



## V V Raghavendra Sai, Ph.D.

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### Education

**Ph.D.** Indian Institute of Technology, Bombay, India 07/2003-12/2008

*Thesis Title:* Design and Development of Label-Free Optical Biosensors

- Two novel, cost effective and field deployable sensing schemes for detection of bacteria and proteins have been demonstrated.

**Bachelor of Engg.** Andhra University, Visakhapatnam, India 1998-2002  
(Electronics & Instrumentation)

### Professional Work Experience

**Assistant Professor,** IIT Madras, India 08/2011 – Present

**Post Doctoral Fellow,** University of Idaho, Moscow, ID 03/2009 – 02/ 2011

Working on development of surface enhanced Raman scattering (SERS) based DNA biosensor, receptor mediated detection of explosives and applications of nanomaterials for development of drug delivery systems for anti-sense and anti-gene oligonucleotide based therapeutics.

**Research Associate,** IIT Bombay, Mumbai, India Jan 2009

Continued a part of my Ph.D. work i.e. the development of sensing modalities for field deployable biosensors. Improvements to the existing sensor probes were proposed. Some of the proposed sensor designs have been demonstrated successfully.

**Lecturer,** GVP College of Engg, Visakhapatnam, India, 08/2002 – 06/2003

Responsibilities consisted of teaching courses and running lab sessions.

## Research interests

- Clinical diagnostics and therapeutics using nanomaterials and nano-devices
- Sensors for environmental monitoring, detection of toxins & explosives
- Fiber optic sensors, nanotechnology, noble metal nanoparticles
- Localized surface plasmon resonance (LSPR) and Surface enhanced Raman Scattering (SERS)

## Research Experience

### Surface enhanced Raman scattering (SERS) based sensors

- Design of highly sensitive SERS substrates using noble metal nanoparticles coated silica nanosprings that have very high surface-to-volume ratio.
- Investigation of different sizes of gold and silver nanoparticles to achieve highest possible Raman enhancement. Enhancement factor approaching a theoretical maximum, up to  $10^{10}$ , was obtained.

### Drug delivery using gold nanostructures

- Investigation of Gold nanoparticles and nanorods as carriers for a variety of chemically modified oligonucleotides in the cellular medium
- Synthesis and characterization of nanoconjugates as a part of research on drug delivery using nanomaterials

### Explosive detection

- Functionalization of gold nanoparticles coated nanospring with specific receptors for detection of explosive molecules in gas phase using conduction based measurements

### Optical waveguide (fiber optic) based chemical and biosensors

- Development of evanescent wave absorbance based fiber optic biosensors exploiting absorbance properties of proteins and bacteria at 280 nm wavelength
- Demonstration of suitability of U-bend probes for very large target analytes such as *E.coli* and other bacteria (>100 nm size) using the above-mentioned technique
- Development of localized surface plasmon resonance (LSPR) based biosensor using gold nanoparticle bound fiber optic probes with ability to detect less than 35  $\mu$ RIU (refractive index units)

### Surface modification techniques to introduce organic functional groups

- Aminosilanization on SiO<sub>2</sub>, silica core optical fiber, SU-8 and use of crosslinkers
- Self-assembled monolayers (SAMs) of thiols on gold or AuNP coated substrates
- Surface functionalization of *Polyaniline* and SU-8 for biosensor applications
- Improvement in *hydrophilicity* of gold and PDMS microchannels for microfluidics

## **Immobilization of gold nanoparticles and proteins**

- Thin films of gold nanoparticles on aminosilanized silica nanostructures, glass and fiber substrates
- Antibody immobilization on glass and other similar surfaces by means of silanization, CM-Dextran method and through biotin-avidin complex

## **Characterization tools**

- Hands-on experience in *fluorescence and optical microscopy*, scanning electron microscopy (**SEM**) and dynamic light scattering (**DLS**)
- Surface characterization tools for organic functional group analysis such as X-ray photoelectron spectroscopy (**XPS**), **FTIR** spectroscopy in grazing angle and ATR modes and **contact angle meter**
- Spectroscopic techniques such as **UV-Vis** and **fluorescence spectroscopy** and quartz crystal microbalance (**QCM**) mass sensitive technique
- Knowledge in other *nanocharacterization tools* such as **TEM** and **AFM**

## **List of funded research projects participated**

- I. **Development of SERS based substrates for toxin detection (Rs. 163.55 L) 2013-15**  
Role: Co-PI with Prof. Subrahmanyam (PI), Funded by: DRDE, Gwalior, India
  
- II. **Plasmonic Biosensors for Clinical Diagnosis (Rs. 15.0 L) 2011-14**  
Role: PI, Funded by: IIT Madras, India
  
