

CURRICULUM VITAE

NAME: RITESH AGARWAL

Address: Department of Materials Science and Engineering, University of Pennsylvania
308 LRSM, 3231 Walnut St., Philadelphia PA 19104.

Citizenship: India; US Permanent Resident

EDUCATION

- December 2001, Ph.D. in *Chemistry*, University of California, Berkeley.
Advisor: Prof. Graham R. Fleming. Thesis title: "One- and two-color three-pulse photon echo studies of protein and liquid dynamics"
- 1997, M.S. in *Chemistry*, University of Chicago
- 1996, M.Sc. (5yr Integrated) in *Chemistry*, Indian Institute of Technology, Kanpur

POSITIONS HELD

- Sep 1 2005 – Present, Assistant Professor, Department of Materials Science and Engineering, University of Pennsylvania
- Jan 2002-Aug 2005, Postdoctoral Fellow, Department of Chemistry and Chemical Biology, Harvard University. (Advisor: Prof. Charles M. Lieber)

RESEARCH INTERESTS

Nanoscale phenomena, novel nanowire growth, transformations and assembly, nanoscale photonics and electronics, nanocavity plasmonics, light-matter interaction in nanostructures, organic-inorganic photovoltaics, photosynthesis in plants and bacterial systems.

HONORS/DISTINCTIONS

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| 2010 | NIH Director's New Innovator Award |
| 2007-2012 | NSF CAREER Award |
| 2007 | Phase Change Nanowire Memory work included in Top 5 biggest advance in Nanoscience in 2007 by MIT Technology Review magazine |
| 1996 | Proficiency Medal for Best Overall Performance, Department of Chemistry, Class of 1996, Indian Institute of Technology, Kanpur |
| 1994-95 | Best Academic Performance, Indian Institute of Technology, Kanpur |

TEACHING EXPERIENCE

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| 2010 Fall | Special Topics: Optics of Advanced Materials (MSE 795) |
| 2006/07 Fall | Thermodynamics of Materials (MSE 530) |
| 2006/07/08/09/10 Spring | Introduction to Nanoscale Materials (MSE 215) |
| 2006/07/08/09 | Nanoscale Materials Laboratory (MSE 250) |

DISSERTATIONS/THESES SUPERVISED

Ph.D. STUDENTS

Past

Yeonwoong Jung (Nanowire Phase Change Memory): PhD Awarded May 2009. Currently postdoctoral fellow at Yale University. Recipient of MRS-silver medal award, NBIC-Penn Student Research award, Stein Prize for best PhD Thesis.

Current

Christopher Rodd (Nanowire-Conducting Polymer Hybrid Systems): May 2011
Brian Piccione (Light-Matter Coupling in Nanowire Optical Cavities): May 2012
Carlos Aspetti (Nanowire plasmonics): May 2014
Pavan Nukala (Phase Change Nanowires: insitu microscopy analysis): May 2014
Rahul Agarwal (Chalcogenide nanowires: Phase change and thermoelectrics): May 2015
Joohee Park (Nanowire Optics): May 2015
Siddharth Ghosh (jointly with G. Piazza, ESE, Penn): Nanowire optomechanics: May 2014

MASTER'S STUDENTS

Current

Haofeng Li (Nanowire Photovoltaics), expected May 2011

Past

Dong-Kyon Ko (Growth of Phase Change Nanowires): Dec 2006. Currently PhD. student at Penn Chemistry.
Yu-Han Cheng (Controlled Growth of High-Density Nanowires): May 2007. Currently PhD. student at UCSD.
Tyler Zimmerman (Nanowire Solar Cells): May 2008. Currently at Boeing Corporation.
Chung-Ying Yang (Recrystallization Mechanism in Phase Change Nanowires): May 2009. Currently at Taiwan Semiconductors.
Chien-An Chen (Growth Dominant Recrystallization in Phase Change Nanowires): May 2009

POSTDOCS

Past

Dr. Se-Ho Lee (Phase Change Nanowires); Currently, Senior MTS, Hynix Semiconductor Inc, Korea
Dr. Bin Zhang (Cation Exchange Phenomena in II-VI Nanowires); currently, Assistant Professor of Chemistry, Tianjin University.
Dr. Huacheng Zhang (Nanowire Surface Engineering for Organic/Inorganic Devices)
Dr. Mukut Mitra (Drift in nanowire phase change memory), currently at Applied Materials

