

BIOGRAPHICAL SKETCH

NAME Sanjay Krishna	POSITION TITLE Professor, Electrical and Computer Engg, Chief Technology Officer, SKINfrared LLC		
EDUCATION/TRAINING			
INSTITUTION AND LOCATION	DEGREE <i>(if applicable)</i>	YEAR(s)	FIELD OF STUDY
S.S.I.H.L Bangalore	B. Sc (Hons)	1994	Physics
Indian Institute of Technology, Madras	M.Sc	1996	Physics
University of Michigan Ann Arbor	M.S.	1999	Electrical Engineering
University of Michigan Ann Arbor	Ph D	2001	Applied Physics

Positions and Employment History

1995	Visiting Student Researcher, Tata Inst. Fundamental Research, India
1996-1997	Graduate Student Assistant, Tata Inst. Fundamental Research, India
1997-1998	Graduate Student Instructor, University of Michigan, Ann Arbor
1998-2001	Graduate Student Research Assistant, University of Michigan, Ann Arbor
2001-2006	Assistant Professor, ECE Dept, University of New Mexico, Albuquerque
2006-2010	Associate Professor, ECE Dept, University of New Mexico, Albuquerque
2010-Present	Professor, ECE Dept, University of New Mexico, Albuquerque
2009-2012	Associate Director, Center for High Technology Materials, University of New Mexico
2009-2012	UNM Regents Lecturer
2010-Present	Chief Technology Officer, SK Infrared LLC, Albuquerque

Honors and Distinctions

1996	Gold Medal from Indian Institute of Technology, Madras
1997	First in Grad School of Physics at Tata Institute of Fundamental Research
1997	Graduate Student Fellowship, Dept. of Physics, University of Michigan
1999	Best student paper award at North American Molecular Beam Epitaxy Conference
2003	Outstanding Young Engineer Award by IEEE Albuquerque Chapter
2004	ECE Outstanding Researcher Award
2004	Oak Ridge Associated Universities Ralph Powe Jr. Faculty Enhancement Award
2005	School of Engineering Junior Faculty Teaching Award
2007	North American Molecular Beam Epitaxy Young Investigator Award
2007	Defense Intelligence Agency Chief Scientist Award for Excellence
2008	IEEE-Nanotechnology Council Early Career Achievement Award
2008	SPIE Early Career Achievement Award
2009	UNM School of Engineering Sr. Research Excellence Award
2009	UNM Regents Lecturer Award
2010	UNM Teacher of the Year Award
2010	Fellow, SPIE
2010	Sr. Gledden Fellow, University of Western Australia
2011	Lange Lecturer in Materials, University of California, Santa Barbara
2011	ECE Gardner-Zemke Award for Research Excellence

Conference Committees

2007	Conference Co-Chair of the North American Molecular Beam Epitaxy Conference
2006	Publications Chair of IEEE Conference on Nanotechnology
2005-2008	Chair of the program committee on "Optoelectronic Materials and Processing (OMP) for IEEE/LEOS
2005-2009	Chair of the Center for Integrated Nanotechnologies (CINT) Users Executive Committee
2008-2009	Associate Editor for IEEE Transactions in Nanotechnology
2008-2009	Associate Editor for IEEE Photonics Technology Letters
2007	Program committee of "The International Conference on Electronic Materials"
2007-Present	Program committee of "IEEE LEOS Optical MEMS & NanoPhotonics
2010	Technical Symposium Co-chair, IEEE Lester Eastman Conference
2010	Program committee, North American Molecular Beam Epitaxy Conference
2009-Present	Program committee, IEEE Photonics Society "Photodetectors and Imaging" subcommittee

2011	Program committee, Pacific Rim CLEO meeting
2011	Program committee, Infrared Sensors, Devices, and Applications, SPIE Annual Meeting
2011	Advisory Board, North American Molecular Beam Epitaxy Conference
2011	Editorial Advisory Board, Optoelectronics Review
2012	Proceedings Editor, International Symposium on Compound Semiconductors (ISCS)
2014	Chair, Quantum Structures Infrared Photodetectors Conference (QSIP)

