

Robert A. Norwood

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Education

- B.S. Physics, Massachusetts Institute of Technology, 1983
- B.S. Mathematics, Massachusetts Institute of Technology, 1983
- Ph. D. Physics, University of Pennsylvania, 1988

Employment

- University of Arizona:
 - Wyant College of Optical Sciences, Professor, 2009 - present
 - Wyant College of Optical Sciences, Research Professor, 2004-2009
 - College of Engineering, Department of Materials Science and Engineering, Professor, 2018-present
- Photon-X:
 - Vice President/Chief Technology Officer, 1999-2004
- Allied Signal (Honeywell):
 - Senior Technical Leader, 1998-1999
 - Senior Project Leader, 1996-1998
 - Senior Research Scientist, 1995 – 1996
- Hoechst Celanese:
 - Staff Physicist/Project Leader, 1993-1995
 - Senior Research Physicist, 1992-1993
 - Senior Research Physicist, 1990 - 1991
 - Research Physicist, 1988-1990
- Hoechst Japan:
 - Supervisor, Advanced Technology Laboratory, 1992
- Haverford College:
 - Visiting Instructor, 1988
- University of Pennsylvania:
 - Research and Teaching Fellow, 1983-1988

Professional Affiliations

- National Academy of Inventors (NAI), **Fellow**
- OSA – Optical Society of America, **Fellow**
- SPIE – The International Society for Optical Engineering, **Fellow**
- APS – American Physical Society, Member
- IEEE – Institute for Electronics and Electrical Engineers

University of Arizona: Long—Term Research Goals

- Further the understanding and performance of advanced materials for photonics and electronics applications

University of Arizona: Current Funded Research Projects

- Electro-optic polymers and devices
 - L3Harris Corporation, "High Index Electroactive Polymer Development," PI (2020-2023)
- Photonics devices and networks
 - National Science Foundation, "A Unified Framework for the Emulation of Classical and Quantum Physical Layer Networks," co-PI (2021 - 2025)
 - Sandia National Laboratories, "Integrated Photonics at SWIR Wavelengths," PI (2021-2022)
- Optical materials
 - National Science Foundation, "DMREF: Computational Chemistry to Accelerate Development of Long Wave Infrared Polymers," co-PI (2021 - 2026)

- National Science Foundation, "Translational Research with Chalcogenide Hybrid Inorganic/Organic Polymers (CHIPs) for Infrared Imaging and Sensing Technologies," co-PI (2020-2023)
- National Science Foundation, "Sulfonyl Chloride Electrophilic Addition to Olefinic Monomers: A New Step-Growth Polymerization Reaction to Prepare Optical Polymers," co-PI (2022 - 2025)
- Azimuth Corporation (for AFRL), "Synthesis and Characterization of Novel Sulfur Based Optical Polymers," (2021-2023)
- University of Arizona RDI 18th Mile Program, "Magnetic Polymer Brushes via Surface Initiated ATRP as Ultra-high Verdet Constant Materials for Magneto-Optics," (2023)
- Solar energy/Optical engineering
 - DOE RAPID, "A Hybrid Optical Technology for Concentrate Management," co-PI (2020-2022)

University of Arizona: Additional Research Interests

- Sol-gels
- Polymer optical interconnects
- Infrared optical materials
- Silicon photonics
- Polymer/nanoparticle composites
- Solar energy systems
- Fiber lasers
- Liquid photonics
- Plasmonics
- Tunable optical filters
- Multiphoton microscopy of 2D materials
- Nonlinear optical materials
- Engineered dielectric materials
- Materials for advanced photolithography
- Precise measurement of thin film linear optical properties

University of Arizona: Teaching

- OPTI 439A/539A – From Photonics Innovation to the Marketplace (undergraduate/graduate)
- OPTI 553 – Nonlinear Photonics (graduate)

Photon-X: Key Industrial Research Projects

- Achieved lowest loss single mode polymer optical waveguide at telecommunications wavelengths
- Compact, low power consumption erbium doped fiber amplifiers for avionics applications
- Low-loss athermal arrayed waveguide grating router in polymers
- Organic optical amplifier materials with the highest luminescence efficiencies ever recorded