Current

Dr. Lambert van Vugt
Dr. Chang-Hee Cho
Dr. Sung-Wook Nam
Dr. Hee-Suk Chung
Dr. Moon Hyung Jang

SERVICE (TO DEPARTMENT/SCHOOL/UNIVERSITY OR RESEARCH COMMUNITY)

DEPARTMENTAL SERVICE

Chair, Materials Science and Engineering, ABET Committee (Spring 2007-present)

MSE Chair Selection Committee: April, 2010

Seminar Series Organizer, Penn Materials Science and Engineering (AY: 2007-08)

Graduate Students Admissions Committee: Spring 2006-present

RESEARCH COMMUNITY SERVICE

Member, Strategic Planning Committee, Materials Research Society, 2010-present

Co-organized a symposium titled “Nanowires: Growth and Device Assembly for Novel Applications” at the Fall MRS meeting in December 2010.

Co-organized a symposium titled “Nanowires: Novel Assembly Concepts and Device Integration” at the Fall MRS meeting in December 2007. Also chaired two sessions.

Session Chair, American Chemical Society Meeting, August 2007, Boston.

SYNERGISTIC ACTIVITIES

Presented lectures to high school students as a part of Penn Summer Science Initiative (PSSI) program on “Nanotechnology” (2006-2010)

Presented a lecture to high school teachers as a part of Penn monthly high school teacher lecture series program on “Nanowire Optics and Devices”

Presented a lecture to REU students as a part of Penn lecture series program on “Nanowire Optics”

Presented a television program on Philadelphia Science Television on “Nanotechnology”, October 2007.

REVIEWED ARTICLES FOR THE FOLLOWING JOURNALS AND AGENCIES

Nature Nanotechnology, Nature Physics, Nano Letters, ACS Nano, Applied Physics A, Journal of Physical Chemistry A, Journal of Physical Chemistry B, Journal of Physical Chemistry C, Journal of Chemical Physics, Advanced Materials, Advanced Functional Materials, Biomacromolecules, Small, IEEE Transactions on Nanotechnology, IEEE Transactions on Electron Devices, Langmuir, J. Amer. Chem. Soc., Nanotechnology, Applied Physics Letters, J. Appl. Phys., Materials Research Bulletin, Optics Express, Inorganic Chemistry, Journal of Materials, Crystal Growth and Design, Chemistry of Materials, Optics Letters, Optics Express.

NSF (ECCS) proposal review panelist, NSF (DMR), NSF (International Research and Education), FONDAPE (Chile) reviewer.

PATENTS

Agarwal R, Mitra M, Jung Y, “System and Method for the Relaxation of Stress in Phase Change Memory Devices”, International patent application, PCT/US2010/050134

C. M. Lieber, X. Duan, Y. Huang, and R. Agarwal, “Nanoscale Coherent Optical Components”, 10/624,135, U.S. patent pending; 10/734,086 U.S. Continuation Patent, Pending of 10/624,135.

D.G. Grier, R. Agarwal, G. Yu, K. Ladavac, and C. M. Lieber, “System and Method for Processing Nanowires with Holographic Optical Tweezers”, U.S. Provisional Patent, awarded 2009.

INVITED TALKS

5/11 Probing Size-dependent Light-matter Interactions and Structural Phase Change Properties with Nanowires”, Department of Materials Science and Engineering, Drexel University.

2/11, “Probing Size-dependent Light-matter Interactions and Structural Phase Change Properties with Nanowires”, Department of Materials Science and Engineering, University of Michigan.

2/11, “Nanowire Transformations and size-dependent properties”, TMS Society Meeting, San Diego, CA

2/11, “Probing Size-dependent Light-matter Interactions and Structural Phase Change Properties with Nanowires”, Department of Chemical Engineering, Stevens Institute of Technology, NJ.