Research Group Members

Senior Researchers: DDr. Greg Von Winckel (Research Associate Professor)
 Dr. Elena Plis (Research Assistant Professor)
 Dr. Yagya Sharma (Research Assistant Professor)
 Dr. Thomas Rotter (Research Assistant Professor)
 Dr. Zhaobing Tian (Research Assistant Professor)
 Dr. David Ramirez (Postdoctoral Researcher)
 Dr. Jun Oh Kim (Postdoctoral Researcher)

Current Graduate Students:

Stephen Myers (PhD, Candidate)
 Maya Kutty (PhD, Candidate)
 Freddie Santiago (PhD, Candidate)
 Vincent Cowan (PhD, Candidate)
 John Montoya (PhD, Post-Qualifying)
 Brianna Klein (PhD, Post-Qualifying)
 Ted Schuler Sandy (PhD, Post-Qualifying)
 Glauco Fiorante (PhD, Post-Qualifying)
 Sebastian Godoy (PhD, Post-Qualifying)
 Marziyeh Zamiri, (PhD, Pre-Qualifying)
 Alireza Kazemi, (Phd, Pre-Qualifying)

Undergraduate Students:

Ricky Flores (Fall 2012-Present)
 Emily Tansey (Summer 2012)
 Travis Nelson (Summer 2012)
 Nathan Henry (Summer 2010-Fall 2012)
 Nina Rae Weisse-Bernstein (Summer 2004-Spring 2005, LANL)
 Shawn Humphrey (Spring 2005, Naval Postgrad School)
 Darren Formann (Spring 2004, Industry)
 Mark Spencer (Spring 2005)
 Nicole Escude (Summer 2005, Biola Univ)
 Vaibhav Tripathi (Summer 2005, IIT, Kanpur)
 Rasika Behl (Summer 2006, USC)
 Pooja Singh (Summer 2006, IIT, Roorkee)
 Amit Siroya (Summer 2007, IIT Mumbai)
 Jennifer Hou (Summer 2008, Johns Hopkins University)
 Shreyas Shah (Summer 2008, IIT Mumbai)
 Niyanti Datye (Summer 2009, Georgia Tech)
 Sreejan Meesala (Summer 2010, IIT Mumbai)
 Patrick Wanninkhof (Summer 2010, Univ of Florida)

High School Students:

Sean Yonemoto (Spring 2012-Present)
 Spencer Kent (Fall 2010-Present)
 Mathew Rush (Fall'03/Spr'04)
 Victoria Fowler (Summer'03)
 Mallory Mallet (Summer 07, Fall 07)

Past Group Members:

Postdoctoral Fellows: Dr. Tom Vandervelde (Faculty at Tufts University), Dr. Jean Baptiste Rodriguez (Faculty, CNRS, Montpellier), Dr. Jay Brown, Dr. Abdenour Amtout (Abound Solar), Dr. Phil Dowd (Arizona State University); Dr. Mike Naydenkov (Lightspin Tech)
PhD Students: Greg von Winckel, Zhimei Zhu, Elena Plis, Ram Attaluri, Fred Newmann, Jonathan Andrews, Chris Wilcox, Arezou Khoshakhlagh, Hasul Kim, Rajeev Sheno, Jiayi Shao, David Ramirez, Ajit Barve, Nutan Gautam, Eric Jang

M.S. Students: Greg Bishop, Jason Shelton, Michael Lenz, Eric Varley, Kalyan Teja Posani, Senthil Annamalai, Diana Jepson, Chris Wilcox, Mario Serna, Sunil Raghavan, Andrea Scott, Nina Weisse Bernstein

Graduated Students (15 PhD and 12 M.S)

