Annual Report 2024

Centre for nano Science and Engineering

Indian Institute of Science

From Science to Systems to Society

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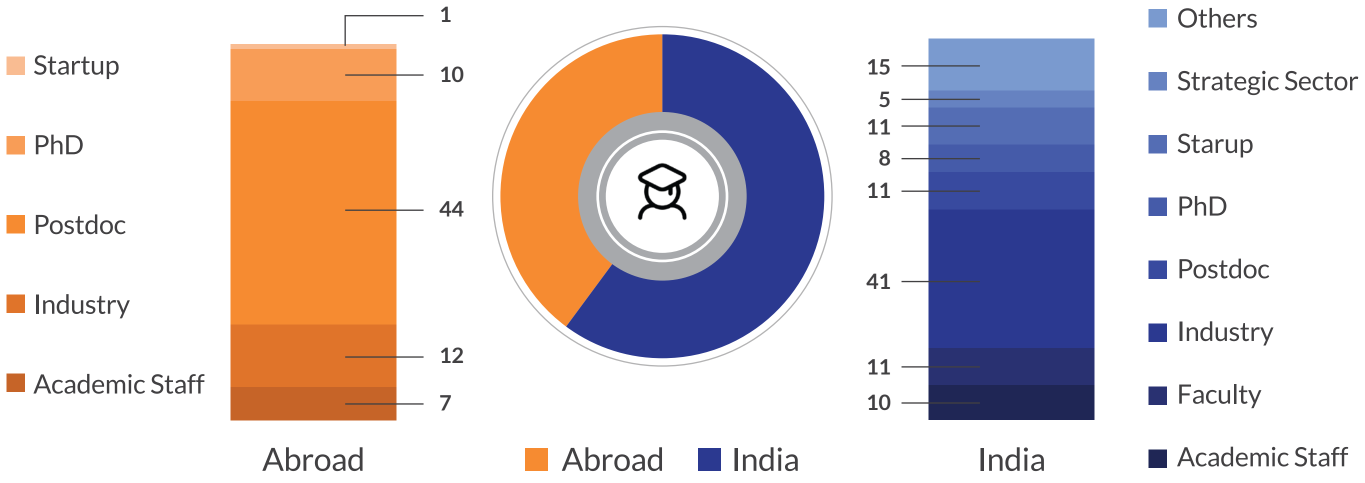
CeNSE in numbers

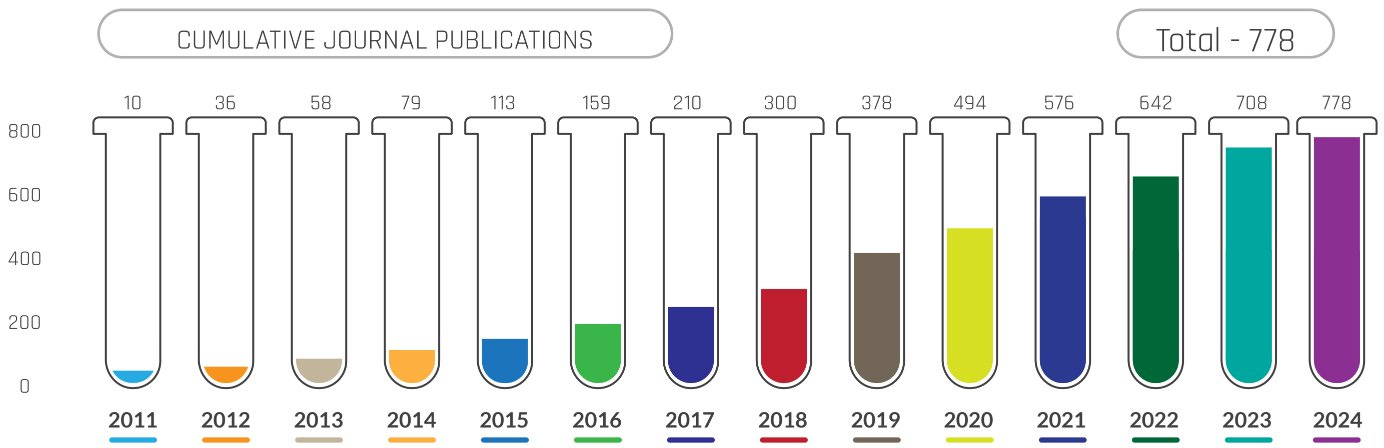
Core Faculty	19	1	Visiting Faculty
NNFC Staff	50	22	MNCF Staff
PASF Staff	13	42	Functional support staff

Technologies transferred	24	102	Patents Granted
Industry Affiliate Members	5	12	Startups Incubated at INCeNSE
PhD Students Admitted (2024)	35	15	M.Tech Students Admitted (2024)
PhD Graduates (2024)	17	18	M.Tech Graduates (2024)
PhD Graduates (2019-2023)	81	29	M.Tech Graduates (2016-2018)
PhD Graduates (2014-2018)	51	25	M.Tech Graduates (2016-2018)
Alumni in India	112	74	Alumni abroad
Journal Publications (2024)	70	29	Conference Publications (2024)
Journal Publications (total)	810	551	Conference Publications (total)

PhD and M.Tech Alumni



Journal Publications



CeNSE Overview

There is lot of room at the bottom. So said the renowned scientist Feynman of the field of nano science and engineering about exploration at length scales of the order of one billionth or 10-9 of a metre. The Centre for Nano Science and Engineering (CeNSE) is involved in scientific exploration all the way down to these - close to atomic - length scales and using this understanding to engineer technology.

Founded in 2010 within the esteemed Indian Institute of Science, CeNSE is home to an interdisciplinary group of faculty, staff and students from all branches of science and engineering. From an initial focus on materials, devices, and systems for applications in electronics, photonics and MEMS (micro and nano electro-mechanical systems) research in CeNSE has evolved to encompass the quantum realm, applications in biology and medicine and new – neuromorphic and quantum- computation paradigms.

This research is enabled by world-class facilities. CeNSE is home to India's largest micro and nano fabrication and characterization facility that is operational 24/7 and about 20 thematic research labs. Our two central facilities, NNfC, the National Nano Fabrication Facility, and MNCF, Micro and Nano Characterization Facility, are now also ISO certified. A third central facility, the Systems and Packaging Facility, is now also on the path to getting ISO certified. Indeed, as the CeNSE slogan goes, they enable Science To Systems To Society. These are indeed national facilities accessible by all - academia, industry, government labs and the strategic sector – through various programs such as INUP or through the newly created CeNSE projects office.

The world is changing and rather rapidly. The courses offered by CeNSE faculty and the hands on training offered by our central facilities prepares both our PhD and Masters students coming from various traditional streams of science and engineering to branch out in these emerging areas. The immediate national requirements are in the area of semiconductor and quantum technologies as evidenced by the India Semiconductor and National Quantum Missions announced by the Indian Government and CeNSE is uniquely positioned to cater to these requirements.

Situated in the vibrant tech and entrepreneurial ecosystem of Bangalore, CeNSE also provides opportunities through INCeNSE, our departmental incubator, to create startups. 9 of the 19 faculty members are founders of startups, with 4 startups having been founded by CeNSE PhD students who are now its CXOs.

From its inception, CeNSE has envisioned becoming a driving force behind India's aspirations in emerging areas and is well on its way to achieving these ambitious goals.

CENTRE FOR
NANO SCIENCE
AND **ENGINEERING**

IISC Overview

Founded in 1909, as a result of the joint efforts of Jamsetji Nusserwanji Tata, the Government of India, and the Maharaja of Mysore, the Indian Institute of Science has become the premier institution for advanced scientific and technological research and education in India. Over the 114 years since its establishment, IISc has grown rapidly to the position of being the best university in India as well as the 27th in Asia.