AlliedSignal: Key Industrial Research Projects

- Polymer waveguide Bragg gratings with exceptional spectral performance and tunability
- Invented reconfigurable optical add-drop multiplexers and tunable filters
- MEMS single-mode fiber switch with ultra-low loss
- Fluorinated UV-patternable optical waveguide with low loss and superior stability

Hoechst Celanese: Key Industrial Research Projects

- Quasiphasematching in poled polymer waveguides for frequency doubling and difference frequency generation
- Picosecond degenerate four wave mixing measurements of the optical nonlinearities of organic thin films
- Photothermal deflection spectroscopy for the measurement of very small absorptions in organic films
- Organic crystal for frequency doubling from 840nm to 420nm with exceptional transparency (Hoechst Japan)
- Non-invasive high speed electric field measurements using electro-optic polymer patch sensors (Hoechst Japan – collaboration with NTT)
- Sol-gel barrier coatings for polymer films providing wet coatings with ultra-high barrier
- Novel top and bottom anti-reflection coatings for photolithography

Scientific Community Service

- *Optica*, Associate Editor 2015 - 2018
- Member: Program Committee CLEO 2017-2019
- *IEEE Photonics Technology Letters*, Associate Editor 2010 – 2013
- *Optical Materials Express*, Associate Editor 2011 – 2013
- *Nature Photonics*, Reviewer
- *Applied Physics Letters*, Reviewer
- *Chemistry of Materials*, Reviewer
- *IEEE Journal of Quantum Electronics*, Reviewer
- *Journal of the Optical Society of America B*, Reviewer
- *Optics Letters*, Reviewer
- Member: Committee, OSA *Optical Materials Studies Technical Group* 2015 - 2019
- Member: Program Committee, *Photonics in Switching*, 2014-2020
- Member: Program Committee, SPIE *Organic Photonic Materials and Devices* 2010-2016
- Member: Program Committee, SPIE *Integrated Optics: Devices, Materials and Technologies*, 2014 - present
- OSA Fellows Committee Chair 2010
- OSA Fellows Committee Member 2009
- Conference Chair: SPIE *Linear and Nonlinear Optical Properties of Organic Materials VI* 1999-2006
- Chair: Subcommittee D, *Optical Switching and Wavelength Routing Devices*, OFC 2006
- Member: Program Committee, OFC 2003 - 2005
- Member: Program Committee, CLEO 2002 - 2004
- Member: Program Committee, SPIE *Polymer Photonic Devices* 1998-2003
- Member: Program Committee, OSA/ACS *Organic Thin Films '01* 1998 - 2002
- Program Co-Chair: OSA/ACS *Organic Thin Films* 1999-2000

Book Chapters

- C. T. DeRose, C. Greenlee, A. Yeniay, and R. A. Norwood, "Organic waveguides, ultra-low loss demultiplexers, and electro-optic polymer devices," in *Handbook of Optical Materials for Optical and Optoelectronic Devices: Properties and Applications* edited by O. Ostroverkhova (Woodhead Publishing Series on Electronic and Optical Materials, 2013).
- J. Thomas, R. A. Norwood, and N. Peyghambarian, "Photorefractive polymers for dynamic holography," in *New Directions in Holography and Speckle* ed. by H. J. Caulfield and C. S. Vikram (American Scientific Publishers, 2008).
- R. A. Norwood, "Four-wave mixing tables and measurement techniques," for *Handbook of Electrooptical and Optical Materials: Linear and Nonlinear Properties* ed. by M. G. Kuzyk and C. W. Dirk (Marcel Dekker, 1998).
- G. Khanarian, M. Mortazavi, and R. A. Norwood, "Frequency doubling and parametric interactions in organic thin films," in *Organic Thin Films for Waveguiding Nonlinear Optics*, ed. by J. Swalen (Gordon and Breach, 1996).
- R. A. Norwood, T. K. Findakly, H. A. Goldberg, G. Khanarian, J. B. Stamatoff, and H. N. Yoon, "Optical polymers and multifunctional materials," in *Polymers for Lightwave and Integrated Optics: Technology and Applications* ed. by L. A. Hornak (Marcel Dekker, 1992).
- H. N. Yoon, R. A. Norwood, and H.-T. Man, "Nonlinear optics and materials," in *Ullman's Encyclopedia*, 5th edition, Volume A17, p. 541 (VCH Verlagsgesellschaft, Weinheim, 1991).

