

**Sudip Nag Ph.D.**

Senior Member, IEEE

Assistant Professor, Indian Institute of Technology (IIT) Kharagpur

Associate Editor, IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology

Member of Working Group, IEEE P2731, Standard for a Unified Terminology for Brain-Computer Interfaces

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Website: <http://www.iitkgp.ac.in/departement/EC/faculty/ec-sudipnag1#resp-tab1>**1.1. OBJECTIVES**

Deliver positive impacts through scientific research, academic teaching, and societal service. Develop futuristic energy-autonomous internet-of-thing (IoT) systems for maintenance-free remote deployment and innovative battery-free medical implants for disabled subjects. Generate and apply multi-disciplinary knowledge for the benefit of billions.

**1.2 RESEARCH INTERESTS**

Intelligent medical systems and smart environment sensors and actuators:

- Intelligent and energy-autonomous systems for air and water quality monitoring and protection (*environment-IoTs*)
- Implantable medical devices with wireless power-data transfer
- Point-of-care remote diagnostic IoT systems (*E-health* and *E-doctor*)
- Remote telemedicine for elderly
- Biocompatible-ergonomic packaging, and reliability studies
- Animal and human trials

**1.3 EDUCATION**

- Aug. 2006-May 2014 Doctor of Philosophy (Ph.D.), Electrical Engineering, Indian Institute of Technology Bombay (IITB), India [in collaboration with the Johns Hopkins University (JHU), USA]
  - Best Ph.D. Thesis Award, IITB, 2014]
- Aug. 2001-Jul. 2004 Bachelor of Engineering (B.E.), Industrial Electronics, Nagpur University, India
  - 1<sup>st</sup> rank with distinction, Nagpur University, 2004

**1.4. PROFESSIONAL POSITIONS**

- Jul. 2015-present Assistant Professor (Grade-I, Grade-II, and Tenure-Track), Indian Institute of Technology Kharagpur (IITKGP), India  
Department of Electronics and Electrical Communication Engineering (E&ECE)
- Aug. 2020-present Associate Editor, IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology
- May 2020-present Member of Working Group, IEEE P2731, Standard for a Unified Terminology for Brain-Computer Interfaces
- Jan. 2019-present Chair, IEEE Engineering in Medicine and Biology Society (EMBS), Kharagpur Section
- May 2019-July 2019 Visiting Assistant Professor, Case Western Reserve University (CWRU), USA
- May 2018-Jul. 2018 Visiting Researcher/ Faculty, University of Alberta, Canada
- Jul. 2015-Dec. 2018 Visiting Senior Research Fellow, National University of Singapore (NUS), Singapore N.1 Institute [formerly, Singapore Institute for Neurotechnology (SINAPSE)]
- Dec. 2017-Jan. 2018 Visiting Scientist, CWRU, USA
- May 2014-Jun. 2015 Post-Doctoral Research Fellow, NUS, Singapore N.1 Institute [formerly SINAPSE]
- May 2012-Apr. 2014 Research Assistant, NUS, Singapore N.1 Institute [formerly SINAPSE]
- Aug. 2011-Feb. 2012 Visiting Graduate Student, Johns Hopkins University (JHU) School of Medicine, USA  
Department of Biomedical Engineering
- May 2004-Jul. 2006 Research Assistant, Indian Institute of Technology Bombay, India  
Department of Electrical Engineering

**1.5. AWARDS/ RECOGNITIONS**

- 2016-2021 Excellent Teaching Feedbacks (multiple theory and laboratory courses), IITKGP, India
- 2019 Senior Member, IEEE, USA
- 2018 Shastri Indo-Canadian International Faculty Fellowship, Alberta, Canada
- 2014 Award for Excellence in Ph.D. Thesis Work (Best Thesis Award), IITB, Mumbai, India
- 2011 Best Student Paper Award, IEEE Global Interposer Technology Workshop (GIT 2011), Atlanta, USA
- 2008 Budding Innovators Award 2008, Government of India (NRDC/DST), New Delhi, India
- 2007 TCS Graduate Student Fellowship, Tata Consultancy Services, Bangalore, India
- 2006 IEEE ISSS-MDBS Student Award, IEEE and Harvard-MIT HST, Cambridge, USA