Beginning with 2 departments and 21 students in 1911, today IISc has 43 departments, units and centres, 5000 students, and about 500 academic and scientific staff, supported by 600 administrative personnel. Research students make up more than 70% of the entire student body at IISc.

Academics at IISc conduct research in several areas of science and engineering including space science, material science and engineering, environmental and atmospheric sciences, endocrinology and genetic engineering. Amongst the areas identified by IISc for special research emphasis are nanoscience and nanotechnology.

MESSAGE FROM THE CHAIR

SRINIVASAN RAGHAVAN, CeNSE

As ages go, it would be hard to describe the last 60 odd years as anything else but the age of silicon electronics. Today, the smart phones we carry in our pockets pack in more computing ability than a room sized computer of the 1950s. This has been enabled by miniaturization of electronic circuit elements, a flag bearer of which has been a reduction in the size of the silicon transistor from about 20 microns (human hair is 100 microns wide, so even 20 microns is by no yardstick big) in 1960 to 3 nm now. It is expected to get down to 1 nm in 2027. That is 7 atoms of Si! The demise of silicon scaling, the so called Moore's law, has been predicted many times, only to fail. It is imminent however, as we near an atom. Hopefully!

If nanoscience is about the discovery of phenomena at smaller length scales, nanotechnology is about the ability to design, fabricate and measure at these length scales. Si CMOS technology, that has enabled the electronics age, is the zenith of the nano technology domain. It is realized in highly specialized manufacturing units called fabs, which enable probably the most complex and consistent manufacturing endeavour that humans may have ever achieved. There are no commercial fabs in India in the private sector. As this note is being written up, the first such fab is coming up in the country courtesy of the Indian Semiconductor Mission of the Ministry of Electronics and Information Technology and Tata Electronics. Entities like CeNSE, which host academic fabs, are an essential part of ecosystems in which semiconductor electronics manufacturing has succeeded such as in the US, Europe and far eastern nations like Taiwan, Korea, Japan and China. I and CeNSE await this pivotal and historical moment when the first wafers will start rolling out of an Indian fab and we will be able to support the ecosystem required to sustain such efforts. Our expanded MTech, the new MEng and skilling programs in particular are aimed at catering to this requirement.

What after Si? What after Moore's law? "More than Moore" or "beyond Moore" or "Moore+" are phrases we often get to hear these days. These refer to Si-CMOS continuing to remain the central technology but getting heterogeneously integrated with sensors, photonics, compound semiconductors through advanced packaging. Packaging which was, for the most part, an activity distinct from a fab, is now itself shrinking to a point where it may move into a fab. These may also refer to technologies that may replace or augment Si. Technologies that leverage quantum effects or "mimic" our human brain, neuromorphic, are very much expected to become reality in my lifetime. An area particularly close to heart is to impact the bio and medical sectors though nano-engineering approaches to enable indigenous lower cost solutions. CeNSE is acutely aware of these impending changes and is preparing for the future. It must not be forgotten that CeNSE was created for a new interdisciplinary requirement about 20 years ago and hence to remain relevant, we need to keep catering to that for the next (and every) 20 years as well.

As I often like to say, it is one thing to set up a fab, another to run it. CeNSE has been running for the last 14 years. Our main facilities are now ISO certified and open 24x7. Notwithstanding all the inefficiencies we complain about, it could not have been possible without tax-payer money from the government. Thank you. Thank you to all the GoI ministries, MeitY, MoE, DST, that support us, the strategic sectors, Government of Karnataka and the Institute. It is also not possible without the untiring efforts of our faculty and staff members. It is time to wean ourselves away from purely public funding for science to private funding for technology. However, in my opinion there needs to be a healthy optimum. Thanks to our incubation efforts, 9 of our 19 faculty members are startup founders. I am a little worried that the momentum is a little too much towards an application and even commercialization focus. Technologies, shorter lived, stem out of a fertile scientific, long term, topsoil base. That top soil can never be allowed to wither.

CeNSE Timeline

1998-2000
Germination of Nanofab Vision

2002
PSA's office + MCIT, India launch "National Nanoelectronics Initiative"

2003
IISc identified as leading Institute to set up Centre for Excellence in Nanoelectronics (CEN)

2005
MCIT, now MeitY sanctions money to setup CEN at IISc, Bangalore

2010
CeNSE is born

2015
Prime Minister dedicates CeNSE to the Nation

2017
Shri Prakash Javadekar, Minister MoE, visits CeNSE and recommends long term support.

AgNIT Semiconductors Pvt Ltd

Theranautilus Pvt Ltd

2021
GEECI (Gallium Nitride Ecosystem Enabling Centre and Incubator) is born

2024
Today, CeNSE has ISO certified 24x7 operating national facilities open to all poised to support the nation in its goal of achieving self reliance in electronics and the future aims in nano science and technology.

CORE FACULTY

Dr. Aditya Sadhanala

2019 – present

PhD, University of Cambridge

Advanced Opto-nano-Electronics (A-OnE) Laboratory

Research Areas

Nanofabrication, nano-structured materials, optoelectronics, spectroscopy, device engineering, automation

Key Career Achievement

Developed one of the world's most sensitive absorption measurement techniques - Photothermal Deflection spectroscopy (PDS) with 4-5 orders of dynamic sensitivity range compared to 1-2 that a conventional absorption spectrometer achieves. Using PDS, various critical photophysical properties have been probed, leading to several seminal findings and breakthroughs in the thin-film semiconductor optoelectronics area. Significant breakthroughs have also been achieved in the fields of Light Emitting Diodes (LEDs) and Photovoltaics (PVs), leading to key outcomes including five main global intellectual properties (one already commercialized). He and his team are establishing India's first perovskite PV technology startup with an aim of bringing this next generation PV technology to the markets.

3 Key Publications

Aditya Sadhanala et al, Richard H. Friend: Preparation of Single Phase Films of CH3NH3Pb(I1-xBrx)3 with Sharp Optical Band Edges. Journal of Physical Chemistry Letters, 5(15), 2501-2505, 08/2014; DOI:10.1021/jz501332v

Aditya Sadhanala et al, Henning Sirringhaus: Approaching disorder-free transport in high-mobility conjugated polymers. Nature, 515 (7527), 384-388, 11/2014; DOI:10.1038/nature13854

Aditya Sadhanala et al, Henry J. Snaith: Ligand-engineered bandgap stability in mixed-halide perovskite LEDs. Nature, 591, 72–77, 03/2021; DOI:10.1038/s41586-021-03217-8

PROF. AKSHAY NAIK

2011 – present

PhD, University of Maryland, College Park

NEMS@CeNSE laboratory

Research Areas

Nanoelectromechanical sensors, Optomechanics, nonlinear dynamics

Key Career Achievement

With over 20 years of NEMS device experience, my research at CeNSE, IISc Bangalore, has significantly advanced understanding of 2D material-based NEMS devices. Achievements include manipulating graphene resonators to enhance signal-to-noise ratio by 25 dB, achieving a mass resolution of 10-22gm. We have also pioneered all-electrical actuation of MoS2 resonators to study novel nonlinear effects including internal resonances. Our expertise extends to controlling nonlinearities and studying their impact on dynamics response of devices.

3 Key Publications

"Gate Tunable Cooperativity between Vibrational Modes", P Prasad, N Arora, AK Naik, Nano letters 19 (9), 5862-5867.