PhD

1. Greg von Winckel, PhD "Spectral Element Modeling of Semiconductor Nanostructures" (Spring 2006) (Faculty Member, University of Linz)
2. Zhimei Zhu, PhD "Materials Characterization of InAs/GaInSb Type II Superlattices " (Spring 2006) (Working in Law Firm in DC)
3. Elena Plis, PhD, " InAs/(In,Ga)Sb Strain Layer Superlattice (SLS) Photovoltaic Infrared Detectors" (Summer 2007) (Postdoc at UNM)
4. Ram Attaluri, PhD "Growth and Optimization of Dot-in-well (DWELL) Infrared Photodetectors" (Summer 2007) (Post doc at Lehigh University)
5. Fred Newmann, PhD "Study of Techniques to Obtain Metamorphic Low Bandgap Devices on GaAs Substrates" (Fall 2007) (Emcore Corp)
6. Jonathan Andrews, PhD "High Precision Radiometry Using an InAs/InGaAs Quantum Dot-in-a-Well Focal Plane Array, (Fall 2008) (Naval Research Lab)
7. Chris Wilcox, PhD "Atmospheric Turbulence Simulation Using a Liquid Crystal Spatial Light Modulator", (Fall 2009) (Naval Research Lab)
8. Arezou Khoshakhlagh, PhD, "Longwave and Bi-color Type-II InAs/(In)GaSb Superlattice Infrared Detectors" (Spring 2010) (NASA-JPL)
9. Hasul Kim, PhD "Investigation of InAs/GaSb Superlattice based nBn Detectors and Focal Plane Arrays" (Summer 2010) (UC Berkeley)
10. Rajeev Sheno, PhD, "Multispectral Plasmon Enhanced Quantum Dots-in-a-Double Well Infrared Detectors" (Fall 2010) (RPI)
11. Jiayi Shao, PhD, "Engineered Quantum Dots for Infrared Photodetector", (Fall 2011) (Purdue)
12. David Ramirez, PhD "Modeling and Engineering the Impact Ionization in Avalanche Photodiodes for Near and Mid Infrared Applications" (Fall 2011) (UNM)
13. Ajit Barve, PhD "Hetrostructure Engineering of Quantum Dots-in-a-Well Infrared Photodetectors" (Spring 2012) (UCSB)
14. Nutan Gautam, PhD " Unipolar Barrier Strained Layer Superlattice Infrared Photodiodes: Physics and Barrier Engineering" Summer 2012 (UCSB),
15. Wooyang (Eric) Jang, "Data Compressive Paradigm for Spectral Sensing and Classification Using Electrically Tunable Detectors" Fall 2012 (AFRL)

M.S.

1. Nina Weisse-Bernstein, M.S., **with distinction**, "Investigation of the Feasibility of Creating Arbitrary Optical Transmission Using Surface Acoustic Waves and Surface Plasmons", Spring 2009 (LANL)
2. Andrea Scott, M.S. "A Survey on Implementations of Integrated System Health Management (ISHM) for Air and Space Vehicles", Fall 2008 (AFRL)
3. Greg Bishop M.S. (Thesis), Spring 2008, "nBn Based Strain Layer Superlattice Detectors". (Sandia National Lab)
4. Jason Shelton M.S. (Thesis), **with distinction**, Summer 2008, "Series Connected Photovoltaic Arrays". (Sandia National Lab)
5. Eric Varley, M.S. (Thesis), Spring 2007, "Two color quantum dots in a well focal planer arrays". (Sandia National Lab)
6. Diana Jepson, M.S. (Thesis), Spring 2007, " 1/f Noise measurements in HgCdTe Detectors". (Air Force Research Lab)
7. Michael Lenz, M.S. (Thesis) Summer 2007, " Characterizing Spectral Response of Quantum Dots in a Well Focal Plane Arrays" (Sandia National Lab)
8. Kalyan Teja Posani M.S. (Thesis), Fall 2006 "Nanoscale Quantum Dot Photonic Crystal Detectors" (Qualcomm, San Diego)
9. Christopher Wilcox, M.S. (Thesis), Fall 2005, "The Design of an Adaptive Tip/Tilt Mirror for Adaptive Optics", (Continuing with PhD) (Naval Research Lab)
10. Senthil Annamalai, M.S. (Thesis), Spring 2006, "Quantum Dots in a Well Detector grown by Molecular Beam Epitaxy and Metal Organic Chemical Vapor Deposition" (Triquint Semiconductors)
11. Capt. Mario Serna, M.S. (Thesis) Summer 03, "Model and Fabrication of a Proof of Concept Polarimeter in a Pixel" (Presently Teaching Physics at the Airforce Academy in Colorado Springs)

12. Sunil Raghavan, M.S. (Thesis), **with distinction**, Summer 03, "Intersubband Quantum Dots in a Well Infrared Detectors" (Research Engineer in India)

Selected Publications (> 200 publications, > 3600 citations, H-index=33, Source: Google Scholar)