- 2004 Academic Excellence Award for Rank 1 in University (Nagpur University), India

## 1.6. TEACHING EXPERIENCE

(at IIT Kharagpur)

- Theory courses Microcontrollers and Embedded Systems, VLSI Engineering, Introduction to Electronics, and Basic Electronics
- Laboratory courses VLSI Engineering, Introduction to Electronics, Basic Electronics

## 1.7. RESEARCH EXPERIENCE

- Publications Peer reviewed Journal Papers (up to *impact factor* 8.249): #18; Conference Papers: #26; Book chapters: #04; Patent Applications: #04
- Students' Supervision/ Co-supervision Doctoral: #06; Masters: #16; Bachelors: #18; includes ongoing and/ or completed
- Fund Attraction
  - Aug. 2016-Jul. 2021 Principal investigator; INR 1.00 crore (CA \$ 165,893); Bioelectronics Innovation Laboratory
  - Aug. 2016-Aug. 2021 Principal investigator; INR 28 lakhs (CA \$ 46,450); Electrical stimulator for motor prosthesis
  - Aug. 2018-Jul. 2021 Principal investigator; INR 25 lakhs (CA \$ 41,473); Non-resonant capacitive power and data transfer scheme for bioelectronic implants
  - Apr. 2016-Mar. 2017 Principal investigator; INR 1.5 lakhs (CA \$ 2,488); Bioinstrumentation circuits facility
  - Jan. 2019-Dec. 2023 Co- Principal Investigator: Rs. 9.00 crores (CA \$ 1,493,032); Common research and technology development hub: Affordable health
  - Jun. 2018-May 2023 Co- Principal Investigator: Rs. 1.46 crores (CA \$ 242,799); Air quality monitoring (AQM) prototype
  - Mar. 2017-Feb. 2020 Co Principal Investigator, INR 3.16 crore (CA \$ 525,428); Development of smartphone integrated generic microfluidic devices for rapid, portable and affordable point of care diagnostics

## 1.8. ADMINISTRATIVE SERVICE

- 2018 Special Session Chairman, Topic: Implantable systems for neural interfaces; IEEE BioCAS 2018 conference, USA
- 2016-present Director or Faculty In-Charge (IITKGP): Bioelectronics Innovation Laboratory (founder), Electronic Hobby Hub, and SMDP-DOE Laboratory  
Coordinator (IITKGP): E&ECE Undergraduate Society
- 2007-2008 Welfare Coordinator and General Secretary (IITB), Tansa House Hostel
- 2008 Organizing Committee (IITB), INUP Workshop
- 2007 Organizing Committee (IITB), IEEE IEDST Conference
- 2003-2004 Branch Vice-Chairman (Nagpur University): IEEE Students Branch

## 1.9. PEER REVIEW SERVICE (JOURNALS)

- IEEE Transactions on Biomedical Circuits and Systems, Transactions on Neural Systems and Rehabilitation Engineering, Transactions on Circuits and Systems-II, Transactions on Instrumentation and Measurement, Sensors Journal
- Elsevier Sensing and Bio-Sensing Research
- Springer Medical and Biological Engineering & Computing

