Materials Science Engr. April (1997).

BOARD MEMBER

- ❖ *Annual Reviews of Materials Research*, Associate Editor, Editorial board member from 2006 to 2018.
- ❖ *Collinear, Inc.* CA. Technical Advisory Board member 2004-2008.
- ❖ *Chair, Users Executive Committee*, Center for Nanophase Materials, Oak Ridge National Laboratory, 2009-2010.

EDITOR

1. Associate Editor of the *Annual Reviews of Materials Research* 2014-2018. On the editorial board from 2006-2018.
2. G. Wegner, V. Gopalan, Porous and colloidal materials, *Annual Review of Materials Research* **36**, XI-XII (2006).
3. M. Ruhle, D. Clarke, V. Gopalan, Ferroelectrics and related materials, *Annual Review of Materials Research*, volume 37, (2007).
4. Ferroelectrics, Multiferroics, and Magnetoelectrics, edited by J.F. Scott, V. Gopalan, M. Okuyama, and M. Bibes (*Mater. Res. Soc. Symp. Proc.* Volume 1034E, Warrendale, PA, (2008).
5. Editor, *Annual Reviews of Materials Research*, Volume 36 (2006).
6. Editor, *special Topics on Ferroelectrics and Related Materials*, *Annual Reviews of Materials research* Volumes 37 (2007).
7. Editor, *special Topics on Modern Optical Microscopy Techniques in Materials Research*, *Annual Reviews of Materials research*, Volume 43 (2013).
8. Editor, *special Topics on Oxide Electronics*, *Annual Reviews of Materials research*, Volume 44 (2014).