"On-Chip Optical Transduction Scheme for Graphene Nano-Electro-Mechanical Systems in Silicon-Photonic Platform", Aneesh Dash, S.K. Selvaraja, and A. K. Naik, Optics letters 43 (4), 659-662. (Editor's Pick) (Editor's Pick)

"The effect of strain on effective Duffing nonlinearity in the CVD-MoS 2 resonator", C Samanta, N Arora, S Raghavan, AK Naik, Nanoscale 11 (17), 8394-8401

PROF. AMBARISH GHOSH

2009 – present

PhD, Brown University

QuAN2M Laboratory

Research Areas

Nanorobotics, Quantum Fluids, Liquid and Superfluid Helium, Active matter, Nanobiotechnology, Biophysics, Quantum sensing, Plasmonic metamaterials, 2D materials, Optoelectronics

Key Career Achievement

The group led by Ambarish Ghosh is a global leader in nanorobotics, realizing the science fiction of miniaturized vehicles carrying out tasks inside a living being. In addition to fundamental discoveries in non-equilibrium statistical mechanics and cellular biophysics, this work has led to multiple commercialized technologies and successful startups (see Theranautilus Pvt Ltd). The group is also recognized for their experiment in plasmonic nanomaterials and quantum fluids, particularly studying electron bubbles inside superfluid helium.

3 Key Publications

Bubbles in superfluid helium containing six and eight electrons: Soft, quantum nanomaterial. Neha Yadav, Prosenjit Sen and Ambarish Ghosh, Science Advances 7, eabi7128, 2021.

Nanomotors Sense Local Physicochemical Heterogeneities in Tumor Microenvironments, Debayan Dasgupta, Dharma Pally, Deepak K. Saini, Ramray Bhat and Ambarish Ghosh, Angewandte Chemie (chosen as VIP paper), 2020

All optical dynamic nanomanipulation with active colloidal tweezers, Souvik Ghosh and Ambarish Ghosh, Nature Communications, 10, 1, 4191, 2019

DR. CHANDAN KUMAR

2022 – present

PhD, Indian Institute of Science

Quantum Matter Laboratory

Research Areas

Quantum Sensing, Scanning SET of 2D materials, Quantum transport of van der Waals heterostructures, Nanoelectronics, Electron hydrodynamics, Low temperature physics, Moire superlattice

Key Career Achievement

Chandan Kumar has made significant contributions in the field of 2D materials and understanding the flow of electrons in mesoscopic devices. His doctoral work in India pioneered the creation of an artificial moiré superlattice, settling debates on graphene's Berry phase and electrical noise origins, and presenting innovative avenues for noise reduction in 2D materials. Secondly, during his postdoctoral work, he established the world's best charge detector. The scanning measurements with the detector provided the first real space image of quantum and hydrodynamic resistance flow profile.

3 Key Publications

Chandan Kumar, John Birkbeck, Joseph A. Sulpizio, et al. "Imaging Hydrodynamic Electrons Flowing Without Landauer-Sharvin Resistance" Nature 609 (7926), 276-281 (2022)

Chandan Kumar, Manabendra Kuiri, et al. "Tunability of 1/f noise at Multiple Dirac Cones in hBN Encapsulated Graphene Devices", Nano letters 16 (2), 1042-1049 (2016)

Chandan Kumar, Anindya Das "Effect of boron nitride defects and charge inhomogeneity on 1/f noise in encapsulated graphene" Appl. Phys. Lett. 119, 223106 (2021)

DR. DHAVALA SURI

2023 – present

PhD, BITS Pilani, Goa Campus

Quantum Materials and Interfaces Lab

Research Areas

Molecular Beam Epitaxy, Material Interfaces, Topological Insulators, Superconductors, Magnetic semiconductors

Key Career Achievement

Dhavala was instrumental in setting up a transport lab in her PhD that involved instrumentation from scratch. Her significant research works involve demonstration of electric field gating in superconductors, and subtle electronic signatures of spin textures in topological materials and hybrids grown via molecular beam epitaxy. She was awarded the Marie Sklodowska-Curie fellowship for her postdoctoral research work in TU-Munich on superconductor-ferromagnet systems.

3 Key Publications

Large Enhancement of Critical Current in Superconducting Devices by Gate Voltage, Mirko Rocci, Dhavala Suri, Akashdeep Kamra, Gilvânia Vilela, Norbert Nemes, Jose Luis Martinez, Mar Garcia Hernandez, Jagadeesh S Moodera, Nano letters (2020)

Non-reciprocity of vortex-limited critical current in conventional superconducting micro-bridges Dhavala Suri , Akashdeep Kamra, Thomas N. G. Meier, Matthias Kronseder, Wolfgang Belzig, Christian H. Back, Christoph Strunk, Applied Physics Letters 121, 102601 (2022)

Observation of Planar Hall Effect in Topological Insulator--Bi_2Te_3, Archit Bhardwaj, Karthik Raman Dhavala Suri, Applied Physics Letters (2021)

DR. DIGBIJOY N NATH

2014 – present

PhD, Ohio State University

Wide bandgap devices group

Research Areas

Wide band gap devices for microwave and power electronics

Key Career Achievement

Digbijoy has been involved in developing indigenous gallium nitride (GaN) device technology for microwave and power electronics. His group has helped develop the process for GaN C-band and X-band transistors, both on silicon and SiC substrates. His students have also made India's first truly indigenous power switch (200 V, 8 A) in a multi-disciplinary effort. He is a co-founder of AGNIT Semiconductors Pvt. Ltd. Which is India's first and the only startup developing & manufacturing GaN transistors. He is also a co-PI on MeitY-funded incubator GEECI where he's responsible for developing RF devices on a 4-inch pilot production line.

3 Key Publications

Singh Pratiyush, Anamika, et al. "High responsivity in molecular beam epitaxy grown □-Ga_2O_3 metal semiconductor metal solar blind deep-UV photodetector." Applied Physics Letters 110.22 (2017).

Baby, Rijo, et al. "8 A, 200 V normally-off cascode GaN-on-Si HEMT: From epitaxy to double pulse testing." Microelectronic Engineering 282 (2023): 112085.

Gowrisankar, Aniruddhan, et al. "Compensation Dopant-Free GaN-on-Si HEMTs With a Polarization Engineered Buffer for RF Applications." IEEE Transactions on Electron Devices 70.4 (2023): 1622-1627.

DR. GAYATHRI PILLAI

2021 – present

PhD, National Tsing Hua University

Multidisciplinary Micro and Nano Systems Laboratory

Research Areas

Acoustics, MEMS/NEMS, Inertial Sensors, MEMS/NEMS Nonlinearity, Piezoelectricity, Sensors and Actuators, Systems on chip

Key Career Achievement

Gayathri has pioneered new transduction topologies using piezoelectric thin film for M/NEMS devices which has set a new benchmark in microresonators. She leads the Center for Excellence for Piezoelectric MEMS. She holds three US/Taiwan patents on resonator topology design, nonlinear MEMS devices, and inertial sensors. Her lab at CeNSE has reported one of the highest energy confinement resonators using ferroelectric thin-film transducers. The group has demonstrated acoustic wave devices spanning HF-Ka band which are used as sensors, actuators and RF modules. The group also works on the wafer-scale packaging of MEMS devices.

3 Key Publications

G. Pillai, A. A. Zope, and S.-S. Li, "Piezoelectric based support transducer design to enable high performance bulk mode resonators," IEEE/ASME J. Microelectromech. Syst. (JMEMS), vol. 28, no. 1, pp. 4-19, Feb. 2019.

G. Pillai, and S.-S. Li, "Quality Factor Boosting of Bulk Acoustic Wave TPoS Resonators Using Based on a Two-Dimensional Array of High-Q Resonant Tanks," Applied Physics Letters, vol. 116, no. 16, April 2020.

G. Pillai, and S.-S. Li, "Controllable Multichannel Acousto-Optic Modulator and Frequency Synthesizer Enabled by Nonlinear MEMS Resonator," Scientific reports, vol. 11, no. 1, pp. 1-13, 2021.

