

Rajeev J. Ram

Professor of Electrical Engineering and Computer Science
Massachusetts Institute of Technology

Rajeev Ram is Professor of Electrical Engineering at MIT. His research focuses on the development of novel photonics & electronics for communications, energy, and sensing.

2013 Milestones:

- Demonstrated $< 5\text{fJ/bit}$ CMOS photonic modulator in collaboration with University of Colorado
- Demonstrated all-silicon infrared (1180-1550nm) detectors and monolithically integrated receivers
- Developed an optoelectronic filter capable of separating signals buried within noise

Key Research Milestones

- Demonstration of a thermally pumped light-emitting diode – first light-source to achieve greater than 100% electrical-to-optical conversion efficiency (2012)
- CMOS photonics in a deep-submicron technology (2008).
- Demonstration of a lab-on-a-chip microreactor for scale-down bioprocessing (2006)
- Measurement of thermoelectric parameters inside p-n junction (2004)
- Room temperature, continuous-wave lasers on Si using graded SiGe/Si interlayers (2002)
- Proposed telecom switch based on electromagnetically induced transparency (2000)
- First room temperature, continuous-wave bipolar cascade laser (1999)
- Proposed semiconductor polariton laser (1996)
- Proposed semiconductor laser without population inversion (1994)
- On the team that produced the first electrically pumped, telecom VCSEL (1993)
- Developed III-V wafer bonding process (eg. high brightness LEDs) (1992)

Research Training

More than two dozen graduate and post-doctoral researchers have worked with Ram in the Physical Optics and Electronics Laboratory. These students have gone on to leading semiconductor companies such as Intel, Sun, Samsung and Freescale as well as to tenured professorships at Cornell, the University of California, the University of Michigan, and MIT. He has received the Ruth & Joel Spira Award and Jamieson Award for teaching. He is a MacVicar Faculty Fellow – MIT's highest honor for teaching.

Government Service

Until June 2012, he served as a Program Director at the Advanced Research Projects Agency within the Department of Energy. He joined ARPAe in its first year. His primary focus was in advanced electrical components and systems ranging from transportation to the generation and transmission of electric power. He created three programs at ARPAe: Agile Delivery of Electrical Power Technology (ADEPT), Solar ADEPT (part of the President's Sunshot Initiative), and Green Electricity Network Integration (GENI). His portfolio of projects exceeded \$100M and included the demonstration of the highest voltage transistor and supported the breakthrough development of GaN-on-Si power electronics technology. He worked closely with path-breaking start-ups (Transphorm, Autogrid, Varentec, Foro Energy, FastCap, APEI), supported cutting-edge research at companies including IR, Cree, GE, GM, Toyota, and consulted with the Office of Science and Technology Policy and the White House

Education:

California Institute of Technology Applied Physics	BSc	1991
University of California, Santa Barbara Electrical Engineering	PhD	1997

Research Employment

Hewlett-Packard Laboratories	1992	1994
Assistant Professor, MIT	Jan. 1997	June 2000
Associate Professor (without tenure), MIT	July 2000	July 2003
Associate Professor (with tenure), MIT	July 2003	July 2007
Full Professor, MIT	July 2007	present
Director, Center for Integrated Photonics, MIT	May 2004	March 2012
Associate Director, Research Lab of Electronics, MIT	July 2005	March 2012

Professional service:

Program Director, ARPA-E, Department of Energy	April 2010	May 2012
DARPA Defense Science Research Council	August 2005	January 2007

Program Committees

Conference on Lasers & Electro-Optics (Optical Society of Am.)	2000, 2001, 2004
Advanced Semiconductor Lasers (OSA/IEEE)	2000, 2001
Semiconductor Amplifiers and Lasers (SPIE)	2002
Fluctuations and Noise (SPIE)	2003
International Electronic Devices Meeting (IEEE)	2003, 2004
Photonics in Switching (IEEE)	2007, 2008
Electronic Materials Conference (TMS)	2007
Chair, Optics for Advanced Energy Technology (CIPS/OSA)	2009
Advisor, MIT Optical Society of America Student Chapter	2006-present
Advisor, IEEE Photonics Society Student Chapter	2007-present