12/10 “Growth and chemical transformation of Nanowires”, Pacific Chem, Honolulu, HI

11/10 “Probing Size-dependent Light-matter Interactions and Structural Phase Change Properties with Nanowires”, Department of Materials Science and Engineering, University of California, Berkeley

11/10 “Growth and Chemical Transformation of Nanowires and their Size-dependent Properties”, Nanowire Growth Workshop, Rome, Italy

10/10 “Probing Size-dependent Light-matter Interactions and Structural Phase Change Properties with Nanowires”, Department of Materials Science and Engineering, University of Pennsylvania, Philadelphia

10/10 “Nanowires: Size-dependent Optical and Structural Phase Change Properties”, Department of Materials science and Engineering, University of Alabama, Tuscaloosa

10/10 “Nanowires: Size-dependent Optical and Structural Phase Change Properties”, Department of Physics and Applied Physics, NYU-Poly, New York

9/10 “Extremely low temporal drift and field-induced nucleation and switching in phase change nanowire memory devices”, E/PCOS 2010, Milan, Italy.

4/10 “Novel Size-Dependent Chemical Reactivity, Light-Matter Interaction and Phase Change Properties of Semiconductor Nanowires”, MRS Spring Meeting, San Francisco

4/10 “Extremely low temporal drift in phase change nanowire memory devices”, MRS Spring Meeting, San Francisco

12/09 “Nanowires: Size-dependent Optical and Structural Phase Change Properties”, Department of Physics, University of Delhi, India

12/09 “Size-Dependent structural and optical properties of nanowires”, ICANN, Guwahati, India

11/09 “Nanowires: Size-dependent Optical and Structural Phase Change Properties”, Department of Materials Science and Engineering, Seoul National University, Seoul, Korea.

11/09 “Phase Change Nanowires”, Hynix Semiconductor Inc, South Korea

11/09 “Phase Change Nanowires”, Korea Institute of Science and Technology, Seoul, Korea

11/09 “Nanowires: Size-dependent Optical and Structural Phase Change Properties”, Department of Chemistry, Drexel University, Philadelphia, PA.

11/09 “Nanowire Phase Change Memory: Fundamental Size Effects”, Tenth Annual Non-Volatile memory Technology Symposium”, Portland, OR.

3/09 Size-Dependent Phenomena in Phase Change nanowires”, Semicon China, Shanghai

3/09 “Nanowires: Size-dependent Optical and Phase Change Properties”, Department of Materials Science and Engineering, University of Illinois at Urbana-Champaign.

11/08 “Nanowire Phase Change Memory: Fundamental Size Effects”, Ninth Annual Non-Volatile memory Technology Symposium”, Pacific Grove, CA.

10/8 “Nanowires; Size-dependent Optical and Phase Change Properties”, Department of Mechanical Engineering, Princeton University.

9/8 “Nanowires: Size-dependent Optical and Phase Change Properties”, Department of Materials Science and Engineering, Cornell University.

9/8 “Fundamental Size-Effects in Phase Change Nanowires, “European Symposium on Phase Change and Ovonic Science”, Prague, Czech Republic.

7/08 “Phase Transitions and Memory Switching in Self-Assembled Nanowires”, Gordon Research Conference (Nanostructure Fabrication), Tilton, NH.

5/08 “Nanowire Optoelectronics and Electronic Memory”, Department of Electrical Engineering and Computer Science, Carnegie Mellon University, Pittsburgh, PA.

11/07 “Nanowire Phase Change Memory”, Physical Sciences Seminar, IBM T. J. Watson Center, Yorktown Heights, NY.

11/07 “Nanowire Optoelectronics and Electronic Memory”, Department of Materials Science and Engineering, Rutgers, Piscataway, NJ.

9/07 “Nanowire Optoelectronics and Electronic Memory”, Joint Engineering Seminar, University of Pittsburgh.

9/07 “Nanowire Optoelectronics and Electronic Memory”, Optics East 2007, Boston.

8/07 “Phase Transitions and Memory Switching in $\text{Ge}_2\text{Sb}_2\text{Te}_5$ Self-assembled Nanowires”, American Chemical Society, Boston.

5/07 “Semiconductor Nanowires”, Department of Physics, University La Sapienza, Rome.