PROF. MANOJ VARMA

2008 – present

PhD, Purdue University

Nanopore Research Group

Research Areas

Solid-state nanopores, nanopore based single molecule DNA and protein sequencing, single molecule sensing using nanopores

Key Career Achievement

Manoj Varma has established a research program that aims to develop solid-state nanopore technologies for single molecule sensing and sequencing. The lab is engaged in all aspects of technology development from nanopore chip fabrication to novel biochemical schemes for sensitive and accurate detection. In addition to nanopore technology development, the lab also has a strong interest in the development of accessory technologies for molecular sensing, specifically, robotic automation of sample processing.

3 Key Publications

Sohini Pal, Akshay Naik, Anjana Rao, Banani Chakraborty, Manoj M Varma, "Aptamer-DNA Origami-Functionalized Solid-State Nanopores for Single-Molecule Sensing of G-Quadruplex Formation", ACS Applied Nano Materials, 5, 8804 (2022)

Ramkumar Balasubramanian, Sohini Pal, Anjana Rao, Akshay Naik, Banani Chakraborty, Prabal K Maiti, Manoj M Varma, "DNA translocation through vertically stacked 2D layers of graphene and hexagonal boron nitride heterostructure nanopore", ACS Applied Bio Materials, 4, 451 (2020)

Sohini Pal, B Ramkumar, Sanket Jugade, Anjana Rao, Akshay Naik, Banani Chakraborty, Manoj M Varma, "Effect of single nanoparticle-nanopore interaction strength on ionic current modulation", Sensors and Actuators B: Chemical, 325, 128785 (2020)

PROF. NAVAKANTA BHAT

1999 – present

PhD, Stanford University

Nanodevices and Sensors Laboratory

Research Areas

Electrochemical Biosensors, SERS & Lab-on-a-chip devices, Gas sensors, 2D nanoelectronics with MoS2 and Graphene, Al/GaN high electron mobility transistors, novel materials and processes for CMOS & MEMS applications

Key Career Achievement

Navakanta Bhat was instrumental in establishing the National Nanofabrication Centre. His research in the area of Nanoelectronic device physics and technology has addressed key challenges in transistor scaling such as gate dielectrics, metal contacts on Silicon, Germanium and 2D materials 2D materials. His research work in electrochemical biosensing technology has been translated into a successful point of care diagnostics product through the startup PathShodh Healthcare that he cofounded. This healthcare product is being used in more 15 states in India and the technology is protected by 30 international patents in 8 countries. He has also worked on developing chemi-resistive gas sensing technology and has transferred it to SCL and ISRO.

Key Publications

Das, S. K., Nayak, K. K., Krishnaswamy, P. R., Kumar, V., & Bhat, N. (2022). Electrochemistry and other emerging technologies for continuous glucose monitoring devices. ECS Sensors Plus, 1(3), 031601.

Das, S., Sebastian, A., Pop, E., McClellan, C. J., Franklin, A. D., Grasser, T., ... & Singh, R. (2021). Transistors based on two-dimensional materials for future integrated circuits. Nature Electronics, 4(11), 786-799.

Kumar, V., & Bhat, N. (2018, October). anuPath™: Novel Sensing Chemistry to Lab on Palm Sensor System for Diabetes and its Complications. In 2018 IEEE SENSORS(pp. 1-4). IEEE.

DR. PAVAN NUKALA

2020 – present

PhD, University of Pennsylvania

Functional Thin Films and Electron Microscopy Laboratory

Research Areas

Correlated Systems, Ferroic Oxides, in situ electron microscopy and spectroscopy, material networks for neuromorphic materials and networks, phase change materials, thin film x-ray diffraction

Key Career Achievement

Discovery of ultralow power solid-state amorphization in phase-change memory, Global leader in the area of hafnia-based ferroelectrics: discovery of a new rhombohedral phase in ferroelectric hafnia and developing niche microscopy tools to understand its unconventional ferroelectricity.

3 Key Publications

S. Parathe#, S. Vura#, ..., P. Nukala, Giant electromechanical response from defective non-ferroelectric epitaxial BaTiO3 integrated on Si (100), Just accepted in Nature Communications, Research square, doi: 10.21203/rs.3.rs-2661707/v1

A. Rao, S. Sooraj, ..., P. Nukala, Realizing neuromorphic networks at self-organized criticality on a 2D hexagonal BN platform, Materials Horizons, doi: 10.1039/D3MH01000G

P. Nukala, M. Ahmadi, Y. Wei et al., “Reversible oxygen migration and phase transitions in hafnia-based ferroelectric devices”, Science, 372, 6542, 2021

PROF. PROSENJIT SEN

2013 – present

PhD, University of California Los Angeles

Multidisciplinary Micro and Nano Systems Laboratory

Research Areas

Microfluidics, Lab-on-chip, Droplets, Interfacial phenomenon in microfluidics, Fluidic sensors, Heterogeneous integration

Key Career Achievement

Prosenjit Sen has developed a research program in engineering surfaces and surface forces at micro and nano scale for various applications. His group has developed several droplet-based technologies. His research has developed microfluidic devices for studying cells and cell clusters for clinical applications. His group is playing a key role in development of organ-on-chip technology for drug testing and personalized medicine. His research is also developing advanced packaging and heterogeneous integration technologies for miniaturization of sensor systems. For example, his group is miniaturizing Quantum sensor systems based on MEMS vapor cells.

3 Key Publications

R. Lathia, S. Nagpal, C.D. Modak, S. Mishra, D. Sharma, B.S. Reddy, P. Nukala, R. Bhat and P. Sen, "Tunable encapsulation of sessile droplets with solid and liquid shells," Nature Communications 14 (1), 6445, 2023.

C.D. Modak, A. Kumar, A. Tripathy, and P. Sen, "Drop impact printing," Nature communications 11 (1), 4327, 2020.

S. Bansal and P. Sen, "Mixing enhancement by degenerate modes in electrically actuated sessile droplets", Sensors and Actuators B: Chemical, 2016.

PROF. RUDRA PRATAP

1996 – present

PhD, Cornell University

MEMS Laboratory

Research Areas

MEMS/NEMS, MEMS & NEMS Sensors, Vibratory Mechanobiology, Materials for MEMS/NEMS, Fundamental research in NEMS/MEMS, Transduction-targeted material development

Key Career Achievement

Rudra Pratap was the founding chair of the Centre for Nano Science and Engineering and hence coordinator of the team that created CeNSE. He was instrumental is setting up MEMS research in India and developing the pressure sensor and gyro technology that has now flown into space. He is also the founder of i2N a startup that is commercializing the MEMS technologies developed by him.

3 Key Publications

Sudhanshu Tiwari, Randhir Kumar, Saurabh Arun Chandorkar, and Rudra Pratap, "Fully Differential Actuation and Sensing in Piezoelectric a Resonators for High Signal to Background Resonant Sensing", Journal of Microelectromechanical Systems, DOI: 10.1109/JMEMS.2020.3001246, June 2020.

Meera Vikas Garud and Rudra Pratap, "A Novel MEMS Speaker With Peripheral Electrostatic Actuation", Journal of Microelectromechanical Systems, DOI: 10.1109/JMEMS.2020.3003463, June 2020.

M. Sharma, P. Kumar, A. V. Irzhak, S. Kumar, R. Pratap, S. V. von Gratovski, V. G. Shavrov & V. V. Koledov, "Melting and Electromigration in Thin Chromium Films", Physics of the Solid State, Vol. 62, pp 988992, 2020.