US Patents

- L. Jiang, S. K. H. Pau, R. A. Norwood, and T. L. Koch, "High-throughput manufacturing of photonic integrated circuit (PIC) waveguides using multiple exposures," 11,454,759
- T. L. Koch, R. A. Norwood, S. K. H. Pau, and N. N. Peyghambarian, "Fabrication of optical interconnect structures for a photonic integrated circuit," 11,402,752
- T. L. Koch, S. K. H. Pau, R. A. Norwood, and N. N. Peyghambarian, "Optical printed circuit board with polymer array stitch," 11,327,225
- L. Jiang, S. K. H. Pau, and R. A. Norwood, "Fabrication of polymer waveguide interconnect between chips with a gap and/or step," 11,275,208
- R. S. Witte, L. G. Montilla, R. Olafsson, C. M. Ingram, Z. Wang, R. A. Norwood, C. Greenlee, "Ultrasonic/photoacoustic imaging devices and methods," 10,241,199

- R. A. Norwood, K. Q. Kieu, and R. Himmelhuber, "SHG imaging technique for assessing hybrid EO polymer/silicon photonic integrated circuits," 9,645,045
- P. Gangopadhyay, R. A. Norwood, A. A. Miles, J. Kato, S. Virji, and M. Miyawaki, "Method of purifying nanodiamond powder and purified nanodiamond powder," 9,446,956.
- P. Gangopadhyay, A. Lopez-Santiago, and R. A. Norwood, "Magnetic-core polymer-shell nanocomposites with tunable magneto-optical and/or optical properties," 9,378,880.
- D.-C. Pyun, J. J. Griebel, W. J. Chung, R. Glass, R. A. Norwood, R. Himmelhuber, and A. G. Simmonds, "High sulfur content copolymers and composite materials and electrochemical cells and optical elements using them," 9,306,218.
- P. Gangopadhyay, A. Lopez-Santiago, and R. A. Norwood, "Magnetic-core polymer-shell nanocomposites with tunable magneto-optical and/or optical properties," 9,011,710
- R. A. Norwood, D. A. Loy, R. Himmelhuber, and J. Kato, "Method for producing metal oxide organic compound, composite," 8,940,807.
- R. A. Norwood, P. Gangopadhyay, A. A. Mile, J. Kato, S. Virji-Khalfan, and M. Miyawaki, "Method of purifying nanodiamond powder and purified nanodiamond powder," 8,940,267.
- R. S. Witte, L. G. Montilla, R. Olafsson, C. M. Ingram, Z. Whang, R. A. Norwood, and C. Greenlee, "Ultrasonic/photoacoustic imaging devices and methods," 8,879,352.
- J. Thomas, N. N. Peyghambarian, R. A. Norwood, P. Gangopadhyay, and A. A. Khosroabadi, "Nanostructured electrodes and active polymer layers," 8,859,423.
- X. Zhu, N. N. Peyghambarian, and R. A. Norwood, "Mid-infrared supercontinuum fiber laser," 8,804,777.
- R. A. Norwood and T. Skotheim "Nanoamorphous carbon-based photonic crystal infrared emitters," 8,076,617.