## 1.10. LIST OF PUBLICATIONS

### 1.10.1. Journals (Peer Reviewed):

- [19] S. Acharyya, **S. Nag**, S. Kimbature, A. Ghose, A. Pal, and P.K. Guha, "Selective Discrimination of VOCs Applying Gas Sensing Kinetic Analysis over a Metal Oxide-Based Chemiresistive Gas Sensor," accepted for publication, *ACS Sensors*, 2021.
- [18] A. Banerjee, T. K. Bhattacharyya, and **S. Nag**, "High Efficiency CMOS Active Rectifier with Adaptive Delay Compensation," Elsevier *Microelectronics Journal* (accepted for publication).
- [17] S. Acharyya, **S. Nag**, and P. K. Guha, "Selective Detection of VOCs With WO<sub>3</sub> Nanoplates-Based Single Chemiresistive Sensor Device Using Machine Learning Algorithms", *IEEE Sensors Journal*, vol. 21, no. 5, pp. 5771–5778, 2021.
- [16] T Bhowmick, **S. Nag**, SB Majumder, "Understanding the ethanol and acetone sensing behaviour of CuO thin films through elements of gas diffusion theory," Elsevier *Materials Chemistry and Physics*, vol. 262, no. 124286, pp.1-12, April 2021.
- [15] S. Acharyya, B. Jana, **S. Nag**, G. Saha, and P.K. Guha, "Single resistive sensor for selective detection of multiple VOCs employing SnO<sub>2</sub> hollowspheres and machine learning algorithm: A proof of concept," Elsevier *Sensors and Actuators B: Chemical*, vol. 321, no. 128484, pp. 1-11, Jun. 2020.

- [14] **S. Nag**, A. Koruprolu, S. M. Saikh, R. Erfani and P. Mohseni, "Auto-Resonant Tuning for Capacitive Power and Data Telemetry Using Flexible Patches," *IEEE TCAS-II Express Briefs*, vol. 67, no. 10, pp. 1804-1808, Oct. 2020.
- [13] R. Erfani, F. Marefat, **S. Nag** and P. Mohseni, "A 1–10MHz Frequency-Aware CMOS Active Rectifier with Dual-Loop Adaptive Delay Compensation and >230mW Output Power for Capacitively Powered Biomedical Implants," accepted for publication, *IEEE Journal of Solid State Circuits*, 2019.
- [12] R. Veerubhotla, D. Das and **S. Nag**, "Internet of Things Temperature Sensor Powered by Bacterial Fuel Cells on Paper," Elsevier, *Journal of Power Sources*, vol. 438, no. 226947, pp. 1-9, Oct. 2019. [Also, refer to the corrigendum {J. Power Sources 438 (2019) 226947}]
- [11] **S. Nag** and N. V. Thakor, "Implantable Neurotechnologies: Electrical Stimulation and Applications," Springer *Medical and Biological Engineering and Computing*, vol. 54, no.1, pp.63-76, Jan. 2016.
- [10] Lahiri, I.M. Delgado, S. Sheshadri, K.A. Ng, **S. Nag**, S.C. Yen and N.V. Thakor, "Self-organization of fibro-axonal composite tissue around unmodified metallic micro-fluidic electrodes can form a functioning interface with a peripheral nerve: A new direction for creating long-term neural interfaces," *Muscle Nerve*, vol. 53, no. 5, pp. 789-796, May 2016.
- [9] H.U. Lee, **S. Nag**, A. Blasiak, Y. Jin, N.V. Thakor and I.H. Yang, "Subcellular Optogenetic Stimulation for Activity-Dependent Myelination of Axons in a Novel Microfluidic Compartmentalized Platform," *ACS Chemical Neuroscience*, vol. 7, pp. 1317-1324, Oct. 2016.
- [8] **S. Nag**, S. K. Sikdar, N. V. Thakor, V. R. Rao and D. Sharma, "Sensing of Stimulus Artifact Suppressed Signals from Electrode Interfaces," *IEEE Sensors Journal*, vol 15, no. 7, pp. 3734-3742, Jul 2015.
- [7] R. Jegadeesan, **S. Nag**, K. Agarwal, N.V. Thakor and Y.X. Guo, "Enabling Wireless Powering and Telemetry for Peripheral Nerve Implants," *IEEE Journal of Biomedical Health Informatics*, vol. 19, no. 3, pp. 958-970, May 2015.
- [6] **S. Nag**, X. Jia, N. V. Thakor, and D. Sharma, "Flexible charge balanced stimulator with 5.6 fC accuracy for 140 nC injections," *IEEE Transactions on Biomedical Circuits and Systems*, vol. 7, no. 3, pp. 266-275, Jun. 2013.
- [5] S. G. Surya, **S. Nag**, N. M. Duragkar, D. Agarwal, G. Chatterjee, S. Gandhi, S. Patil, D. K. Sharma, and V. R. Rao, "Low power instrumentation system for nanoelectromechanical sensors for environmental and healthcare applications," *Journal of Low Power Electronics*, vol. 8, pp. 1-7, 2012.
- [4] N. A. Gilda, **S. Nag**, S. Patil, M. S. Baghini, D. K. Sharma, and V. R. Rao, "Current excitation method for  $\Delta R$  measurement in piezo-resistive sensors with a 0.3 ppm resolution," *IEEE Transactions on Instrumentation and Measurement*, vol. 61, no. 3, pp. 767-774, Mar. 2012.
- [3] V. Seena, N. S. Kale, **S. Nag**, M. Joshi, S. Mukherji, and V. R. Rao, "Developing a polymeric microcantilever platform technology for biosensing applications," *International Journal of Micro and Nano Systems*, vol. 1, no. 1, pp. 65-70, Jun. 2009.
- [2] N. S. Kale, **S. Nag**, R. Pinto, and V. R. Rao, "Fabrication and characterization of a polymeric microcantilever with an encapsulated hotwire CVD polysiliconpiezoresistor," *IEEE-ASME Journal of Microelectromechanical Systems*, vol. 18, no. 1, pp. 79-87, Feb. 2009.
- [1] M. S. Baghini, **S. Nag**, R. Lal, and D. K. Sharma, "An ultra low power CMOS instrumentation amplifier using current balancing technique for personal ECG recorders," *World-SciNet Journal of Circuits and Systems*, vol. 17, no. 6, pp. 1053-1067, Dec. 2008.