DR. SAURABH CHANDORKAR

2017 – present

PhD, Stanford University

Microsystems and Fluctuation Dissipations Laboratory

Research Areas

MEMS/NEMS fabrication, Materials for MEMS/NEMS, MEMS/NEMS sensors, Study of Energy Loss Mechanisms and Noise in MEMS/NEMS, Phononic crystals, Wafer-scale MEMS Packaging

Key Career Achievement

Saurabh Chandorkar is one of the leading researchers in the field of study of energy loss mechanisms in MEMS/NEMS resonators and an expert in quantum limits of energy. He has developed a research program that focusses on study of energy loss and noise physics at confluence of micro/nano-resonator design, materials for MEMS/NEMS and analog circuits. His group also works on wafer scale encapsulation of MEMS devices, a technology that was pioneered by a team of researchers including him at Stanford University.

3 Key Publications

Upanya Khandelwal, Qikai Guo, Beatriz Noheda, Pavan Nukala, and Saurabh Chandorkar, "Dynamics of Voltage-Driven Self-Sustained Oscillations in NdNiO3 Neuristors", ACS Applied Electronic Materials 2023 5 (7), 3859-3864

S. Tiwari, R. Kumar, S. A. Chandorkar and R. Pratap, "Fully Differential Actuation and Sensing in Piezoelectric Diaphragm Resonators for High Signal to Background Resonant Sensing," in Journal of Microelectromechanical Systems, vol. 29, no. 5, pp. 888-893, Oct. 2020,

Rodriguez, J., Chandorkar, S.A., Watson, C.A. et al. Direct Detection of Akhiezer Damping in a Silicon MEMS Resonator. Sci Rep 9, 2244 (2019).

PROF. SHANKAR KUMAR SELVARAJA

2014 – present

PhD, Ghent University-imec

Photonics Research Laboratory

Research Areas

Silicon Photonic Integrated Circuits, High-speed data communication, Photonics Radar, Optical Sensor, Photonic IC packaging.

Key Career Achievement

Shankar Kumar Selvaraja has established 200 and 300 mm silicon photonics platform at imec Belgium, which was then transferred to production foundry. He has demonstrated the state-of-the-art silicon photonics device and circuit performance in a 300 mm wafer platform. He has established a silicon photonics research laboratory at IISc Bangalore that has developed and demonstrated indigenous best-in-class passive and active photonic IC devices and circuits for communication, computing and sensing applications. He has published over 300 scientific journal and conference articles. He has 8 patents including 6 granted patents. He is a cofounder of India's first startup in the area of device manufacturing AGNIT Semiconductors Pvt. Ltd. He is leading a project to develop indigenous photonic integrated-circuit based quantum processors through the Quantum Computing Hub under the National Quantum Mission.

3 Key Publications

Chatterjee and Selvaraja, S. K., "On-chip silicon nano-slab photodetector integrated wavelength division de-multiplexer in 850 nm band", Optica Applied Optics., vol. 61, no. 6, pp. 1403-1412, 2022.

V. Mere, Muthuganesan, H., Kar, Y., Van Kruijsdijk, C., and Selvaraja, S. K., "On-chip Chemical Sensing using Slot-waveguide based Ring Resonator", IEEE Sensors, vol. 20, no. 11, pp. 5970 - 5975, 2020.

Pandey and Selvaraja, S. K., "Tunable coupling-induced resonance splitting in self-coupled Silicon ring cavity with robust spectral characteristics", Optics Letters, vol. 42, no. 14, 2017.

DR. SREETOSH GOSWAMI

2021 – present

PhD, National University of Singapore

Molecular Neuromorphic computing and Cognitive Systems Lab (MoNCS)

Research Areas

Artificial intelligence, Neuromorphic circuits, In-memory computing, Molecular electronics, Nanoelectronics, Nonlinear dynamics and chaos

Key Career Achievement

Sreetosh pioneered the development of the most energy-efficient neuromorphic circuit elements available today. By harnessing transitions between different thermodynamic molecular states in circuit elements, he demonstrated features like edge-of-chaos dynamics, parallelism, plasticity, and reconfigurability, marking a quantum leap in brain-inspired computing. He has now established the foundation for constructing a neuromorphic processor capable of notably surpassing the efficiency of contemporary computing engines in handling AI and ML workloads.

3 Key Publications

Sreetosh Goswami*, Rajib Pramanick, Abhijeet Patra, et.al. “Decision Trees within a Molecular Memristor”, Nature, 2021, 597, 51–56

Sreetosh Goswami*, Santi. P. Rath, Damien Thompson, et.al. “Charge disproportionate molecular redox for discrete memristive and memcapacitive switching”, Nature Nanotechnology, 2020, 15, 380-389

Sreetosh Goswami, Adam J Matula, Santi P Rath, et.al. “Robust resistive memory devices using solution-processable metal-coordinated azo aromatics”, Nature Materials, 2017, 16, 1216–1224

PROF. SRINIVASAN RAGHAVAN

2006 – present

PhD, The Pennylvania State University

Crystal Growth Group

Research Areas

Thin Film growth, nano-structures and bulk crystals, Growth of group IIIA (Ga, In, Al) nitrides, oxides & 2d materials, Stress and defect structure evolution, Effects of stress on crystal properties and device performance.

Key Career Achievement

Srinivasan Raghavan, one of the founding team members of CeNSE, has helped establish a platform for growth of 2D materials, oxides and III-V materials required for electronic devices by chemical vapor deposition. In particular, he nucleated GaN activity in CeNSE, IISc. The research thus spawned has resulted in the incubation of India’s first startup in the area of device manufacturing, AGNIT Semiconductors Pvt. Ltd. and the setting up of a low volume production fab for GaN devices in the clean room in IISc GEECI.

3 Key Publications

Srinivasan Raghavan, “Kinetic Approach to Dislocation Bending in Low Mobility Films,” Phys. Rev. B, v. 83, p. 052102, 2011.

Krishna Balasubramanian, Tathagatha Biswas, Priyadarshini Ghosh, Swathi Suran, Abhishek Mishra, Rohan Mishra, Ritesh Sachan, Manish Jain, Manoj Varma, Rudra Pratap and Srinivasan Raghavan, “Reversible Defect Engineering in Graphene Grain Boundaries” Nature Communications, 10, 1090, 2019.

S Vura, V Jeyaselvan, R Biswas, V Raghunathan, SK Selvaraja and Srinivasan Raghavan, “Epitaxial $BaTiO_3$ on Si(100) with In-Plane and Out-of-Plane Polarization Using a Single TiN Transition Layer,” ACS Applied Electronic Materials 3 (2), 687-695, (2021).

PROF. SUPRADEEPA V R

2014 – present

PhD, Purdue University

Nonlinear Photonics and High-Power Lasers Laboratory

Research Areas

Photonics, Optical Data/Tele-Communications, Nonlinear Optics in Fibers and Integrated Nanophotonic Devices, Fiber Lasers and Amplifiers, Optical Frequency Combs and Ultrafast Lasers, Optical Signal Processing

Key Career Achievement

Prof. Supradeepa's group is among the forefront in the world in the commercially and scientifically important field of high-power fiber lasers. Specifically, his group's expertise is in the technology of wavelength conversion of these high-power fiber lasers into inaccessible wavelength regions using nonlinear frequency conversion and in controlling nonlinear effects in high power fiber lasers to achieve extreme power levels. His group has enabled the setting up and successful operations of fiber laser groups in the country in government organizations and in private industry through technology transfers, R&D collaborations and consulting efforts.