1. Lee, S.J, Ku, ZY, Barve, A, Montoya, J, Jang, WY, Brueck, SR, Sundaram, M, Reisinger, A, Krishna, S, and Noh, SK, **Nature Communications**, 2, 286 DOI: 10.1038/ncomms1283, 2011
2. Hyunhyub Ko, Kuniharu Takei¹, Rehan Kapadia, Steven Chuang, Hui Fang, Paul W. Leu¹, Kartik Ganapathi, Elena Plis, Ha Sul Kim, Szu-Ying Chen, Morten Madsen, Alexandra C. Ford, Yu-Lun Chueh, Sanjay Krishna, Sayeef Salahuddin & Ali Javey, "Ultrathin compound semiconductor on insulator layers for high-performance nanoscale transistors", **Nature**, Vol. 468, Pg. 286, Nov 2010.
3. Chun-Chieh Chang, Yagya D. Sharma, Yong-Sung Kim, Jim A. Bur, Rajeev V. Shenoi, Sanjay Krishna, Danhong Huang, and Shawn-Yu Lin, "A Surface Plasmon Enhanced Infrared Photodetector Based on InAs Quantum Dots", *Nano Lett.* 10, 1704–1709(2010,)
4. K. Banerjee, S. Ghosh, S. Mallick, E. Plis, S. Krishna, and C. Grein, "Midwave infrared InAs/GaSb strained layer superlattice hole avalanche Photodiode", *APPLIED PHYSICS LETTERS* 94, 201107,(2009)
5. Woo-Yong Jang, Majeed M. Hayat, J. Scott Tyo, Ram S. Attaluri, Thomas E. Vandervelde, Yagya Sharma, Rajeev Shenoi, Andreas Stintz, Elizabeth R. Cantwell, Steven C. Bender, Sang Jun Lee, Sam Kyu Noh, and Sanjay Krishna, "Demonstration of Bias-Controlled Algorithmic Tuning of Quantum Dots in a Well (DWELL) MidIR Detectors", *IEEE Journal of Quant. Electronics*, VOL. 45, JUNE 2009
6. H. S. Kim, E. Plis, J. B. Rodriguez, G. D. Bishop, Y. D. Sharma, L. R. Dawson, S. Krishna, J. Bundas, R. Cook, D. Burrows, R. Dennis, K. Patnaude, A. Reisinger, and M. Sundaram, "Mid-IR focal plane array based on type-II InAs/GaSb strain layer superlattice detector with nBn design" *Appl. Phys. Lett.* 92, 183502 (2008)
7. Fan, W; Zhang, S; Panoiu, NC; Abdenour, A; Krishna, S; Osgood, RM; Malloy, KJ; Brueck, SRJ "Second harmonic generation from a nanopatterned isotropic nonlinear material" *NANO LETTERS*; MAY 2006; v.6, no.5, p.1027-1030
8. Sarath D. Gunapala, Sumith V. Bandara, Cory J. Hill, David Z. Ting, John K. Liu, Sir B. Rafol, Edward R. Blazejewski, Jason M. Mumolo, Sam A. Keo, Sanjay Krishna, Y.-C. Chang, and Craig A. Shott, "640 512 Pixels Long-Wavelength Infrared (LWIR) Quantum-Dot Infrared Photodetector (QDIP) Imaging Focal Plane Array" *IEEE JOURNAL OF QUANTUM ELECTRONICS*, VOL. 43, NO. 3, MARCH 2007
9. A. B. Weerasekera, M. B. M. Rinzan, S. G. Matsik, A. G. U. Perera, M. Buchanan, H. C. Liu, G. von Winckel, A. Stintz, and S. Krishna "n-type GaAs/AlGaAs Heterostructure detector with a 3.2 threshold frequency" *Optics Letters*, 32 (10), 1335-1337, (2007)