Awards and Honors

John and Fannie Hertz Foundation Fellowship	1995
NSF Early Career Award	1998
ONR Young Investigator Award	1999
NAE Frontiers in Engineering Symposium	1999
ITT Career Development Chair	2001-2003
Ruth and Joel Spira Distinguished Teaching Award	2002
Global Indus Technovator Award	2006
Jamieson Teaching Award	2009
MacVicar Faculty Fellow	2010-2020
Advisor, Student Paper Award, International Conference on Advanced Vibrational Spectroscopy	2003
Advisor, Student Paper Award, Materials Research Society Symposium	2005, 2009
Advisor, Widmer Award, μ TAS Symposium	2007
Co-author, Top Picks, Hot Interconnects 16	2008

Entrepreneurship

Founder, Board of Directors, Pharyx Incorporated	2007-present
Scientific Advisory Board (founding), Joule Unlimited	2007-2010

Patents Awarded (8)

1. Yang L. and R.J. Ram , “Semiconductor laser that generates second harmonic light by means of a nonlinear crystal in the laser cavity,” US Patent #5,363,390, November 1994; European Patent # 94,308,586, January 1995.
2. H. Schmidt, R.J. Ram, “All-optical Wavelength Conversion using Electromagnetically Induced Transparency.” US Patent #6,426,831, July 30, 2002.
3. S. G. Patterson, R. J. Ram, ”Bipolar Cascade ARROW Laser,” US Patent # 6,587,492, July 1, 2003.
4. Brennan, III; James F Chou; Patrick C. Lee; Harry L. T. Ram; Rajeev J. Haus; Hermann A. Ippen; Erich P “Method and apparatus for generating frequency modulated pulses” US Patent #6,834,134, December 21, 2004
5. K. P. Pipe and R. J. Ram, “Method and apparatus for characterization of photonic devices and circuits,” US Patent # 6,921,195, July 26, 2005.
6. R. J. Ram, T. Zaman, and X. Guo, “Magnetically active semiconductor waveguides for optoelectronic integration,” US Patent #7,130,494, October 31, 2006
7. J. Hudgings, D. Lueerssen, P. Mayer, R. J. Ram “High Performance CCD-Based Thermoreflectance Imaging Using Stochastic Resonance,” US 7,429,735 , issued 2009
8. Charles W Holzwarth, Judy L Hoyt, Jason Orcutt, Milos Popovic and Rajeev J Ram, “Reduction of Substrate Optical Leakage in Integrated Photonic Circuits Through Localized Substrate Removal” US 7,920,770 issued 2011

Papers in Refereed Journals

1. R. J. Ram, L. Yang, K. Nauka, M. Ludowise, Y. M. Hounq, D. E. Mars, J. J. Dudley, and S. Y. Wang, "Analysis of Wafer Fusing for 1.3 μ m Vertical Cavity Surface Emitting Lasers", Applied Physics Letters vol. 62, pp. 2474-2476, May 17,1993.
2. R. J. Ram and R. A. York, "Parametric Oscillation in Nonlinear Dipole Arrays" IEEE Trans. on Antennas and Propagation, vol. 42, pp. 406-411, March 1994.
3. J. J. Dudley, D. I. Babic, R. Mirin, L. Yang, B. I. Miller, R. J. Ram, T. Reynolds, E. L. Hu, and J. E. Bowers, "Low Threshold, Wafer Fused Long Wavelength Vertical Cavity Lasers" Applied Physics Letters, vol. 64, pp. 1463-1593, March 21,1994.
4. D. I. Babic, R. J. Ram, J. E. Bowers, M. Tan, L. Yang. "Scaling Laws in Gain Guided Vertical Cavity Lasers" Applied Physics Letters, vol. 64, pp. 1762-1764, April 4, 1994.
5. Imamoglu, A and R. J. Ram, "Semiconductor Lasers Without Population Inversion," Optics Letters., vol. 19, pp. 1744-1746 , November 1, 1994.
6. R. J. Ram, D. I. Babic, R. A. York and J. E. Bowers, "Spontaneous Emission in Microcavities with Distributed Mirrors," IEEE Journal of Quantum Electronics., vol. 31, pp. 399-410, February 1995.
7. E. F. Goobar, R. J. Ram, R. Nagarajan, J. E. Bowers, L. A. Coldren, "Intensity Noise and Facet Correlation in Fabry-Perot Laser Diodes with Low Facet Reflectivities," Applied Physics Letters vol. 66, pp. 3419-3421, June 19, 1995.
8. R. J. Ram, J. J. Dudley, J. E. Bowers, L. Yang, K. Carey, S. J. Rosner and K. Nauka, "GaAs to InP Wafer Fusion," Journal of Applied Physics, vol. 78, pp. 4227-4237 Sept. 15 1995.
9. R. J. Ram, E. Goobar, M. Peters, L. A. Coldren and J. E. Bowers, "Spontaneous Emission Factor in Post Microcavity Lasers," IEEE Phot. Tech. Lett., May 1996.
10. A. Imamoglu and R. J. Ram, "Quantum Dynamics of Nonequilibrium Excitons," Physics Letters A, May 13, 1996.
11. A. Imamoglu, R. J. Ram, S. Pau, and Y. Yamamoto "Nonequilibrium Condensates and Lasers without Inversion," Physical Review A June 1996.
12. E. Goobar, R. J. Ram, J. Ko, G. Bjork, M. Oestreich and A. Imamoglu, "Vacuum Field Mixing of Light and Heavy Hole Excitons in a Semiconductor Microcavity," Applied Physics Letters, vol. 69, pp. 3465-3467 December 2, 1996.
13. Dalal RV, Ram RJ, Helkey R, Roussell H, Choquette KD. "Low distortion analogue signal transmission using vertical cavity lasers". Electronics Letters, vol.34, pp.1590-1, 6 Aug. 1998. *
14. Patterson SG, Petrich GS, Ram RJ, Kolodziejski LA. "Continuous-wave room temperature operation of bipolar cascade laser". Electronics Letters, vol.35, pp.395-7, 4 March 1999. *
15. Jianyao Chen, Ram RJ, Helkey R. "Linearity and third-order intermodulation distortion in DFB semiconductor lasers". IEEE Journal of Quantum Electronics, vol.35, pp.1231-7, Aug. 1999. *