- III. **Biological Applications of Nanotechnology (BANTech) 2009-10**  
Role: PDF, Funded by: University of Idaho, Moscow, USA
  
- IV. **Functionalized Nanospring-mats for detection of Explosive Materials 2009-11**  
Role: Co-Investigator, Funded by: Department of Defense, USA
  
- V. **Optoelectronic biosensors for waterborne pathogenic bacteria 2004-09**  
Role: Graduate student, Funded by: Naval Material Research Lab, Ambernath
  
- VI. **Center for excellence in Nanoelectronics 2006-08**  
Role: Graduate student, Funded by: Ministry of IT & communications, Govt. of India
  
- VII. **Polymeric waveguide based biosensors 2006-08**  
Role: Graduate student, Funded by: Dept. of Biotechnology, Govt. of India
  
- VIII. **Microcantilever based biosensor for cardiac markers (i-sens) 2004-05**  
Role: Graduate student, Funded by: Dept. of Science & Technology, Govt. of India

## **Teaching & Guidance**

### **Courses Taught:**

Jan-May 2012	AM1100 Engineering Mechanics (85 Students)
Jul-Nov 2012	AM3010 Introduction to Biomechanics (37 students)
Jan-May 2013	AM5140 Biomedical Instrumentation (19 students)
	AM3020 Fundamentals of Medical Instrumentation (62 students)
Jul-Nov 2013	AM3010 Introduction to Biomechanics (35 students)
Jan-May 2014	AM5140 Biomedical Instrumentation (25 students)
	AM3020 Fundamentals of Medical Instrumentation (36 students)
Jul-Nov 2014	AM3010 Introduction to Biomechanics (20 students)
Jan-May 2015	AM1100 Engineering Mechanics (85 students)
Jul-Sept 2015	Medical Electronics (proposed)

### **Current Students:**

Aashresha (M.Tech., Jun 2015)  
Thrilok N (M.Tech., Jun 2015)  
Ravikiran Reddy N (Dual Degree, Jun 2014)  
Ali Javed Dual Degree, Jun2014)  
Priyanka V (M.S., Jul 2013)  
Gowri A (Ph.D., Jan 2013)  
Christina Christopher (Ph.D., Jul 2013)  
Ramakrishna B (Ph.D., Dec 2011)

### **Past Students:**

Gayathri Subramanian (Summer Intern 2015)  
Sanjuna S (Winter Intern, 2014)  
Manojit Roy (M.Tech., 2014)  
Aswini S (Summer Interns, 2013)  
Kavita Pujari (Dual Degree, 2013)

Saicharan Mahendrakar (Dual Degree , 2013)

Mathews John (Summer Intern, 2012)

Ramya Ramesh (Summer Intern, 2012)

### **Invited Talks & Seminars**

*Some Real World Problems and Solutions: A Research and Development Perspective*, National Conference on Signal Processing and Communication Engineering (NCSPCE 2015), Sri Venkateswara College of Engineering, Sriperumbudur, April 10-11, 2015

*Fiber optic probes for biosensing and cancer research* in 2nd Workshop On Ultrafast Photonic Processes And Interactions Dublin City University, Glasnevin, Dublin 9, Ireland 28<sup>th</sup> – 29<sup>th</sup> Jan. 2015. (via video conference)

*Biomedical Applications of Nanomaterials* – Invited Talk, National Seminar on Futuristic Trends of Nanocomposites and their Fabrication, RVR & JC college of Engg., Guntur, Sept 2013.

*Mass-sensitive and Spectroscopic Optical Techniques for Biomolecular Sensing* – Invited Talk, Workshop on QCM and SAW Sensors, Jadavpur University, Kolkata, May 2013.

*LSPR and SERS based Biosensors* – Invited Talk, Indo-US International Workshop on Nanosensor Science & Technology 2013, NIST, Behrampur, Odisha, Mar 2013.

*Biosensors* – Invited Lecture, Bio-Instrumentation'13, A value-addition course: concept to prototype, BMS college of Engg, Bangalore, Feb 2013.

*Surface Enhanced Raman Scattering (SERS): Materials & Substrates* – Seminar, Raman Research Institute, Bangalore, Jan 2013.

*Biomedical Sensors* – Invited Lecture, AICTE-QIP Short Term Training Program on Biomedical Systems, Signals & Images, IIT Madras, Nov 2011.