10. S. Mallick, K. Banerjee, S. Ghosh, J. B. Rodriguez, and S. Krishna, "Midwavelength Infrared Avalanche Photodiode Using InAs–GaSb Strain Layer Superlattice", *IEEE Photonics Technology Letters*, Vol. 19, No. 22, November 15(2007)
11. E. Varley, M. Lenz, S. J. Lee, J. S. Brown, D. A. Ramirez, A. Stintz, and S. Krishna, Axel Reisinger and Mani Sundaram, "Single bump, two-color quantum dot camera", *APPLIED PHYSICS LETTERS* 91, 081120(2007)
12. Kartik Srinivasan, Matthew Borselli, Oskar Painter, Andreas Stintz and Sanjay Krishna "Cavity Q, mode volume, and lasing threshold in small diameter AlGaAs microdisks with embedded quantum dots", *Optics Express*, Vol. 14, 1094, Feb 2006
13. Statistical adaptive sensing by detectors with spectrally overlapping bands Ünal Sakoglu, Majeed M. Hayat, J. Scott Tyo, Philip Dowd, Senthil Annamalai, Kalyan T. Posani, and Sanjay Krishna *Appl. Opt.* 45, 7224 (2006)
14. G. von Winckel, E. A. Coutsias and S. Krishna "Spectral element modeling of semiconductor heterostructures" *Mathematical and Computer Modeling*, Volume 43, Issues 5-6, Pages 582-591 (March 2006)
15. K.T. Posani, V. Tripathi, S. Annamalai, N.R. Weisse-Bernstein, S. Krishna, R. Perahia, O. Crisafulli and O.J. Painter, "Nanoscale Quantum-Dot Infrared Sensors with Photonic Crystal Cavity", *Appl. Phys. Lett.* 88, 151104, 2006.
16. Sanjay Krishna, "InAs/InGaAs Quantum Dots in a Well Photodetectors", *Journal of Physics D (Applied Physics)*; 7 July 2005; vol.38, no.13, p.2142-50
17. S.Krishna, D. Forman, S. Annamalai, P. Dowd, P. Varangis, T. Tumolillo, A. Gray, J.Zilko, K. Sun, M. Liu, J. Campbell, D. Carothers "Demonstration of a 320 x 256 Two-Color Focal Plane Array Using InAs/InGaAs Quantum Dots in a Well Detectors" *Appl. Phys. Lett.* 86, 193501, 2005.
18. U. Sakoglu, J. S. Tyo, M. M. Hayat, S. Raghavan, and S. Krishna, " Spectrally adaptive infrared photodetectors using bias-tunable quantum dots" *J. Opt. Soc. Am. B.* Vol 21, p.7, Jan 2004.
19. Kartik Srinivasan, Andreas Stintz, Sanjay Krishna, and Oskar Painter" Photoluminescence measurement of quantum-dot-containing semiconductor microdisk resonators using optical fiber taper waveguides" *Physical Review B* 72, 205318 (2005)
20. G. Balakrishnan, S.H. Huang, A. Khoshakhlagh, P. Hill, A. Amtout, S. Krishna, G.P. Donati, L.R. Dawson and D.L. Huffaker, "Room-temperature optically-pumped InGaSb quantum well lasers monolithically grown on Si(100) substrate", *IEE Electronics Letters*, Vol. 41, No. 9, pg 531, 2005.