5/07 “Nanowire Optoelectronics and Electronic Memory”, European Materials Research Society, Strasbourg, France.

3/07 “Nanowire Optoelectronics and Electronic Memory”, Department of Materials Science and Engineering, Rensselaer Polytechnic Institute.

1/07 “Nanowire Optics and Photonic Devices”, Penn-Academia Sinica Joint Symposium on Frontiers of Materials Research, Taipei, Taiwan.

12/06 “Nanowire Optics and Optoelectronics”, Department of Chemistry, Indian Institute of Technology, Kanpur, India

12/06 “Nanowire Optics, Optoelectronics and Assembly with Tweezers”, Photonics 2006, Hyderabad, India

5/06 “Nanowire Optoelectronics and Nanowire Assembly with Optical Tweezers”, *IBM*, Yorktown Heights, NY

2/06 “Nanowire Optics and Optoelectronics”, Department of Chemistry, University of Pennsylvania

10/05, “Nanowire Optoelectronic Devices and Nanowire Assembly with Optical Tweezers”, Department of Chemical Engineering, Johns Hopkins University.

1/2005, “Single Nanowire Laser Optics and Optoelectronics”, Department of Materials Science and Engineering, University of Pennsylvania.

1/2005, “Single Nanowire Laser Optics and Optoelectronics”, Department of Materials Science and Engineering, University of California, Berkeley.

1/2005, "Single Nanowire Laser Optics and Optoelectronics", Department of Chemistry, University of New Mexico, Albuquerque.

12/2004, "Single Nanowire Laser Optics and Optoelectronics", Department of Chemistry, University of Pittsburgh.

1/2001, "Photosynthetic Light Harvesting: A three pulse photon echo peak shift study", Department of Chemistry, Indian Institute of Technology, Kanpur, India

CONTRIBUTED PRESENTATIONS

12/10 "Transforming Semiconductor Nanowires Into Heterostructures and Superlattices by Size-dependent Cation Exchange Reactions", MRS, Boston 2010 (talk).

1/08 "Nanowire Phase Change Memory", US-India Nanoscience and Engineering Institute, Chennai, India.

11/07 "Highly-scalable nonvolatile and ultra-low power phase-change nanowire memory", MRS Meeting, Boston (Talk).

11/06, "Chalcogenide Nanowire Devices for Highly Scalable Phase Transition Memory", MRS Meeting, Boston, November 2006 (Poster).

11/06, "Synthesis and Structural Characterization of Single-Crystalline Branched Nanowire Heterostructures", MRS Meeting, Boston, November 2006 (Poster)

6/06 "Nanowire Optoelectronics", Nanomaterials Summer School-2006, Tsukuba, Japan.

4/2005, "Nanowire Avalanche Photodiodes", MRS Meeting (Poster)

3/2005, "Manipulation and assembly of semiconductor nanowires with holographic optical traps", APS Meeting (Talk)

4/2004, "Optical studies of the mechanism of lasing in single cadmium sulfide nanowires", ACS Meeting (Talk)

3/2004, "Nanowire-Based Avalanche Photodiodes", APS Meeting (Talk)

3/2004, "Optical studies of the mechanism of lasing in single cadmium sulfide nanowires", APS Meeting (Talk)

12/2003, "Lasing in Single CdS Nanowires", MRS Meeting (Poster)

6/2002, "Two-Color Three Pulse Photon Echo Peak Shift", Ultrafast Phenomena XIII (Poster)

6/2000, "Disorder in Photosynthetic Light Harvesting Complexes: A Three-Pulse Photon Echo Peak Shift Study", Ultrafast Phenomena XII (Talk)

MEDIA COVERAGE OF RESEARCH

Nanowire cation exchange research was cited in the January 15 issue of *Scientific American* in "The Next 20 Years of Microchips: Pushing Performance Boundaries." <http://www.scientificamerican.com/article.cfm?id=the-next-20-years-of-microchips>

Research cited for "Transforming nanowires into nano-tools using cation exchange reactions," a novel method for creating nanoscale structures. Reported in *over 300 websites and magazines* all across the globe.

Commented in *C&E News* on an article about ternary memory devices (April, 2010).