### **Before 2011**

- *Functionalization of nanomaterials* - a part of CHEM/AVS/MMBB/PHYS 414/514, Application of Nanomaterials in Biomolecular Engineering, Spring 2010, the Univ. of Idaho, Moscow
- *X-ray imaging* as a part of BM632, Medical Instrumentation in 2006-07 at IIT Bombay
- Computer Technology, Programming and Numerical Methods – A 1<sup>st</sup> year B.Tech course, 2002-03 at GVP College of Engg., A.P., India
- Laboratory courses
  - BM659 Elements of Circuits and Instrumentation
  - BM600 Introduction to Biomedical Engineering during 2004-06 at IIT Bombay
  - Basic electronics lab course for 1st year B.Tech course, 2002-03 at GVP College of Engg., A.P., India

- Students trained
  - Deep Pokharel, undergraduate, Univ. of Idaho
  - Mason Fredrickson, undergraduate, Univ. of Idaho
  - Reshma Bharadwaj, project staff, IIT Bombay
  - Jitendra Satija, graduate, IIT Bombay
  - Kamini Thakare, project staff, IIT Bombay
  - Deepu A, project staff, IIT Bombay

## **Patents**

**V. V. R. Sai**, T. Kundu and S.Mukherji, “Optical fiber probe,” US Provisional **Patent** Application 12/708,953, filed 19/02/2010.

## Publications

- Fouetio Kengne, Blaise-Alexis, Karmakar, S., Corti G., V V R Sai; Ishwar N., Larin, A., Hall J., Sowell D., Hrdlicka P., Dobrokhotov, V., McIlroy, D., “Self-Assembled Monolayers of Thiols Adsorbed on Au/ZnO-Functionalized Silica Nanosprings: Photoelectron Spectroscopy-Analysis and Detection of Vaporized Explosives” *ACS Appl Mater Interfaces*, 2014, 6(16):13355-66. doi: 10.1021/am504371k
- Satija J., Punjabi N. S., **Sai V.V.R.**, Mukherji S., “Optimal Design for U-bent Fiber-Optic LSPR Sensor Probes,” *Plasmonics*, 2014, 9, 251-260.
- Satija J., Sai V. V. R. and Mukherji S., Dendrimers in biosensors: Concept and applications – Review, *J. Mater. Chem.*, 2011, 21, 14367-14386. doi:10.1039/C1JM10527B.
- Bharadwaj R., **Sai V.V.R.**, Thakare K., Dhavangale A., Verma P.K., Titus S., Kundu T. and Mukherji S., “Evanescent wave absorbance based fiber optic biosensor for label-free detection of E.coli at 280 nm wavelength,” *Biosensors and Bioelectronics*, 2011, 26, 3367-3370. doi:10.1016/j.bios.2010.12.014. (Note: This manuscript is expanded based on a proof-of-concept described in my Ph.D. thesis.)
- Sai V.V.R.**, Gangadean D., Niraula I.B., Jabal J.M.F., Corti G., McIlroy D.N., Aston D.E., Branen J.R., Hrdlicka P.J., “Silica nanosprings coated with noble metal nanoparticles – highly active SERS substrates,” *J. Physical Chemistry C*, 2011, 115, 453–459. doi:10.1021/jp109586f
- Kundu T., **Sai V.V.R.**, Dutta R., Titus S., Kumar P., Mukherji S., “Development of evanescent wave absorbance-based fiber-optic biosensor,” *Pramana- J. Phys.*, 2010, 75 (6), 1099–1113.
- Satija J., Bharadwaj R., **Sai V.V.R.**, Mukherji S., “Emerging use of nanostructure films containing capped gold nanoparticles in biosensors,” *Nanotechnology, Science and Applications*, 2010, 3, 171-188. doi:10.2147/NSA.S8981
- Sai V.V.R.**, Kundu T. Chitra Deshmukh, Susan Titus, Pradeep Kumar, and Mukherji S., “Label-free fiber optic biosensors based on evanescent absorbance at 280 nm” *Sensors & Actuators B: Chemical*, 2010, 143, 724–730. doi:10.1016/j.snb.2009.10.021
- Sai V.V.R.**, Kundu T. and Mukherji S., “Novel U-bent fiber optic probe for Localized surface plasmon resonance based biosensor” *Biosensors and Bioelectronics*, 2009, 24, 2804–09. doi:10.1016/j.bios.2009.02.007
- Deepu A., **Sai V.V.R.**, Mukherji S., “Simple surface modification techniques for immobilization of biomolecules on SU-8,” *Journal of Materials Science: Materials in Medicine*, 2009, 20, Supp 1, 25-28. doi:10.1007/s10856-008-3471-9
- Sai, V.V.R.**, Mahajan, S., Contractor, A. Q., Mukherji, S., “Immobilization of antibodies on polyaniline films and its application on a piezoelectric immunosensor,” *Analytical Chemistry*, 2006, 78(24), 8368-73. doi:10.1021/ac060120a