21. Kartik Srinivasan, Matthew Borselli, Thomas J. Johnson, Paul E. Barclay, Oskar Painter, Andreas Stintz and Sanjay Krishna "Optical loss and lasing characteristics of high-quality-factor AlGaAs microdisk resonators with embedded quantum dots" *Applied Physics Letters*, v.86, no.15, p.151106, 2005.
22. B. Kochman, A.D. Stiff-Roberts, S. Chakrabarti, J.D. Phillips, S. Krishna, J. Singh and P. Bhattacharya, "Absorption, Carrier Lifetime, and Gain in InAs-GaAs Quantum Dot Infrared Photodetectors", *IEEE. J. Quant. Electron.*, 39, 459, 2003.
23. Matsik, SG; Rinzan, MBM; Esaev, DG; Perera, AGU; von Winckel, G; Stintz, A; Krishna, S; Liu, HC; Byloos, MD; Oogarah, T; Sproule, GI ; Liu, K ; Buchanan, M., "Effect of doped substrate on GaAs-AlGaAs interfacial workfunction IR detector response through cavity effect" *IEEE Transactions on Electron Devices*; v.52, no.3, p.413-418, Mar 2005
24. P. Hill, N. Weisse-Bernstein, L. R. Dawson, P. Dowd, and S. Krishna, "Activation energies for Te and Be in metamorphically grown AlSb and InxAl1-xSb layers", *Appl. Phys. Lett.* 87, 092105 (2005)
25. E. Plis, P. Rotella, S. Raghavan, L. R. Dawson, S. Krishna, D. Le and C. P. Morath, "Growth of room-temperature "arsenic free" infrared photovoltaic detectors on GaSb substrate using metamorphic InAlSb digital alloy buffer layers" *Appl. Phys. Lett.*, 82, 1658, 2003
26. S. Krishna, S. Raghavan, G von Winckel, A. Stintz, , G. Ariyawansa, S.G. Matsik and A.G.U. Perera, "Three-Color (lp1 ~ 3.8 mm, lp2 ~ 8.5 mm and lp3 ~ 23.2 mm) InAs/ InGaAs Quantum Dots In a Well Detector", *Appl. Phys. Lett.*, 83, 2745, October 2003
27. S. Krishna, A. Stiff, P. Bhattacharya, and S. Kennerly " Hot Dot Detectors", *IEEE Circuits and Devices*, p.14, January 2002.
28. S. Raghavan, P. Rotella, A. Stintz, B. Fuchs, S. Krishna, C. Morath, D. A. Cardimona, and S.W. Kennerly, "High-Responsivity, Normal-Incidence Long-Wave Infrared ($\lambda \sim 7.2 \mu\text{m}$) InAs/In_{0.15}Ga_{0.85}As Dots-in-a-Well Detector", *Appl. Phys. Lett.*, 81 (6), 2002
29. S. Krishna, P. Bhattacharya, J. Singh, T. Norris and J. Urayama, P.J. McCann and K. Namjou, "Intersubband Gain and Stimulated Emission in Long Wavelength (l=13 mm) Intersubband Quantum Dot Emitters", *IEEE J. Quant. Electronics*, 37, 1066, 2001
30. K. M. Lewis, Ç. Kurdak, S. Krishna and P. Bhattacharya, "Charge transformer to enhance noise performance of single-electron transistor amplifiers in high-capacitance applications", *Appl. Phys. Lett.*, 80, 142, 2002.
31. J. Sabarinathan, P. Bhattacharya, P-C. Yu, S. Krishna, J. Cheng, D. G. Steel, "An electrically injected InAs/GaAs quantum-dot photonic crystal microcavity light-emitting diode", *Appl. Phys. Lett.*, 81, 3876, , 2002
32. S. Krishna, K. Linder, and P. Bhattacharya, " Photoluminescence linewidth of self-organized In_{0.4}Ga_{0.6}As/GaAs quantum dots grown on InGaAlAs stressor dots", *J. Appl. Phys.*, 86, 4691, 1999.
33. S. Krishna, D. Zhu, J. Xu, K. K. Linder, O. Qasaimeh, P. Bhattacharya and D. L. Huffaker, " Structural and luminescence characteristics of cycled submonolayer InAs/GaAs quantum dots with room temperature emission at 1.3 μm ", *J. Appl. Phys.*, 86, 6135, 1999.