Commented in MIT Technology Review on "Piezoelectric Fibers" (July 2010).

Nanowire Phase Change Memory, University of Pennsylvania

Featured amongst the top five biggest advance in nanoscience in 2007 by MIT Technology Review

Featured on *Comcast Network Channel* on cable television as a part of *Art Fennel Reports* show, Dec 19th, 2007.

Phase Change Nanowire images displayed at the *New York Museum of Modern Art* as a part of the exhibition "Design and the Elastic Mind", Feb 24-May 12, 2008.

University of Pennsylvania Press Release, "Penn Engineers Design Electronic Computer Memory in Nanoscale Form That Retrieves Data 1,000 Times Faster"

Penn Gazette, "Super Memory", Jan 2008.

Daily Pennsylvanian, "Engineers develop nanoscale memory", Sep 2007.

Philadelphia Metro, "Penn Gains Speed" Sep 2007

The Hindustan Times (One of the most widely circulated newspapers in India, Hindi version)

The Telegraph (Calcutta). "Miraculous Memory", October 29, 2007.

ABC news, "Nanowires for Faster Memory", Sep 2007

MIT Technology Review "Nanowires for Faster Memory", October 2007

Technology Review Germany (in German)

Materials Today, "Nanowires rapidly regain their memory", Nov 2007 issue.

Materials World Magazine "Down to the nanowire", Nov 2007 issue

Also featured on at least 50 science and technology websites including: EurekaAlert, Nanotechweb.org, Physics.org, NASA Tech Briefs, Nanotechwire, CCN Magazine, Science Daily, TG Daily, PhysOrg, Primidi.com, Endaget.com, Nanowerk.com, NSTI.org, TRNMag.com, ITBusinessedge.com., Frost & Sullivan

Assembly of Nanowires with Optical Tweezers, Harvard University.

Cover story in *Photonics Spectra* magazine, Jan 2006.

Featured in Harvard Crimson, Jan 2006.

TRN news roundup, “Holograms Organize Nanowires”, Dec 2005.

Nano Today magazine, Feb 2006, “Assembling Nanowires is a HOT Topic”.

PUBLICATIONS IN REFEREED JOURNALS (* Invited Papers)

- C. Rodd and R. Agarwal, “Controlling the crystallization of P3HT on nanowires by coil-rod phase transitions for efficient photovoltaics”, *in preparation*.
- L. K. Van Vugt, B. Piccione, C.H. Cho, P. Nukala and R. Agarwal, “One-Dimensional Polaritons with Size-Tunable and Enhanced Coupling Strengths in Semiconductor Nanowires”, *PNAS*, doi: 10.1073/pnas.1102212108.
- Y. Jung, S.W. Nam, and R. Agarwal, “High Resolution Transmission Electron Microscopy Study of Electrically-Driven Phase Change Phenomena in Ge₂Sb₂Te₅ Nanowires”, *Nano Letters*, 11, 1364 (2011).
- Y. Jung, R. Agarwal, C.Y. Yang and R. Agarwal*, “Chalcogenide Phase-change Memory Nanotubes for Lower Writing Current Operation”, *Nanotechnology*, **22**, 254012 (2011). invited paper for the nanoscale memory issue.
- L. K. Van Vugt, B. Piccione, C.H. Cho, C. Aspetti, A. Wirshbha and R. Agarwal*, “Variable Temperature Spectroscopy of as-grown and Passivated CdS Nanowire Optical Waveguide Cavities”, *J. Physical. Chemistry*, invited paper for special issue for G. R. Fleming, DOI: 10.1021/jp108167t.
- L. K. Van Vugt, B. Piccione, and R. Agarwal, “Incorporating Polaritonic Effects in Semiconductor Nanowire Waveguide Dispersion”, *Applied Physics Letters*, **97**, 061115 (2010)
- M. Mitra, Y. Jung, and R. Agarwal, “Extremely Low Drift of Resistance and Threshold Voltage in Amorphous Phase Change Nanowire Devices”, *Applied Physics Letters*, **96**, 222111 (2010)
- B. Piccione, L. K. Van Vugt and R. Agarwal, “Propagation Loss Spectroscopy on Single Nanowire Active Waveguides”, *Nano Letters*, **10**, 2251 (2010).
- B. Zhang, Y. Jung, H.-S. Chung, L. K. Van Vugt and R. Agarwal’ “Nanowire Transformation by Size-Dependent Cation Exchange Reactions”, *Nano Letters*, **10**, 149 (2010).
- H.-S. Chung, Y. Jung, S. C. Kim, D. H. Kim, K. H. Oh and R. Agarwal, “Epitaxial Growth and Ordering of GeTe Nanowires on Microcrystals Determined by Surface Energy Minimization”, *Nano Letters*, **9**, 2395 (2009).