- N. Peyghambarian, R. A. Norwood, P. A. Blanche, and S. Tay, "System and method using a voltage kick-off to record a hologram on a photorefractive polymer for 3D holographic display and other applications," 7,973,989.
- C. T. DeRose, R. Himmelhuber, R. A. Norwood, and N. Peyghambarian, "Hybrid strip-loaded electro-optic polymer/sol-gel modulator," 7,912,327.
- C. T. DeRose, R. A. Norwood, and N. Peyghambarian, "Technique to enhance the electro-optic coefficient of polymers by using a sol-gel cladding layer to increase poling efficiency," 7,391,938
- R. Gao, D. S. Bitting, R. M. Mininni, R. A. Norwood, K. Takayama, and A. F. Garito, "Polymer optical waveguides on polymer substrates," 6,917,749
- B. Xu, L. Eldada, R. A. Norwood, and R. M. Blomquist, "Optical devices made from radiation curable fluorinated compositions," 6,800,424
- R. M. Blomquist and R. A. Norwood, "Tunable, polymeric core fiber Bragg gratings," 6,768,839
- R. A. Norwood, L. Eldada, S. Yin, C. Glass, and R. M. Blomquist, "Planar polymeric waveguide devices with temperature dependence control features," 6,684,019
- K. Takayama, D. Bitting, and R. A. Norwood, "Planar optical waveguide with core barrier," 6,603,917
- L. Eldada and R. A. Norwood, "Tunable optical add/drop multiplexer," 6,560,386
- B. Xu, L. Eldada, R. A. Norwood, and R. Blomquist, "Optical devices made from radiation curable fluorinated compositions," 6,555,288
- R. A. Norwood, A. F. Garito, and A. Panackal, "Codopant polymers for optical amplification," 6,538,805
- R. A. Norwood and C. C. Teng, "Thin film optical waveguides," 6,473,551
- L. Eldada and R. A. Norwood, "Tunable optical add/drop multiplexer," 6,438,293
- L. Eldada and R. A. Norwood, "Tunable optical add/drop multiplexer," 6,389,199
- R. A. Norwood, "Hybrid integrated optical add-drop multiplexer," 6,385,362
- B. Xu, R. A. Norwood, L. Eldada, and R. Blomquist, "Optical devices made from radiation curable fluorinated compositions." 6,306,563
- A. F. Garito, R. A. Norwood, R. Gao and A. Panackal, "Rare earth polymers, optical amplifiers and optical fibers." 6,292,292
- R. R. Dammel and R. A. Norwood, "Light-absorbing, antireflective layers with improved performance due to refractive index optimization." 6,274,295
- R. A. Norwood, B. Brown, J. Holman, and L. Shacklette, "Polymer gripping elements for optical fiber splicing." 6,266,472
- R. A. Norwood, M. Rudasill and D. Sossen, "Cascading of tunable optical filter elements." 6,256,428
- R. A. Norwood, J. Holman, S. Emo and L. Shacklette, "Micro-optic switch with lithographically fabricated polymer alignment features for the positioning of switch components and optical fibers." 6,169,827