BOOKS AND BOOK CHAPTERS

- S. Krishna and E.Plis, "Physics and Technology of InAs/GaSb Superlattices", John Wiley (in preparation)
- E. Plis, J.B. Rodriguez, S. Krishna "Type II Strain Layer Superlattice Detectors", Elsevier (2011)
- F.Lan, T. Vandervelde, S. Krishna, " Quantum Dot Infrared Photodetectors", CRC Press (2008)
- S.Krishna, "Optoelectronic Properties of Self Assembled InAs/InGaAs Quantum Dots" in III-V Compound Semiconductor Heterojunctions: Physics And Devices, Publisher, Transworld Research, ISBN 81-7736-170-8, Editor: Will Z. Cai, 2003.
- P. Bhattacharya, S. Krishna, A. D. Stiff, " Quantum Dot Infrared Detectors and Sources", *Int. Journal of High Speed Electronics and Systems*, vol. 12, No. 4, pp. 969-994, 2002 (World Scientific Publishing Company)

Issued Patents

1. S. Krishna, M. Hayat, J. S. Tyo, U. Sakoglu and S. Raghavan Detector with tunable spectral response. United States Patent No. 7,217,951 2007
2. S. Krishna, M. Hayat, J.P.R. David, "Intersubband detector with avalanche multiplier region", United States Patent Number 7,271,405 2007.
3. P. Dowd, P. Hill, L.R. Dawson and S. Krishna, "Semiconductor Conductive Layers", US Patent 7, 583, 715 B2, 2009.
4. G.von Winckel, E.A. Coutias and S. Krishna" Spectral Element Eigensolver for Inhomogenous Media", Patent: 7,617,081, 2009
5. S. Krishna and O. J. Painter, "High Performance Hyperspectral Detectors Using Photon Controlling Cavities" US Patent, 7,659,536, Feb 2010.
6. S. Krishna, M.M. Hayat, J.S. Tyo and W.Y. Jang, " The infrared retina", US Patent 8071945 (Issued: Dec 6th, 2011)

Over \$15M in external funded contracts and grants since 2001

SIGNIFICANT RESEARCH ACHIEVEMENTS

- **Demonstration of first Plasmonic Quantum Dot Focal Plane Array:** In collaboration with Prof. Brueck's group at UNM, demonstrated resonant enhancement in a 320x256 focal plane array (Nature Comm, 2011)
- **Design and Development of Quantum Dots in a Well Infrared Detectors:** In Aug 2002, published the first paper on quantum dots in a well detectors, which are now being pursued by at least ten research groups around the world.
- **Demonstration of InAs FETs on Silicon Substrates:** In collaboration with Prof. Ali Javey's group, we demonstrated InAs FETs on silicon substrates with large on-off ratio and small leakage current (Nature, 2010)
- **Demonstration of the first FPA with strain layer superlattice based on nBn Design** In collaboration with QmagiQ LLC, we have demonstrated the first MWIR InAs/GaSb SLS array with a nBn design using a 320x256 focal plane array with a noise equivalent temperature difference of 24mK at 77K
- **Demonstration of the first 640x512 Quantum Dot based Camera:** In collaboration with NASA JPL, we have demonstrated the first quantum dot camera using a 640x512 focal plane array with a noise equivalent temperature difference of 40mK at 60K
- **Demonstration of the first two color Quantum Dot based Camera** In collaboration with QmagiQ LLC, we have demonstrated the first two color (MWIR/LWIR) quantum dot camera using a single bump 320x256 focal plane array.
- **Demonstration of the first long wave infrared Quantum Dot based Camera** In collaboration with BAE systems and a spin-off from UNM, Zia Laser Inc, we have demonstrated the first two long wave infrared (LWIR) QD camera based on a 320x256 focal plane array.
- **Demonstration of three color (MWIR/LWIR/VLWIR) DWELL detector** We have recently demonstrated a 3 color quantum dot in a well detector with response in the MWIR ($\lambda_p \sim 4 \mu\text{m}$), LWIR ($\lambda_p \sim 8 \mu\text{m}$) and VLWIR ($\lambda_p \sim 23 \mu\text{m}$) at 80K. This is the highest reported temperature for any intersubband VLWIR detector.
- **Operating Wavelength Control in DWELL detectors**
By heterostructure engineering of the DWELL structure, we have obtained spectral response tailorable from 7.2 to 10 μm , culminating in a single pixel detector spanning the entire LWIR atmospheric window (8-12 μm).
- **Demonstration of Smart DWELL Sensors**
We have observed quantum confined Stark effect in the DWELL detectors that we have fabricated. The raw data was fed into a projection algorithm developed by Prof. Hayat and Prof. Tyo to realize a "smart" detectors whose center wavelength and spectral width could be independently controlled.
- **Strain patterning of growth front to achieve uniform QDs**
Using a layer of buried InAlAs stressor dots, InAs QDs with very low size fluctuations (PL linewidth = 19 meV at T=17K) and increased areal density ($\sim 2 \times 10^{11} \text{cm}^{-2}$) were grown on a GaAs substrate
- **Demonstration of the first quantum dot laser grown on a Si substrate** Using a thermally cycled buffer layer, we demonstrated the first InGaAs QD laser grown on a silicon substrate. The large lattice and thermal mismatch between GaAs and Si created many dislocations and an optimized buffer layer was designed to filter these dislocations.
- **First demonstration of intersubband emission from QDs**
Demonstration of the first quantum dot intersubband LED and first demonstration of intraband gain and stimulated emission from self organized quantum dots at 13 μm .