3 Key Publications

Roopa Prakash, B. S. Vikram and V. R. Supradeepa, "Enhancing the Efficacy of Noise Modulation for SBS Suppression in High Power, Narrow Linewidth Fiber Lasers by the Incorporation of Sinusoidal Modulation," IEEE Photonics Journal 13 (5), 1-6 (2021)

S. Arun, Vishal Choudhury, V. Balaswamy, and V. R. Supradeepa, "Octave-spanning, continuous-wave supercontinuum generation with record power using standard telecom fibers pumped with power-combined fiber lasers," Opt. Lett. 45, 1172-1175 (2020)

V Balaswamy, Siddharth Ramachandran, and V. R. Supradeepa, " High-power, cascaded random Raman fiber laser with near complete conversion over wide wavelength and power tuning," Opt. Express 27, 9725-9732 (2019)

PROF. SUSHOBHAN AVASTHI

2014 – present

PhD, Princeton University

Heterojunction Lab

Research Areas

Thin-film solar cells, IR photodetectors, thin-film transistors, atomic layer deposition, pulse laser deposition, large-area printable electronics, and advanced optoelectronic characterization

Key Career Achievement

Prof. Sushobhan is leading an effort to upscale thin-film perovskite solar technology in India. He has established an indigenous sheet-to-sheet printing infrastructure for thin-film lead halide perovskite solar cells. The infrastructure led to ABX3PV, India's only perovskite startup with a demonstrated technology for 200 cm^2 perovskite minimodules. He is also a co-founder for Molecular Semiconductors, a semiconductor materials start-up. Prof. Sushobhan also holds the record for hole mobility in p-type oxide thin films. P-type oxides have applications in thin-film transistors, BEOL-compatible PFETs, and sensors.

3 Key Publications

P Singh, R Mukherjee, S Avasthi, "Acetamidinium-Substituted Methylammonium Lead Iodide Perovskite Solar Cells with Higher Open-Circuit Voltage and Improved Intrinsic Stability," ACS applied materials & interfaces 12 (12), 13982-13987

S Avasthi, S Lee, YL Loo, JC Sturm, "Role of majority and minority carrier barriers silicon/organic hybrid heterojunction solar cells," Advanced materials 23 (48), 5762-5766 (2011)

V Singh, J Sinha, SA Shivashankar, S Avasthi, "CVD-deposited Cu_2O thin films with a record Hall hole mobility of 263 $cm^2V^{-1}s^{-1}$ and field-effect mobility of 0.99 $cm^2V^{-1}s^{-1}$ "Journal of Materials Chemistry C 11 (22), 7356-7366 (2023)

DR. VINI GAUTAM

2022 – present

PhD, Jawaharlal Nehru Centre for Advanced Scientific Research

Neuro Electronics Laboratory

Research Areas

Neuroengineering, neural interfaces, neural tissue engineering, nanobiotechnology, bioelectronics, biomaterials

Key Career Achievement

Dr. Vini was named in 40 under 40 most influential Asians in Australia: science and technology category. Awarded in the Asia-Australia business summit (2020). She was awarded the Australia-India Strategic Research Fund Early Career Researcher fellowship, by the Australian Academy of Science (2019) and the Australian Capital Territory Young Tall Poppy award (state-level recognition for science outreach), by the Australian Institute of Policy and Science (2018).

3 Key Publications

V. Gautam, D. Rand, Y. Hanein and K. S. Narayan; A polymer optoelectronic interface provides visual cues to a blind retina; Adv. Mater. 26, 1751–1756 (2014)

V. Gautam, S. Naureen, N. Shahid, Q. Gao, Y. Wang, D. Nisbet, C. Jagadish and V. Daria; Engineering highly interconnected neuronal networks on nanopillar arrays; Nano Lett. 17, 3369–3375 (2017)

H. Tran, V. Gautam; Micro/nano devices for integration with human brain organoids; Biosensors Bioelectronics 218, 114750-63 (2022)

Facility and Services - Leadership

Nanotechnology research needs advanced equipment, electronics, and software. CeNSE offers state-of-the-art laboratories and technical facilities that are open to users to further their nano research goals. These facilities are managed by a dedicated group of highly qualified and skilled Technology Managers, with help from technical staff. The Technology Managers work closely with the research groups on various projects. Together they optimize the experimental setup and the technical infrastructure for each new experiment.

Gajendra M

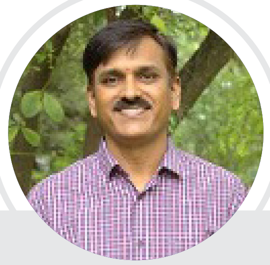
Chief Operating Officer,
National Nano Fabrication Centre

Responsible for NNFC fab operation including all the process bays, utilities and fab management.

Krishna Prasad

Technology Manager,
Packaging and Systems Facility

Responsible for PASF operations and coordination with the user community.



Suresha SJ

Chief Operating Officer,
Micro and Nano Characterization Facility

Responsible for managing MNCF – Micro and Nano Characterization Facility operations. Coordinate and interact with a wide user community of MNCF, including students & researchers from all over India and industry users.

Sabiha Sultana

Chief Technologist, Projects Office

Responsible for Process development and integration. Project management and execution. Product Development, Technology Transfer and Business Development. Nodal contact person for project and technology services and industry interaction.

J Sheila Evangeline

Head of Administration

Responsible for all administrative functions of the department including daily operations, supervision of staff, coordination with the institute and finances, budgeting and resource allocation.

Kalpana Subbaramappa

Program Manager - Industry Office, INCeNSE

Responsible for industry interfacing between the department and external industry partners. As the CEO of the in-house incubator, responsible for strategic leadership, operational management, fundraising, and building a strong ecosystem for deep tech startups.

CENTRE FOR **NANO SCIENCE** AND **ENGINEERING**

Academics

As part of its focus to deliver exceptional education and pursue cutting-edge research, the centre offers MTech and PhD degree programs in nanoscience and engineering to students.

Focus Research Areas

- Materials,
- Electron-devices,
- Photonics,
- MEMS/NEMS/Microfluidics
- Nano-biotechnology,
- Quantum Technologies
- Systems
- Neuromorphic Computing

M. Engg. in Semiconductor Technology

CeNSE has introduced a one-year M.Engg in Semiconductor Technology starting from the 2024-25 academic year. This program aligns with the India Semiconductor Mission to support the growing semiconductor industry both in India and globally. Designed to attract students from diverse fields, it addresses the industry's demand for skilled professionals and advanced R&D in semiconductor technology. Students will benefit from expert guidance, industry interactions, and access to CeNSE's state-of-the-art research facilities, preparing them for critical roles in the fast-evolving semiconductor ecosystem.

Joint MTech in Semiconductor Technology

From the academic year 2024-25, CeNSE, IISc launched a Joint Master's degree program in collaboration with top Taiwanese universities. This initiative aims to strengthen ties between Indian academia and Taiwan's semiconductor industry. Students will gain hands-on experience through academic and industry internships, ensuring exposure to cutting-edge semiconductor technology. The program aligns with the India Semiconductor Mission, preparing graduates for the evolving global semiconductor sector. Partner universities include National University of Taiwan, National Chiao Tung Yang Ming University, National Tsing Hua University, and National Sun Yat-Sen University.

M.Tech Degree Program

CeNSE launched its M.Tech in Semiconductor Technology in August 2023, designed to support the growing semiconductor ecosystem in India and globally, in alignment with the India Semiconductor Mission. The program offers optional minors in Nanoelectronics, Nano-bio, Photonics, Micro-systems & Packaging, Quantum Technology (with the Indian Quantum Science Initiative), and Materials (with the Department of Materials Engineering).

With a multidisciplinary approach, the program is open to students from diverse backgrounds and focuses on industry-relevant skills and cutting-edge R&D. Students benefit from industry interactions, fellowships, internships, and state-of-the-art research facilities.

Industry-sponsored M.Tech Fellowships—offered by Tokyo Electron, LAM Research, MacDermid Alpha, and Applied Materials—provide enhanced financial support to select students, including a monthly stipend of INR 25,000 and INR 55,000 for travel and contingencies.