16. Patterson SG, Petrich GS, Ram RJ, Kolodziejski LA. "X-ray diffraction analysis of bandgap-engineered distributed Bragg reflectors". *Journal of Electronic Materials*, vol.28, pp.1081-3, Oct. 1999. *
17. Knodl T, Choy HKH, Pan JL, King R, Jager R, Lullo G, Ahadian JF, Ram RJ, Fonstad CG Jr, Ebeling KJ. "RCE photodetectors based on VCSEL structures". *IEEE Photonics Technology Letters*, vol.11, pp.1289-91, Oct. 1999. *
18. Ross CA, Smith HI, Savas T, Schattenburg M, Farhoud M, Hwang M, Walsh M, Abraham MC, Ram RJ. "Fabrication of patterned media for high density magnetic storage". *Journal of Vacuum Science & Technology B*, vol.17, pp.3168-76, Nov. 1999. *
19. Lee HLT, Dalal RV, Ram RJ, Choquette KD. "Dynamic range of vertical-cavity surface-emitting lasers in multimode links". *IEEE Photonics Technology Letters*, vol.11, pp.1473-5, Nov. 1999. *
20. Rana F, Ram RJ. "Photon noise and correlations in semiconductor cascade lasers". *Applied Physics Letters*, vol.76, pp.1083-5, 28 Feb. 2000. *
21. Hwang M, Abraham MC, Savas TA, Smith HI, Ram RJ, Ross CA. "Magnetic force microscopy study of interactions in 100 nm period nanomagnet arrays". *Journal of Applied Physics*, vol.87, pp.5108-10, pt.1-3, 1 May 2000. *
22. Schmidt H, Ram RJ. "All-optical wavelength converter and switch based on electromagnetically induced transparency". *Applied Physics Letters*, vol.76, pp.3173-5, 29 May 2000. *
23. Patterson SG, Lau EK, Pipe KP, Ram RJ. "Temperature characteristics of bipolar cascade lasers". *Applied Physics Letters*, vol.77, pp.172-4, 10 July 2000. *
24. Ram RJ, Sporer R, Blank H-R, York RA. "Chaotic dynamics in coupled microwave oscillators". *IEEE Transactions on Microwave Theory & Techniques*, vol.48, pp.1909-16, Nov. 2000.
25. Schmidt H, Ram RJ. "Coherent magnetization reversal of nanoparticles with crystal and shape anisotropy". *Journal of Applied Physics*, vol.89, pp.507-13, 1 Jan. 2001. *
26. Abraham MC, Schmidt H, Savas TA, Ross CA, Smith HI, and Ram RJ. "Magnetic properties and interactions of single-domain nanomagnets in a periodic array". *Journal of Applied Physics*, vol.89, pp.5667-70, 15 May 2001. *
27. Pipe KP, Ram RJ, and Shakhouri A, "Internal cooling in a semiconductor laser diode" *IEEE Photonics Technology Letters*, vol. 14, no. 4, April 2002. *
28. Rana F, Ram RJ, "Theory of current noise and photon noise in quantum cascade lasers," *Physical Review B*, vol. 65, no. 12, March 2002. *
29. Pipe KP and Ram RJ, "Bias-dependent Peltier coefficient and internal cooling in bipolar devices," *Physical Review B*, September 2002.*
30. Rana F, Harry LT Lee, RJ Ram, ME Grein, LA Jiang, EP Ippen, HA Haus, "Characterization of noise and correlations in harmonically mode-locked semiconductor lasers," *Journal of Optical Society of America B*, 2002. *
31. Mayer P., Rana F., and Ram R.J., "Noise Correlations in Coupled Semiconductor Lasers," *Applied Physics Letters*, January 2003.*