### 1.10.2. Conferences (Peer Reviewed):

- [26] T. Karak, L.K. Tiwari, S. Sengupta, and **S. Nag**, "Reference Trajectory Generation for Closed-Loop Control of Electrical Stimulation for Rehabilitation of Upper Limb," in *Proc. 21st IFAC World Congress*, July, 2020, pp. 16438-16444.
- [25] S. Acharyya, B. Manna, **S. Nag**, P.K. Guha, "WO3 Nanoplates based Chemiresistive Sensor Device for Selective Detection of 2-Propanol", in *Proc. IEEE Sensors Conf.*, 2019, pp. 1-4.
- [24] A. Banerjee, T. K. Bhattacharyya, and **S. Nag**, "A Smart Temperature Sensor and Controller for Bioelectronic Implants," in *Proc. IEEE Sensors Conf.*, 2018, India, pp. 1-4.
- [23] S. Acharyya, S. Dey, **S. Nag** and P. K. Guha, "ZnO cladded MnO<sub>2</sub> based resistive sensor device for Formaldehyde sensing," in *Proc. IEEE Sensors Conf.*, 2018, India, pp. 1-4.
- [22] T. Bhowmick, **S. Nag** and S. B. Majumder, "Gas sensing characteristics in ZnO thin film explicated through the analysis of conductance transients and the concept of activation energy," in *Proc. IEEE Sensors 2018*, India, pp. 1-4.
- [21] A. Koruprolu, R. Erfani, P. Mohseni and **S. Nag**, "Capacitive Wireless Power and Data Transfer for Implantable Medical Devices," in *Proc. IEEE BioCAS Conf.*, 2018, USA, pp. 1-4.
- [20] L. J. Ong, S.C. Liu, D. S. W. Marshal, T. Sibindi, G. G. L. Gammad, C.W Tsai, A. Rusly, C. Libedinsky, **S. Nag**, S. C. Yen, "A Fully Wireless Implantable Multi-Channel Muscle Stimulator with Closed-Loop Feedback Control," in *Proc. IEEE BioCAS Conf.*, 2018, USA, pp. 1-4.
- [19] M.D.S. Wong, K.A. Ng, S. Nag, R. Jegadeesan, K.W. Leong, L.J. Ong, A. Rusly, M. Alam, G.G.L. Gammad, C.W.Tsai, S.C. Liu, K. Voges, N.V. Thakor, A. Lahiri, C. Libedinsky, Y.P. Xu, S.C. Yen, "A chronic implantable EMG recording system with wireless power and data transfer," in *Proc. IEEE BioCAS Conf.*, 2017, USA, pp. 19-21.
- [18] **S. Nag**, P. Lee, R. Herikstad, J. Sng, S.C. Yen and N.V. Thakor, "Multi-function Optogenetic Stimulator and Neural Amplifier for Wirelessly Controlled Neural Interface," in *Proc. IEEE BioCAS Conf.*, Atlanta, USA, Oct. 22-24, 2015, pp.1-4.
- [17] **S. Nag**, D. Sharma and N. V. Thakor, "Ultra-low power electrical stimulator for electrode interfaces," in *Proc. BioCAS Conf.*, Lausanne, Switzerland, Oct. 22-24, 2014, pp. 488-491.