- R. Dammel and R. A. Norwood, "Bottom antireflection coatings through refractive index modification by anomalous dispersion." 6,042,992
- G. Khanarian, R. Norwood, J. Sounik, J. Popolo, and S. Meyer, "Waveguide device and method for phase matched second harmonic generation." 5,224,196
- G. Khanarian and R. A. Norwood, "Thickness variation insensitive frequency doubling polymeric waveguide." 5,131,068
- G. Khanarian and R. A. Norwood, "Optical parametric amplifier." 5,064,265
- G. Khanarian, D. Haas, P. Landi, and R. A. Norwood, "Polymeric waveguides with bidirectional poling for radiation phasematching." 5,061,028
- G. Khanarian and R. A. Norwood, "Polymeric waveguide device for phase matched second harmonic generation." 4,971,416

Publications in Refereed Journals

- K.-S. Kang, C. Olikagu, T. Lee, J. Bao, J. Molineux, L. N. Holmen, K. P. Martin, K.-J. Kim, K. H. Kim, J. Bang, V. K. Kumirov, R. S. Glass, R. A. Norwood, J. T. Njardarson, and J. Pyun, "Sulfonyl chlorides: An alternative monomer feedstock from elemental sulfur for polymer synthesis," *J. Amer. Chem. Soc.* **144**, 23044 (2022).
- A. Nishant, K.-J. Kim, S. A. Showghi, R. Himmelhuber, T. S. Kleine, T. Lee, J. Pyun, and R. A. Norwood, "High refractive index chalcogenide hybrid inorganic/organic polymers for integrated photonics," *Advanced Optical Materials* **2022**, 2200176 (2022).
- S. Fu, X. Zhu, J. Zong, M. Li, A. Chavez-Pirson, R. A. Norwood, and N. Peyghambarian, "Single-frequency fiber laser at 880nm," *Optics Express* **30**, 32600 (2022).
- J. I. Frish, T. S. Kleine, R. Himmelhuber, S. Showghi, A. Nishant, K.-J. Kim, L. Jiang, K. P. Martin, L. Brusberg, S. Pau, T. L. Koch, J. Pyun, and R. A. Norwood, "Rapid photolithographic fabrication of high density optical interconnects using refractive index contrast polymers," *Optical Materials Express* **12**, 1932 (2022).
- K. J. Carothers, R. A. Norwood, and J. Pyun, "High Verdet constant materials for magneto-optical Faraday rotation: A review," *Chemistry of Materials* **34**, 2531 (2022).
- S. Fu, L. Li, X. Zhu, R. A. Norwood, and N. Peyghambarian, "10-W picosecond Yb³⁺-doped all-fiber laser source at 976nm," *J. Lightwave Technology* **40**, 4415 (2022).
- L. Jiang, A. Nishant, J. Frish, T. S. Kleine, L. Brusberg, R. Himmelhuber, K.-J. Kim, J. Pyun, S. Pau, R. A. Norwood, and T. L. Koch, "SmartPrint single-mode flexible polymer optical interconnect for high density integrated photonics," *IEEE J. Lightwave Technology* **40**, 3839 (2022).
- J. Wang, X. Zhu, R. A. Norwood, and N. Peyghambarian, "Widely wavelength tunable Dy³⁺/Er³⁺ ZBLAN fiber lasers," *Optics Express* **29**, 38646 (2021).
- S. Fu, X. Zhu, J. Zong, R. A. Norwood, and N. Peyghambarian, "Diode-pumped 1.15W linearly polarized single-frequency Yb³⁺-doped phosphate fiber laser," *Optics Express* **29**, 30637 (2021).
- S. L. Jenkins, S. A. Showghi, and R. A. Norwood, "Optical tuning of Si₃N₄ ring resonators using an external short visible wavelength laser source," *OSA Continuum* **4**, 1669 (2021).
- E. M. Fard, S. Namnabat, S. Arouh, R. A. Norwood, S. Pau, and N. Peyghambarian, "Relaxed tolerance low-loss adiabatic Si₃N₄ to polymer waveguide coupler for dense interconnects," *IEEE Phot. Tech. Lett.* **33**, 1227 (2021).
- J. Wang, X. Zhu, R. A. Norwood, and N. Peyghambarian, "Beyond 3μm Dy³⁺/Er³⁺ co-doped ZBLAN fiber lasers pumped by 976nm laser diode," *Appl. Phys. Lett.* **118**, 151101 (2021).
- K.J. Carothers, N. P. Lyons, N. G. Pavlopoulos, K.-S. Kang, T. M. Kochenderfer, A. Phan, L. N. Holmen, S. L. Jenkins, I.-B. Shim, R. A. Norwood, and J. Pyun, "Polymer-coated magnetic nanoparticles as ultra-high Verdet constant materials: Correlation of nanoparticle size with magnetic & magneto-optical properties," *Chemistry of Materials* **33**, 5010 (2021).
- S. Fu, X. Zhu, J. Zong, M. Li, I. Zavala, V. Temyanko, A. Chavez-Pirson, R. A. Norwood, and N. Peyghambarian, "Single-frequency Nd³⁺-doped phosphate fiber laser at 915nm," *J. Lightwave Tech.* **39**, 1808 (2021).
- R. S. Ketchum, H.-C. Yuan, L. Ruiz-Diaz, N. P. Lyons, S. Cui, M. Frasier, S. A. Showghi, K.-J. Kim, A. Ida, W. Pan, and R. A. Norwood, "Design and characterization of a translucent solar module (TSM) for greenhouse structures," *J. Engineering and Architecture* **8**, 42 (2020).
- N. P. Lyons, S. Cui, R. S. Ketchum, K.-J. Kim, and R. A. Norwood, "Thermal compensation of molded silicone optics," *Applied Optics* **59**, G59 (2020).
- N. G. Pavlopoulos, K. S. Kang, L. N. Holmen, N. P. Lyons, F. Akhoundi, K. J. Carothers, S. L. Jenkins, T. Lee, T. M. Kochenderfer, A. Phan, D. Phan, M. E. Mackay, I. B. Shim, K. Char, N. Peyghambarian, L. J.