- Y. Jung, C.-Y. Yang, S.-H. Lee and R. Agarwal, "Phase-Change Ge-Sb Nanowires: Synthesis, Memory Switching, and Phase-Instability", *Nano Letters*, 9, 2013 (2009).
- L.K. van Vugt, B. Zhang, B. Piccione, A. Spector and R. Agarwal, "Size-Dependent Waveguide Dispersion in Nanowire Optical Cavities: Slowed Light and Dispersionless Guiding", *Nano Letters* (2009). DOI: 10.1021/nl900371r
- N. J. Pinto, K. V. Carrasquillo, C. M. Rodd, and R. Agarwal, "Rectifying Junctions of Tin Oxide and Poly(3-hexylthiophene) Nanofibers Fabricated via Electrospinning", *Applied Physics Letters*, 94, 083504 (2009).
- A.T. Jennings, Y. Jung, J. Engel, and R. Agarwal. "Diameter-Controlled Synthesis of Phase-Change GeTe Nanowires," *J. Phys. Chem. C*, 113, (2009), 6898
- Y. Jung, S.-H. Lee, D.-K. Ko, and R. Agarwal, "Size-dependent Surface-induced Heterogeneous Nucleation Driven Phase-change in Ge₂Sb₂Te₅ Nanowires", *Nano Letters*, 8, 3303 (2008).
- O. Hayden, R. Agarwal*, and W. Lu, "Semiconductor Nanowire Devices - Bottom Up Meets Top Down", *Nano Today*, 3, 12 (2008).
- Y. Jung, S.-H. Lee, A. T. Jennings, and R. Agarwal, "Core-Shell Heterostructured Phase Change Nanowire Multi-state Memory", *Nano Letters*, 8, 2056 (2008)
- S.-H. Lee, Y. Jung and R. Agarwal, "Highly-scalable Nonvolatile and Ultra-low Power Phase-change Nanowire Memory", *Nature Nanotechnology*, 2, 626 (2007).
- S.-H. Lee, Y. Jung, A. T. Jennings and R. Agarwal*, "Comparative Study of Memory Switching Phenomena in Phase Change GeTe and Ge₂Sb₂Te₅ Nanowire Devices", *Physica E*, 40, 2474 (2008).
- R. Agarwal*, "Hetero-interfaces in Semiconductor Nanowires", *Small* 4, 1872 (2008).
- H.-S. Chung, Y. Jung, S.-H. Lee, T. J. Zimmerman, J. W. Kim, S. H. Lee, S. C. Kim, K. H. Oh and R. Agarwal, "A Generic Approach for Catalyst-supported Vertically-aligned Nanowire Growth", *Nano Letters*, 8, 1328 (2008).
- Y. Jung, D-K Ko, and R. Agarwal, "Synthesis and Structural Characterization of Branched Nanowire Heterostructures," *Nano Letters*. 7, 264 -268, 2007.
- Y. Jung, S.-H. Lee, D.-K. Ko, and R. Agarwal, "Synthesis and Characterization of Ge₂Sb₂Te₅ Nanowires with Memory Switching Effect", *J. American Chemical Society*, 128, 14026, (2006).
- S.-H. Lee, D.-K. Ko, Y. Jung and R. Agarwal, "Size-Dependent Phase Transition Memory Switching Behavior and Low Writing Currents in GeTe Nanowires", *Applied Physics Letters*, 89, 223116, (2006).
- R. Agarwal*, and C. M. Lieber, "Semiconductor Nanowires: Optics and Optoelectronics", *Applied Physics. A: Mater. Sci. Proc.* 85, 209-215 (2006).