32. Pipe KP and Ram RJ, "Comprehensive Model for Heat Transfer in Semiconductor Lasers," *IEEE Photonics Technology Letters*, April 2003.*
33. Tepper T, Illievski F, Ross CA, Zaman TR, Ram RJ, Sung SY, Stradler BJG, "Magneto-optical properties of iron oxide films," to appear *Journal of Applied Physics*, vol. 93, no. 10, 2003.*
34. Groenert ME, Pitera AJ, Ram RJ, Fitzgerald EA, "Improved room-temperature continuous wave GaAs/AlGaAs and InGaAs/GaAs/AlGaAs lasers fabricated on Si substrates via relaxed graded Ge_xSi_{1-x} buffer layers," *Journal of Vacuum Science and Technology B*, vol.21, no.3, pp.1064-69, May/June 2003.*
35. Groenert ME, Leitz CW, Pitera AJ, Yang V, Lee HLT, Ram RJ, Fitzgerald EA, "Monolithic integration of room-temperature cwGaAs/AlGaAs lasers on Si substrates via relaxed graded GeSi buffer layers," *Journal of Applied Physics*, vol.93, no.1, pp.362-3671, January 2003.*
36. Hudgings, J.A., Pipe K.P., and Ram R.J., "Thermal Profiling for Optical Characterization of Waveguide Devices," *Applied Physics Letters* 83(19): p. 3882-3884 (2003).*
37. Ho-Ki Lyeo, A.A. Khajetoorians, Li Shi, Kevin P. Pipe, Rajeev J. Ram, Ali Shakouri, and C.K. Shih, "Profiling the Thermoelectric Power of Semiconductor Junctions with Nanometer Resolution", *Science* 2004.*
38. Lee, H.L.T, Boccazzi P, Gorret N, Ram R.J., and Sinskey, A.J., "*In situ* bioprocess monitoring for Escherichia Coli using Raman spectroscopy," *Vibrational Spectroscopy*, Volume 35, Issues 1-2, 17 June 2004, Pages 131-137 2004.*
39. Luerssen D, Ram R J, Hohl-AbiChedid A, Clausen E, Jr, Hudgings J A, "Thermal profiling: locating the onset of gain saturation in semiconductor optical amplifiers," *IEEE Photonics Technology Letters*, v 16, n 7, July 2004, pp. 1625-7.*
40. Rana, F., Ram, R.J.; Haus, H.A., "Quantum noise of actively mode-locked lasers with dispersion and amplitude/phase modulation," *IEEE Journal of Quantum Electronics*, v 40, n 1, Jan. 2004, p 41-56.*
41. F. Rana, P. Mayer, R. J. Ram, "Scaling of the photon noise in semiconductor cascade lasers," *Journal of Optics B*, vol. 6, no. 8, S771-S774 (2004).*
42. P. Mayer, R. J. Ram, "Optimization of Heat-sink Limited Thermoelectric Generators," *Nanoscale and Microscale Thermophysical Engineering*, May, 2006.*
43. Fuchs, E., Bruce E.J., Ram, R.J., Kirchain R.E. "Process Based Cost Modeling of Photonics Manufacture: The Cost Competitiveness of Monolithic Integration of a 1550nm DFB Laser and an Electro-Absorptive Modulator on an InP Platform" *IEEE Journal of Lightwave Technology*, accepted for publication 2006.*
44. Zaman, T., Guo X., and Ram R.J. "Proposal for a Polarization Independent Integrated Optical Circulator," *IEEE Photonics Technology Letters*, vol. 18, no. 12, pp. 1359-1361, 2006.*
45. Lee, H.L.T., Boccazzi P., Ram R.J., and Sinskey, A.J. "Microbioreactor arrays with integrated mixers and fluid injectors for high-throughput experimentation with pH and dissolved oxygen control," *Lab On a Chip*, vol. 6, pp. 1229-1235, 2006*