### International conference presentations:

- B. Ramakrishna and V.V.R. Sai, "PEG protected bioactive plasmonic nanoparticle for reduction of non specific binding in optical fiber based sandwich immuno assay," 4th International Conference on Bio-Sensing Technology 2015 10-13 May 2015, Lisbon, Portugal
- B Ramakrishna and V V R Sai, "LSPR based U-bent fiber optic biosensor using gold nanoparticle as labels," International Conference on MEMS and Sensors (ICMEMSS) 2014, 18-20 Dec 2014, IIT Kharagpur.
- B. Ramakrishna and V V R Sai, "Plasmonic Sandwich Immunoassay on Fiber Optic Sensor: Sensitivity Enhancement using Refractive Index Media," 12<sup>th</sup> International Conference on Fiber Optics and Photonics, 13-16 Dec 2014, IIT Madras, Chennai.
- A. Gowri and V V R Sai, Surface Functionalisation of Plastic Optical Fiber for Biosensing, International workshop on Coatings & Surfaces for Biomedical Engineering (IWCSB) 2014, 16-19 Feb 2014, IIT Madras, Chennai.
- Papasani M.R., Pokharel D., Giri A., **Sai V.V.R.**, Hrdlicka P.J., Hill R.A., "Transformation of gold nanoparticles into effective gene silencing vectors by oligoethylene glycol passivation," Nanotech Conference and Expo, Anaheim, CA, USA, 21-24 Jun, 2010.
- Cheguru P., Østergaard M., Papasani M.R., **Sai V.V.R.**, Wengel J., Hrdlicka P.J., Hill R.A., "Novel Nanoprobes to Detect mRNA in situ Directed Against Mouse Pyruvate Dehydrogenase," Nanotech Conference and Expo, Anaheim, CA, USA, 21-24 Jun, 2010.
- Jitendra Satija, **V.V.R. Sai** and Soumyo Mukherji "Effect of Gold Nanoparticle Coverage on U Bent Fiber Optic Sensors," ISSS-MEMS conference, Kolkata, Oct, 2009.
- V.V.R. Sai**, Kamini Thakare, Reshma Bharadwaj, Tapanendu Kundu, Soumyo Mukherji, "Development of a Label-free Fiber Optic Biosensor based on Evanescent Wave Absorbance at 280nm for detection of proteins and bacteria," ISSS-MEMS conference, Kolkata, Oct, 2009.
- Sai V. V. R.**, Kamini Thakare, Chitra Deshmukh, Tapanendu Kundu, Susan Titus, Pradeep Kumar and Soumyo Mukherji, "Evanescent wave absorbance based U-bent fiber optic biosensor for pathogen detection" The 8th Workshop on Biosensors and Bioanalytical  $\mu$ -Techniques in Environmental and Clinical Analysis, Montreal, Canada, 14-17 Jun 2009.
- Sai V.V.R.**, Kundu T. and Mukherji S., "Evanescent absorbance based fiber optic biosensor: Optimization of fiber parameters" International conference on Nanotechnology and Healthcare Applications (*NateHCA-07*), Mumbai, India, Oct 2007.
- Bharadwaj R., **Vemulakonda S.**, Kundu T., Mukherji S., "A SPR Based Refractive Index Sensor Based on a Linear CMOS Detector" The 8th Workshop on Biosensors and Bioanalytical  $\mu$ -Techniques in Environmental and Clinical Analysis, Goa, India, 3–6 Oct, 2007.
- Venkataraman A., Mujawar L., Ruparelia J., **Sai V.V.R.**, Contractor A.Q., Mukherji S. and Mukherji S., "A Polyaniline/Polystyrene sulfonate/Glutaraldehyde based sensor for detection of *E. coli* in water", The 8th Workshop on Biosensors and Bioanalytical  $\mu$ -Techniques in Environmental and Clinical Analysis, Goa, India, 3–6 Oct, 2007.



Gulia J., **Sai V.V.R.** and Mukherji S., “Development of a protocol for direct method of quantification of active binding sites on an immunobiosensor” *nanoTX USA '07* International Nanotechnology Conference & Trade Expo, Dallas, Texas, USA, 2-4 Oct, 2007.

**Sai V.V.R.** and Mukherji S., “Immobilization and regeneration studies on optical fiber surfaces” International workshop on Biosensors (*IWB 2006*), BITS-Pilani, Goa, India, Feb 2006 (2nd best poster).

**National Conference presentations:**

Kavita Pujari, B Ramakrishna, V V R Sai, Fiber optic immunosensor using gold nanoparticles labels, Indian National Conference on Applied Mechanics (INCAM) 2013, 4-6 July 2013