- R. Agarwal, K. Ladavac, Y. Roichman, G. Yu, C. M. Lieber & D. G. Grier, "Assembling Semiconductor Nanowire Heterostructures with Holographic Optical Traps," *Optics Express* **13**, 8906-8912 (2005).
- O. Hayden, R. Agarwal and C. M. Lieber, "Nanowire based Avalanche Photodiodes," *Nature Materials*, **5**, 352 (2006). (cover article)
- R. Agarwal, C. J. Barrelet and C. M. Lieber, "Lasing Mechanism in Single Cadmium Sulfide Nanowire Optical Cavities," *Nano Letters* **5**, 917-920 (2005).
- X. Duan, Y. Huang, R. Agarwal, and C.M. Lieber, "Single-Nanowire Electrically Driven Lasers," *Nature* **421**, 241 (2003).
- G. R. Fleming, M. Yang, R. Agarwal, B. S. Prall, L. J. Kaufman and F. Neuwahl, "Two-Dimensional Electronic Spectroscopy," invited paper *Bull. Kor. Chem. Soc.*, **24**, 1081 (2003).
- K. Kwak, M. Cho, G. R. Fleming, R. Agarwal, and B. S. Prall, "Two-Color Transient Grating Spectroscopy of a Two-level System," invited paper, *Bull. Kor. Chem Soc.* **24**, 1069 (2003).
- R. Agarwal, A. H. Rizvi, B. S. Prall, J. D. Olsen, C. N. Hunter, and G. R. Fleming, "The Nature of Disorder and Inter-complex Energy Transfer in LH2 at Room Temperature: A Three Pulse Photon Echo Peak Shift Study," *J. Physica. Chemistry A*, **106**, 7573 (2002).
- R. Agarwal, B. S. Prall, A. H. Rizvi, G. R. Fleming, "Two Color Three Pulse Photon Echo Peak Shift Spectroscopy," *J. Chemical Physics*, **116**, 6243 (2002).
- M. Yang, R. Agarwal, G. R. Fleming, "Mechanism of Photosynthetic Energy Transfer in Purple Bacteria," invited paper for Lord Porter issue, *J. of Photochem. and Photobio.*, Part A, **142**, 107 (2001).
- R. Agarwal, M. Yang, Q.-H. Xu, and G. R. Fleming, "Three-Pulse Photon Echo Peak Shift Study of the B800 band of the LH2 complex of *Rps. acidophila* at room temperature: A Coupled Master Equation and Non-linear Optical Response Function Approach," *J. Physical. Chemistry B*, **105**, 1887 (2001).
- R. Agarwal, B. P. Krueger, G. D. Scholes, M. Yang, J. Yom, L. Mets, and G. R. Fleming, "Ultrafast Energy Transfer in LHC-II Revealed by Three-Pulse Photon Echo Peak Shift Measurements," *J. Physical. Chemistry B*, **104**, 2908 (2000).
- M.-L. Groot, J.-Y. Yu, R. Agarwal, J. R. Norris, and G. R. Fleming, "Three-Pulse Photon Echo Measurements on the Accessory Pigments in the Reaction Center of *Rhodobacter sphaeroides*," *J. Physical. Chemistry B*, **102**, 5923 (1998).

REFEREED CONFERENCE PROCEEDINGS

- "Two-Color Three Pulse Photon Echo Peak Shift, " R. Agarwal, B. S. Prall, A. H. Rizvi, M. Yang, and G.R. Fleming, *Ultrafast Phenomena XIII*, Eds. R. D. Miller, M. M. Murnane, N. F. Scherer and A. M. Weiner, (Springer, Berlin), 532 (2003).
- "Disorder in Photosynthetic Light Harvesting Complexes: A Three-Pulse Photon Echo Peak Shift Study," R. Agarwal, M. Yang, and G. R. Fleming, *Ultrafast Phenomena XII*, Eds. T. Elsaesser, S. Mukamel, M. M. Murnane and N. F. Scherer (Springer, New York), 653 (2000).