46. Zaman, T., X. Guo, R.J. Ram, "Faraday rotation in an InP waveguide," Applied Physics Letters, 3 pp., 2006.
47. T. Barwicz, H. Byun, F. Gan, M. Geis, M. Grein, C.W. Holzwarth, J.L. Hoyt, E.P. Ippen, F.X. Kärtner, T. Lyszczarz, O.O. Olubuyide, J.S. Orcutt, M.A. Popović, P.T. Rakich, R.J. Ram, H.I. Smith, S. Spector, V. Stojanovic, M.R. Watts, and J.U. Yoon "Silicon Photonics for Compact, Energy Efficient Interconnects," OSA Journal of Optical Networking, 14 pp., accepted, 2006.
48. Mayer, P., D. Lueerssen, R.J. Ram, J. Hudgings, "Theoretical and experimental investigation of the resolution and dynamic range of CCD-based thermorefectance imaging," Journal of the Optical Society of America A, 25 pp., accepted, 2006.
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50. Huang, R.K., R.J. Ram, M.J. Manfra, M.K. Connors, L.J. Missaggia, and G.W. Turner, "Heterojunction Thermophotovoltaic Devices with High Voltage Factor," Journal of Applied Physics, vol. 101, pp, 2007.
51. Lee, K.S., Lee, H.L.T, Ram, R.J. "Polymer Waveguide Backplanes for Optical Sensor Interfaces to Microfluidics," Lab-on-a-Chip, vol. 7, pp. 1539-1545, 2007.*
52. Liptay T. J., L. F. Marshall, P. S. Rao, R. J. Ram, and M. G. Bawendi, "Anomalous Stokes shift in CdSe nanocrystals," Physical Review B, vol. 76, 155314, 22 October 2007
53. Zaman T, X Guo, RJ Ram, "Semiconductor Waveguide Isolators," IEEE/OSA Journal of Lightwave Technology, vol 26, issue 2, pp. 291 - 301, Jan.15, 2008. (invited)
54. Amatya, R., C. H. Holzwarth, R. J. Ram, H. I. Smith, "Tunable Silicon Compatible Microring Filters," IEEE Photonics Technology Letters, vol. 20, issue 20 , pp. 1739-1741 2008.
55. C.W. Holzwarth, R. Amatya, M. Dahlem, A. Khilo, F.X. Kartner, E.P. Ippen, R.J. Ram and H.I. Smith, "Fabrication strategies for filter bands based on microring resonator," Journal of Vacuum Science and Technology B, vol. 26, no. 6, pp. 2164, December 2008
56. Kevin S. Lee and Rajeev J. Ram, "Plastic-PDMS bonding for high pressure hydrolytically stable active microfluidics," Lab on a Chip, vol. 9, pg. 1618, 2009.
57. M Farzaneh, K Maize, D Lüerßen, J A Summers, P M Mayer, P E Raad, K P Pipe, A Shakouri, R J Ram and J A Hudgings, "CCD-based thermorefectance microscopy: principles and applications," J. Phys. D: Appl. Phys., 42 143001, 2009 (invited).
58. M. Farzaneh, J. Summers, R.J. Ram, and J.A. Hudgings, "Thermal and optical characterization of photonic integrated circuits by thermorefectance microscopy," in press, IEEE Journal of Quantum Electronics, 2009.
59. J. Montoya, K. Parameswaran, J. Hensley, M. Allen, and R. Ram, "Surface plasmon isolator based on nonreciprocal coupling," Journal of Applied Physics, v. 106, 023108, 2009.