- [16] **S. Nag**, K.A. Ng, R. Jagadeesan, S. Sheshadri, I.D. Martinez, S Bossi, S.C. Yen and N.V. Thakor, "Neural Prosthesis for Motor Function Restoration in Upper Limb Extremity," in *Proc. IEEE BioCAS Conf.*, Lausanne, Switzerland, Oct. 22-24, 2014, pp. 388-391.
- [15] **S. Nag**, D. Sharma and N. V. Thakor, "24 Vpp compliant biphasic stimulator for inductively powered animal behavior studies," in *Proc. IEEE EMBC*, Osaka, Japan, Jul. 2013, pp. 3242-3245.
- [14] **S. Nag**, N. Thakor, and D. Sharma, "Accurately charge balanced stimulator with wireless power delivery," in *Proc. 1st International Conference on BioElectronics, BioSensors, BioMedical Devices, BioMEMS/NEMS and Applications*, Singapore, Nov. 2012, pp. 1-2.
- [13] **S. Nag** and D. Sharma, "Wirelessly powered stimulator and recorder for neural interfaces," in *Proc. IEEE EMBC*, Boston, USA, Aug. 2011, pp. 5612-5616.
- [12] **S. Nag**, N. S. Kale, V. R. Rao, and D. K. Sharma, "An ultra-sensitive delta-R/R measurement system for biochemical sensors using piezoresistive micro-cantilevers," in *Proc. IEEE EMBC*, Minneapolis, USA, Sep. 2009, pp. 3794-3797.
- [11] **S. Nag** and D. K. Sharma, "Wireless e-jacket for multi-parameter biophysical monitoring and telemedicine applications," in *Proc. 3rd IEEE International Summer School and Symposium on Medical Devices and Biosensors*, Boston, USA, Sep. 2006, pp. 40-44.
- [10] **S. Nag** and M. S. Baghini, "Multi channel electrocardiogram using custom analog chip," in *Proc. PCEA IFToMM International Conference*, Nagpur, India, Jun. 2006, pp. 1-4.
- [9] A. Blasiak, H.U. Lee, **S. Nag** and I.H. Yang, "Compartmentalized microfluidic platform integrated with subcellular electrical stimulation for studying activity-dependent axon myelination," in *Proc. International Conference on Optical MEMS and Nanophotonics*, Singapore, Aug. 2016, pp. 5.1-5.2.
- [8] K.A. Ng, A. Cutrone, S. Bossi, **S. Nag**, I.D. Martinez, S. Sheshadri, C.A. Poulard, Y.P. Xu, S.C. Yen and N.V. Thakor, "An intrafascicular electrode with integrated amplifiers for peripheral nerve recording," in *Proc. 7th International IEEE-EMBS Neural Engineering Conference 2015*, Apr. 2015, Montpellier, France, pp.394-397.
- [7] S. Sheshadri, J. Kortelainen, **S. Nag**, K.A. Ng, F.A. Bazley, F. Michoud, A. Patil, J. Orellana, C. Libedinsky, A. Lahiri, L. Chan, K. Chng, A. Cutrone, S. Bossi, N.V. Thakor, I.D. Martínez and S.C. Yen, "Correlation between muscular and nerve signals responsible for hand grasping in non-human primates," in *Proc. IEEE EMBC*, Chicago, USA, 2014, pp. 26-30.
- [6] R. Mandal, **S. Nag** and N.V. Thakor, "Wirelessly Powered and Controlled, Implantable, Multi-channel, Multiwavelength Optogenetic Stimulator," in *Proc. IEEE MTT-S International Microwave Workshop Series on RF and Wireless Technologies for Biomedical and Healthcare Applications (IMWS-BIO)*, 9-11 Dec., 2013, pp.1-3.
- [5] V. Seena, **S. Nag**, S. Gandhi, D. Agarwal, G. Chatterjee, S. Patil, S. Mukherji, D. Sharma, and V. R. Rao, "Low cost polymernano-mechanical sensor systems for healthcare and homeland security applications," in *Proc. IEEE Global Interposer Technology Workshop*, Atlanta, USA, Nov. 2011, pp. 1-5.
- [4] S. G. Surya, **S. Nag**, A. J. Fernandes, S. Gandhi, D. Agarwal, G. Chatterjee, and V. R. Rao, "Highly sensitive  $\Delta R/R$  measurement system for nano-electro-mechanical cantilever based bio-sensors," in *Proc. IEEE International Symposium on Electronic System Design*, Kochi, India, Dec. 2011, pp. 34-38.
- [3] V. Seena, **S. Nag**, S. Patil, S. Mukherji, and V. R. Rao, "An ultra-sensitive polymer composite microcantilever platform for explosive detection," in *Proc. 7th International Workshop on Nanomechanical Cantilever Sensors*, Banff, Canada, May 2010, pp. 1-4.
- [2] N. S. Kale, **S. Nag**, R. Pinto, and V. R. Rao, "Photoplastic NEMS with an encapsulated polysiliconpiezoresistor," in *Proc. 8th IEEE Conference on Nanotechnology*, Arlington, USA, Aug. 2008, pp. 18-21.
- [1] V. Seena, N. Kale, **S. Nag**, M. Joshi, S. Mukherji, and V. R. Rao, "Development of a polymeric microcantilever platform technology for biosensing applications," in *Proc. 5th International Conference on Smart Materials Structures and Systems*, Bangalore, India, Jul. 2008, pp. 1-4.