- Lacomb, R. A. Norwood, and J. Pyun, "Polymer and magnetic nanoparticle composites with tunable magneto-optical activity: role of nanoparticle dispersion for high Verdet constant materials," *J Mater. Chem. C* **8**, 5417 (2020).
- S. Fu, X. Zhu, J. Wang, J. Zong, M. Li, A. Chavez-Pirson, R. A. Norwood, and N. Peyghambarian, "High-efficiency Nd³⁺-doped phosphate fiber laser at 880nm," *IEEE Phot. Tech. Lett.* **32**, 1179 (2020).
 - M. Mollaei, X. Zhu, S. Jenkins, J. Zong, E. Temyanko, R. Norwood, A. Chavez-Pirson, M. Li, D. Zelmon, and N. Peyghambarian, "Magneto-optical properties of highly Dy³⁺ doped multicomponent glasses," *Optics Express* **28**, 11789 (2020).
 - E. M. Fard, C. M. Long, A. L. Lentine, and R. A. Norwood, "Cryogenic C-band wavelength division multiplexing system using an AIM Photonics Foundry process design kit," *Optics Express* **28**, 35551 (2020).
 - T. S. Kleine, J. I. Frish, N. G. Pavlopoulos, S. A. Showghi, R. Himmelhuber, R. A. Norwood, and J. Pyun, "Refractive index contrast polymers: Photoresponsive systems with spatial modulation of refractive index for photonics," *ACS Macroletters* **9**, 416 (2020).
 - T. S. Kleine, R. S. Glass, D. L. Lichtenberger, M. E. Mackay, K. Char, R. A. Norwood, and J. Pyun, "100th Anniversary of Macromolecular Science Viewpoint: High refractive index polymers with elemental sulfur for infrared thermal imaging and optics," *ACS Macroletters* **9**, 245 (2020).
 - T. S. Kleine, T. Lee, K. J. Carothers, M. O. Hamilton, L. E. Anderson, L. Ruiz Diaz, N. P. Lyons, K. R. Coasey, W. O. Parker, Jr., L. Borghi, M. E. Mackay, K. Char, R. S. Glass, D. L. Lichtenberger, R. A. Norwood, and J. Pyun, "Infrared fingerprint engineering: A molecular design approach to long-wave infrared transparency with polymeric materials," *Angewandte Chemie* **131**, 1 (2019).
 - J. Wu, X. Zhu, C. Xia, H. Wei, K. Wiersma, M. Li, J. Zong, A. Chavez-Pirson, R. A. Norwood, and N. Peyghambarian, "Investigation of ion-ion interaction effects on Yb³⁺-doped fiber amplifiers," *Optics Express* **27**, 28179 (2019).
 - Y. Ma, X. Zhu, L. Yang, M. Tong, R. A. Norwood, H. Wei, Y. Chu, H. Li, N. Dai, J. Peng, J. Li and N. Peyghambarian, "Numerical investigation of GHz repetition rate fundamentally mode-locked all-fiber lasers," *Optics Express* **27**, 14487 (2019).
 - F. Akhoundi, R. A. Norwood, and N. Peyghambarian, "Low-cost magneto-optic sensor based on tapered fiber and distributed sensing concept," *IEEE Phot. Tech. Lett.* **31**, 901 (2019).
 - S. Arouh, R. Himmelhuber, and R. A. Norwood, "SiO₂ and TiO₂ blends with tunable optical and electronic properties," *MRS Advances* **4**, 689 (2019).
 - S. Cui, N. P. Lyons, L. Ruiz Diaz, R. Ketchum, K.-J. Kim, H.-C. Yuan, M. Frasier, W. Pan, and R. A. Norwood, "Silicone optical elements for cost-effective freeform solar concentration," *Optics Express* **27**, A572 (2019).
 - T. S. Kleine, L. Ruiz-Diaz, K. M. Konopka, L. E. Anderson, N. G. Pavlopoulos, N. P. Lyons, E. T. Kim, Y. Kim, R. S. Glass, K. Char, R. A. Norwood, and J. Pyun, "One-dimensional photonic crystals using ultrahigh refractive index chalcogenide hybrid inorganic/organic polymers," *ACS Macro Letters* **7**, 875 (2018).