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61. Summers, J.A. Farzaneh, M.; Ram, R.J.; Hudgings, J.A. "Thermal and optical characterization of photonic integrated circuits by thermoreflectance microscopy" *IEEE Journal of Quantum Electronics*, v 46, n 1, p 3-10, Jan. 2010
62. J. S. Orcutt and R. J. Ram, "Photonic Device Layout Within the Foundry CMOS Design Environment," *IEEE Photonics Technology Letters*, v 22, n 8, p 544-6, 5 April 2010
63. R. Amatya and R. J. Ram, "Solar thermoelectric generator for micropower applications," *Journal of Electronic Materials*, v 39, n 9, p 1735-1740, September 2010
64. P. Santhanam and R. J. Ram, "Self-Consistent Drift-Diffusion Transport in Thermoelectrics and Implications for Measuring the Scattering Parameter," *Journal of Electronic Materials*, v 39, n 9, p 1944-1949, September 2010
65. J. S. Orcutt, et al., "Nanophotonic Integration in State-of-the-Art CMOS Foundries," *Optics Express*, v 19, n 3, p 2335-2346, January 31, 2011.
66. W. Loh, et al. "Noise Figure of Watt-Class Ultralow-Confinement Semiconductor Optical Amplifiers," *IEEE Journal of Quantum Electronics*, *IEEE Journal of Quantum Electronics*, v 47, n 1, p 66-75, 2011.
67. Kevin S. Lee and Rajeev J. Ram, "Microfluidic chemostat and turbidostat with flow rate, oxygen, and temperature control for dynamic continuous culture," *Lab on a Chip*, vol. 11, pg. 1730, 2011.
68. Joseph A. Summers and Rajeev J. Ram, "Thermal and optical characterization of resonant coupling between surface plasmon polariton and semiconductor waveguides," *Appl. Phys. Lett.* 99, 2011.
69. J.-H. Bahk, Z. Bian, M. Zebarjadi, P. Santhanam, R. Ram, and A. Shakouri, "Thermoelectric power factor enhancement by ionized nanoparticle scattering," *Applied Physics Letters*, vol. 99, August 2011.
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79. Jason S. Orcutt, Benjamin Moss, Chen Sun, Jonathan Leu, Michael Georgas, Jeffrey Shainline, Eugen Zraggen, Hanqing Li, Jie Sun, Matthew Weaver, Stevan Urošević, Miloš Popović, Rajeev J. Ram, and Vladimir Stojanović, "Open foundry platform for high-performance electronic-photonic integration," *Optics Express*, Vol. 20, Issue 11, pp. 12222-12232 (2012).
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86. Jeffrey M. Shainline, Jason S. Orcutt, Mark T. Wade, Kareem Nammari, Benjamin Moss, Michael Georgas, Chen Sun, Rajeev J. Ram, Vladimir Stojanović, and Miloš A. Popović, "Depletion-mode carrier-plasma optical modulator in zero-change advanced CMOS," *Opt. Lett.* **38**, 2657-2659 (2013)
87. Shainline, Jeffrey M., Jason S. Orcutt, Mark T. Wade, Kareem Nammari, Ofer Tehar-Zahav, Zvi Sternberg, Roy Meade, Rajeev J. Ram, Vladimir Stojanović, and Miloš A. Popović. "Depletion-mode polysilicon optical modulators in a bulk complementary metal-oxide semiconductor process." *Opt. Lett.* **38**, no. 15 (2013): 2729-2731.
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89. Gray Jr, Dodd J., Parthiban Santhanam, and Rajeev J. Ram. "Design for enhanced thermo-electric pumping in light emitting diodes." *Applied Physics Letters* 103, no. 12 (2013): 123503.
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92. William Loh, Siva Yegnanarayanan, Rajeev Ram, and Paul Juodawlkis, "A nonlinear optoelectronic filter for electronic signal processing" accepted to *Nature Scientific Reports*.
93. Karan K. Mehta, Jason S. Orcutt, Jeffrey M. Shainline, Ofer Tehar-Zahav, Zvi Sternberg, Roy Meade, Miloš A. Popović, and Rajeev J. Ram, "Polycrystalline silicon ring resonator photodiodes in a bulk complementary metal-oxide-semiconductor process," *Opt. Lett.* **39**, 1061-1064 (2014)