### 1.10.3. Book Chapters:

- [4] A. Banerjee and **S. Nag**, "Energy Efficient Electrical Stimulation Systems," Handbook of Neuroengineering, Springer (in press).
- [3] **S. Nag**, D. Sharma and N. V. Thakor, "Electrical Stimulation," Book chapter, Cambridge University Press, UK, ISBN: 9781107040830, Oct. 2015.
- [2] A. Blasiak, **S. Nag** and I.H. Yang, "Subcellular Optogenetic Stimulation Platform for Studying Activity-Dependent Axon Myelination In Vitro," Methods in Molecular Biology, Springer Human Press, pp. 207-224, 2018.
- [1] T. Bhowmick, V. Ambardekar, A. Ghosh, M. Dewan, P.P. Bandyopadhyay, **S. Nag** and S.B. Majumder, "Multilayered and Chemiresistive Thin and Thick Film Gas Sensors for Air Quality Monitoring," Multilayer Thin Films - Versatile Applications for Materials Engineering, IntechOpen, 2020.

### 1.10.4. Patent Applications:

- [4] **S. Nag**, D. Sharma, S. Jayaraman, and B. Purushothaman, "Cardiac Devices," Indian Patent Application No. 2874/MUM/2009, Dec. 2013.
- [3] **S. Nag** and D. Sharma, "Ultra-low power charge balancing and low noise stimulator using adiabatic and self clocking techniques," Indian Patent Application No. 3580/MUM/2012, Dec. 2012.
- [2] **S. Nag**, S. G. Surya, V. R. Rao, and D. Sharma, "Voltage profile based biphasic constant current stimulator with artifact suppressor," Indian Patent Application No. 2562/MUM/2012, Aug. 2012.
- [1] N. A. Gilda, **S. Nag**, D. Sharma, and V. R. Rao, "AC current driven open-bridge configuration for measuring impedance variations of a sensor," Indian Patent Application No. 2205/MUM/2011, Aug. 3rd, 2011.