 - M. Babaeian, P. Kieffer, M. A. Neifeld, R. Thamvichal, R. A. Norwood, P.-A. Blanche, J. Wissinger, and N. Peyghambarian, "Optical versus electronic implementation of probabilistic graphical inference and experimental device demonstration using nonlinear photonics," *IEEE Phot. Jour.* **10**, 7801412 (2018).
 - M. Babaeian, P.-A. Blanche, R. A. Norwood, T. Kaplas, P. Kieffer, Y. Svirko, T. G. Allen, V. W. Chen, S.-H. Chi, J. W. Perry, S. R. Marder, M. A. Neifeld, and N. Peyghambarian, "Nonlinear optical components for all-optical probabilistic graphical model," *Nature Communications* **9**, 2128 (2018).
 - M. Babaeian, L. Ruiz Diaz, S. Namnabat, T. S. Kleine, A. Azarm, J. Pyun, N. Peyghambarian, and R. A. Norwood, "Nonlinear optical properties of chalcogenide hybrid inorganic/organic polymers (CHIPs) using the Z-scan technique," *Optical Materials Express* **8**, 2510 (2018).
 - A. Autere, H. Jussila, A. Marini, J.R.M. Saavedra, Y. Dai, A. Säynätjoki, L. Karvonen, H. Yang, B. Amirsolaimani, R. A. Norwood, N. Peyghambarian, H. Lipsanen, K. Kieu, F. Javier Garcia De Abajo, and Z. Sun, "Optical harmonic generation in monolayer group-VI transition metal dichalcogenides," *Phys. Rev. B* **98**, 115426 (2018).
 - L. Ruiz Diaz, B. Cocilovo, A. Miles, W. Pan, P.-A. Blanche, and R. A. Norwood, "Optical and mechanical tolerances in hybrid concentrated thermal-PV solar trough," *Optics Express* **26**, A602 (2018).
 - J. Wu, X. Zhu, K. Wiersma, M. Li, J. Zong, A. Chavez-Pirson, V. Temyanko, L. J. LaComb, R. A. Norwood, and N. Peyghambarian, "Power scalable 10W 976nm single-frequency linearly polarized laser source," *Optics Letters* **43**, 951 (2018).
 - V. P. Drachev, A. V. Kildishev, J. D. Borneman, K.-P. Chen, V. M. Shalaev, K. Yamnitskiy, R. A. Norwood, N. Peyghambarian, S. R. Marder, L. A. Padilha, S. Webster, T. R. Ensley, D. J. Hagan, and E. W. Van Stryland, "Engineered nonlinear materials using gold nanoantenna array," *Scientific Reports* **8**, 780 (2018).

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- L. Karvonen, A. Saynatjoki, M. J. Huttunen, A. Autere, B. Amirsolaimani, S. Li, R. A. Norwood, N. Peyghambarian, H. Lipsanen, G. Eda, K. Kieu, and Z. Sun, "Rapid visualization of grain boundaries in monolayer MoS₂ by multiphoton microscopy," *Nature Communications* **8**, 15714 (2017).
- J. Luo, D. H. Park, R. Himmelhuber, Z.-L. Zhu, M. Li, R. A. Norwood, and A. K.-Y. Jen, "Efficient wafer-scale poling of electro-optic polymer thin films on soda-lime glass substrates: large second-order nonlinear coefficients and exceptional homogeneity of optical birefringence," *Optical Materials Express* **7**, 1909 (2017).
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- R. A. Norwood, "Micro/nanofabrication of chalcogenide hybrid inorganic-organic polymer for infrared photonics applications," **invited talk** at *SPIE Photonics West 2021* (March 5, 2021), *Proc.* 11696 (2021).
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