Selected Conference Proceedings

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2. J. E. Bowers, D. I. Babic, J. J. Dudley and R. J. Ram, "Long Wavelength Vertical Cavity Lasers," Session 14D3-1, Fifth Optoelectronics Conference, Makuhari Messe, Chiba, Japan, July 12-15 1994.
3. A.Imamoglu, K. L. Campman, H. Schmidt, R. J. Ram, J. E. Bowers and A. C. Gossard, "Lasers without Inversion in Quantum Well Intersubband Transitions," International Conference on Coherence and Nonlinear Optics, St. Petersburg, Russia, June 27 to July 1 1995.
4. R. J. Ram, C.-K. Sun, J. Ko, G. Wang, E. Goobar, M. Oesterich, J. E. Bowers, and A.. Imamoglu, "Dynamics of Condensing Polaritons," Physics of Quantum Electronics, 26th Winter Colloquium on Quantum Electronics, Snowbird, Utah, January 7-10, 1996.
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8. R. J. Ram and C. H. Cox, "High Performance Microwave Optical Links," International Conference on Communications and Computing Devices, IIT Kharagpur, India, December 2000. *
9. M Groenert, C Leitz, A Pitera, V Yang, EA Fitzgerald, H Lee, and RJ Ram, "Room temperature CW GaAs/AlGaAs lasers on Si," Materials Research Society Spring Meeting 2002, San Francisco, April 2002. *
10. R. J. Ram, K. Pipe, and A. Shakhouri, "Thermoelectric effects in bipolar devices: Internally cooled semiconductor lasers," US-Japan Nanotherm Seminar, Berkeley, California, June 2002. *
11. R. J. Ram, "Semiconductor Cascade Lasers for Telecommunications," International Society for Optical Engineering ITCOM 2002, Boston, July 2002.*

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14. Rajeev J. Ram, "Novel Components For Large Scale Photonic Integration," XXVIIIth General Assembly of International Union of Radio Science (URSI), New Delhi, India, October 2005.
15. Lee H.L.T., Boccazzi P., Ram R.J., and Sinskey, A.J. "New microreactor array technologies for rapid bioprocess development," IBC Cell Line Development and Engineering Conference 2007, La Jolla, CA.
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17. Rajeev J. Ram, Kevin Lee, "Photonic Integration for Lab on a Chip Systems," IEEE Photonics Society Annual Meeting, Antalya, Turkey, October 2009.
18. Rajeev J. Ram, Reja Amatya, "Solar Thermoelectric Generators," 12th International Conference on Modern Materials and Technologies, Italy, June 2010.
19. Rajeev J. Ram, "CMOS Photonic Integrated Circuits ,"Optical Fiber Communication Conference (OFC), Los Angeles, California, March 4, 2012
20. Rajeev J. Ram, "The Role of Power Magnetics in Cleantech," Power MEMs Workshop, Atlanta, Georgia, December 2012.
21. Santhanam, Parthiban, et al. "Electro-luminescent cooling: light emitting diodes above unity efficiency." SPIE OPTO. International Society for Optics and Photonics, 2013.
22. Orcutt, Jason S., Rajeev J. Ram, and Vladimir Stojanović. "Integration of silicon photonics into electronic processes." SPIE OPTO. International Society for Optics and Photonics, 2013.

Plenary Presentations

1. R. J. Ram, "The Road Ahead for Integration and Convergence of Communication Technology" IEEE Interconnections within High Speed Digital Systems Santa Fe, New Mexico, 2005.
2. R. J. Ram, "Integrated Photonics for Lab-on-a-Chip," 6^a Reunión Española de Optoelectrónica, OPTOEL '09, Málaga, Spain, July, 2009.
3. R. J. Ram, "Stimulating Innovation in Energy Technology" IEEE Conference on Innovative Technologies for an Efficient and Reliable Electricity Supply Waltham, Waltham, Massachusetts, 2010.
4. R. J. Ram, "Stimulating Innovation in Energy Technology: The Role of Wide Bandgap Semiconductors" International Conference on Silicon Carbide and Related Materials Cleveland, Ohio, 2011.

Other Major Publications

- 1 R. J. Ram and A. Imamoglu, 'The Exciton Bose: Cooperative Phenomena in Microcavity Excitons,' Microcavities and Photonic Bandgaps, ed. J. Rarity and C. Weisbuch, Kluwer Academic Publishing, 1996.
- 2 R. J. Ram and HLT Lee, "Direct Modulation for Microwave Photonics", Microwave Photonics ed S. Iezekiel, John Wiley & Sons, 2009.
3. J. S. Orcutt, V. Stojanovic, and R. J. Ram "CMOS Photonics for High Performance Interconnects," Optical fiber telecommunications VI A.Ed. Kaminow, Ivan, Tingye Li, and Alan E. Willner. Academic press, 2013.

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