Ph.D Degree Program

The Centre offers a doctoral degree program that involves rigorous course work followed by thesis research in the various research fields in the centre. For conducting their research, the Ph.D scholars have access to some of the best resources in the nation.

The duration of PhD completion varies between 4 and 6 years, with an average of 4.5 years for students joining after a Masters'. There have been exceptional instances where a Ph.D thesis has been successfully defended in 2.5 years.

An undergraduate student with a high GPA from a Centrally Funded Technical Institute (CFTI) can have direct entry to the PhD program at CeNSE through an initiative by IISc.

Student and Staff Placements

Summer Program

Starting from 2013, CeNSE has been conducting a training program every summer, for promising undergraduate and masters' students from India and abroad, selected through a rigorous and competitive process.

Participants must complete the online summer/winter school program, which includes daily assessments and culminates in a cumulative merit list. The top 25 performers will receive a certificate and be invited for a 10-week in-person internship at CeNSE.

The training is primarily based on the facilities available at CeNSE and covers a variety of research topics under the broad umbrella of nano science and engineering.

Research at CeNSE covers both – fundamental questions in the basic sciences and the development of technologies and devices for direct societal impact. With the involvement of almost 50 faculty members across 14 departments, the thrust is on interdisciplinary research, with particular focus on the following areas:

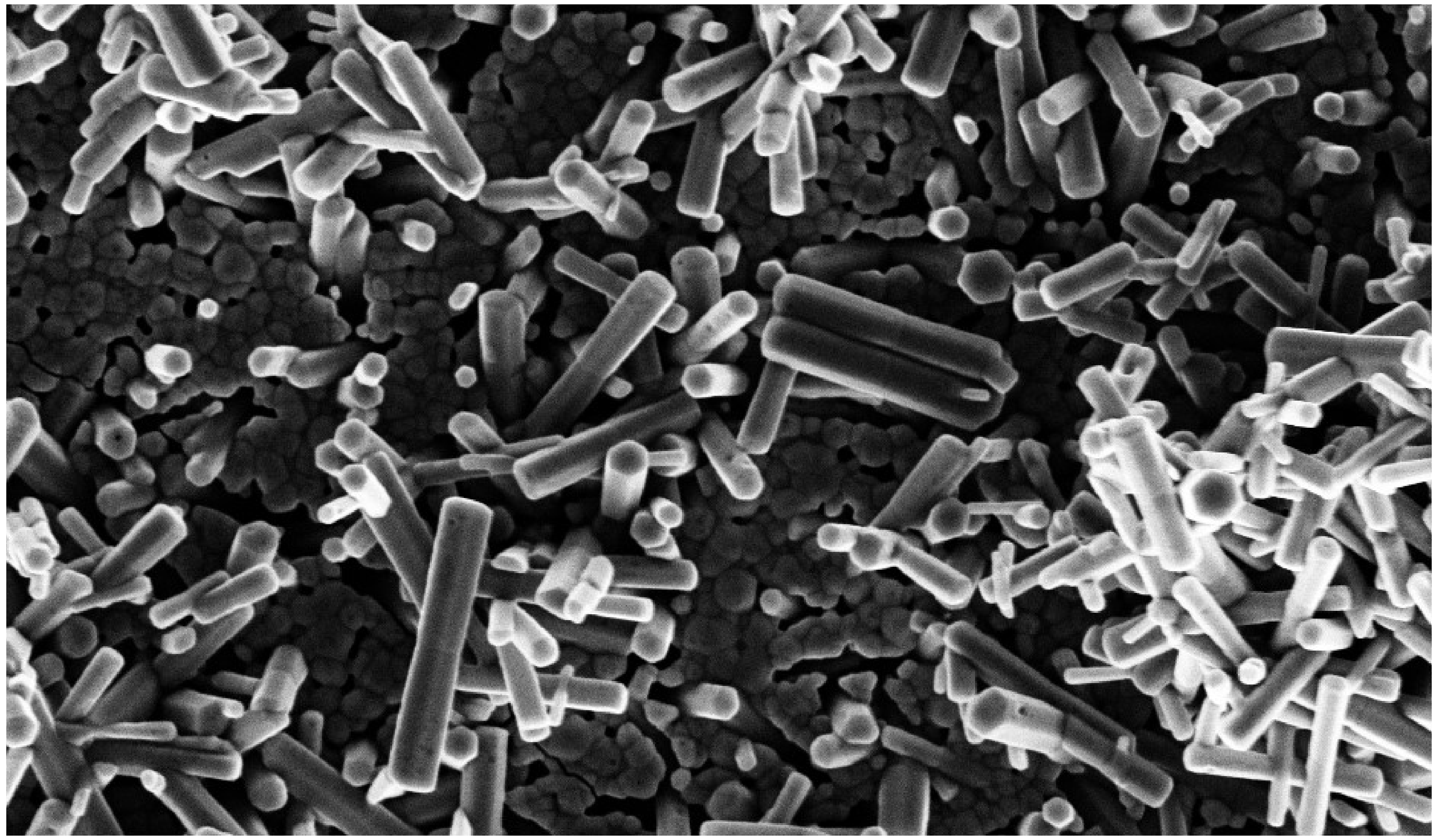
Research - Focus Areas

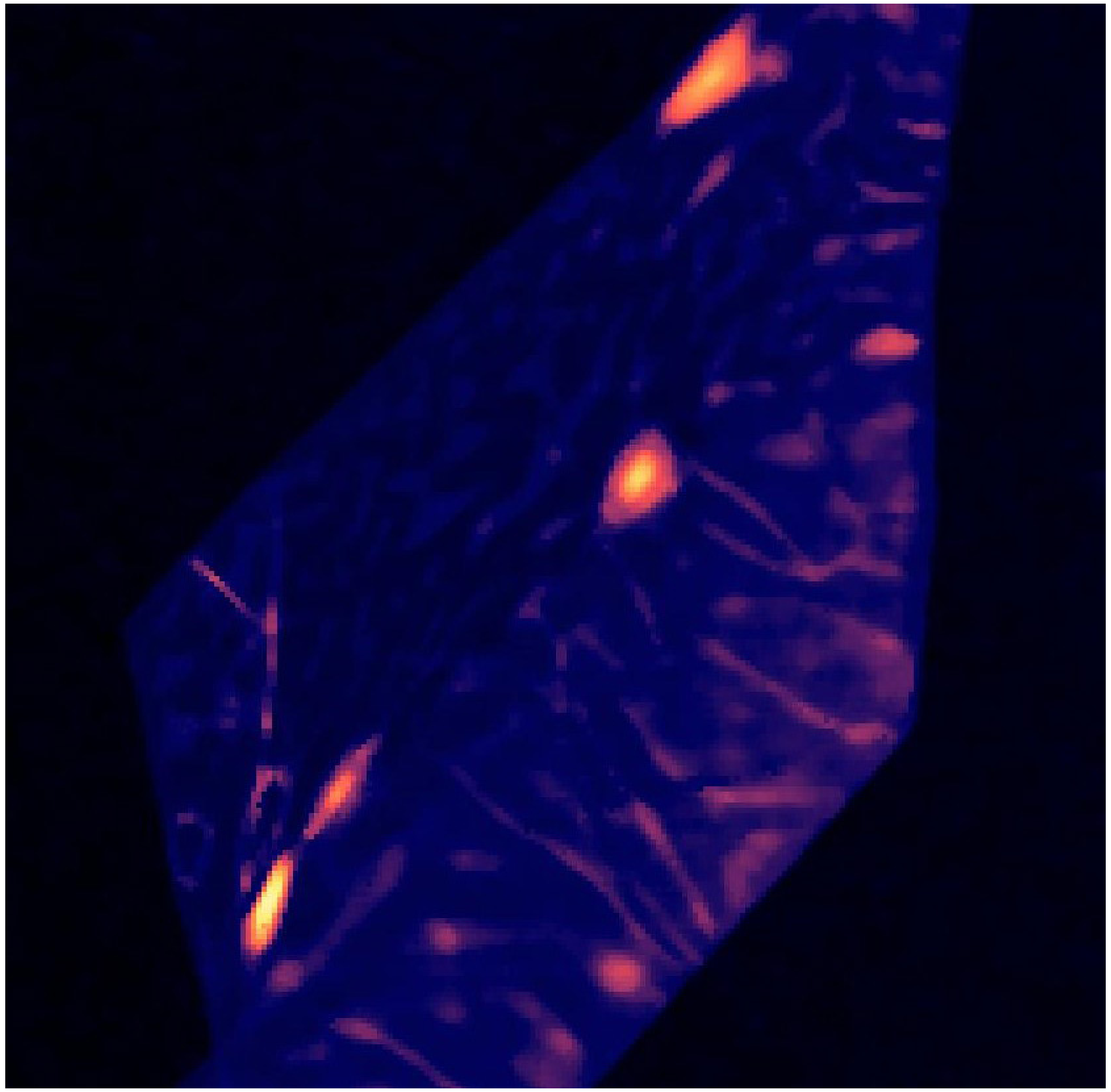
Materials

If the 20th century is often referred to as the silicon age, it is because silicon as a material transformed the way we compute, communicate, and live. In today's world, progress in science and technology continues to be driven by the discovery and engineering of new materials. Materials research explores how atoms are arranged, how that structure can be modified or controlled, and how these properties can be harnessed in devices. From semiconductors that power computers and smartphones, to piezoelectric crystals that convert vibrations into signals, to two-dimensional materials like graphene that promise ultra-thin, ultra-fast electronics, advances in materials form the foundation of all modern technologies.

At CeNSE, faculty specializing in materials research include Professors Pavan Nukala and Srinivasan Raghavan. Together, they bring deep expertise in materials growth, thin-film engineering, advanced microscopy, and functional property analysis.

Materials research at CeNSE covers the full cycle—from synthesis of thin films and bulk crystals, to detailed structural and chemical characterization, to evaluating performance in devices. Researchers employ a variety of methods such as physical vapor deposition (PVD), chemical vapor deposition (CVD), pulsed laser deposition (PLD), and molecular beam epitaxy (MBE) to create high-quality materials. These are then studied using advanced characterization techniques, including high-resolution and in-situ electron microscopy, to uncover





the links between synthesis, structure, and functionality. The ultimate goal is to take these materials from the laboratory bench into real-world applications by integrating them into devices that impact energy, communications, healthcare, and beyond.

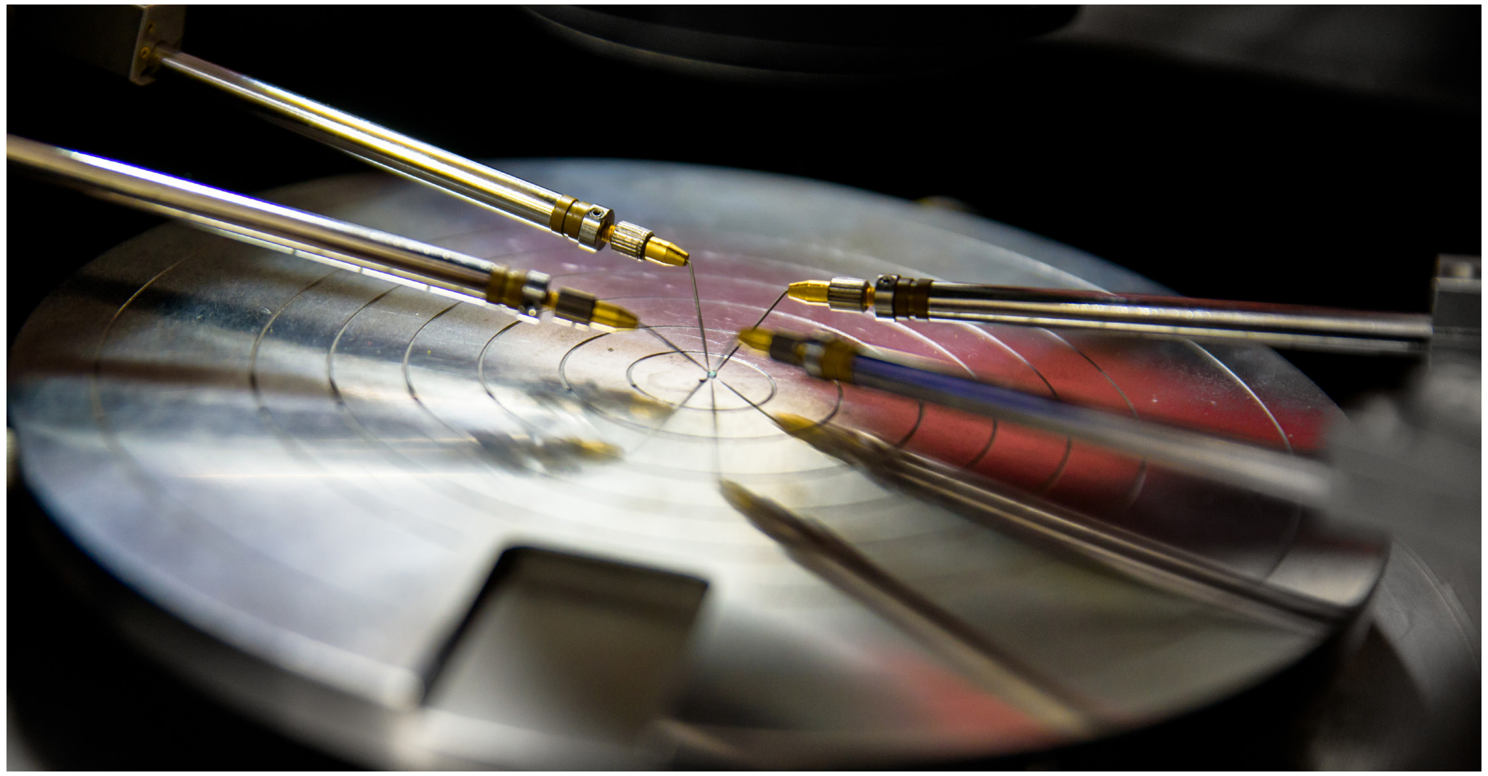
Current research in materials at CeNSE spans both traditional and cutting-edge directions. Functional oxides and nitrides such as gallium nitride (GaN) and its alloys are being studied extensively for their role in high-power and high-frequency electronics, with direct applications in areas like electric vehicles and satellite communication. Two-dimensional materials, including graphene, MoS_2, and hexagonal boron nitride, are synthesized and engineered for their remarkable electronic and optical properties. Researchers are also investigating ferroelectric and piezoelectric materials, which enable applications ranging from sensors and MEMS devices to memory elements for neuromorphic computing. Advanced in-situ transmission electron microscopy is used to probe the growth and defect dynamics of these materials at the atomic scale, offering insights into how to enhance their stability and performance. The materials are further evaluated for their use in devices such as electro-optic modulators, infrared detectors, photovoltaic systems, and piezoelectric MEMS. These efforts are creating a robust materials platform that not only drives fundamental discoveries but also supports the development of next-generation electronic and optoelectronic technologies.

Electronics

Electronics is the backbone of the modern age, powered by semiconductor technology that enabled the digital revolution. At its core, nanoelectronics explores electronic components at the nanometer scale—often from 1 to 100 nm—where quantum effects and atomic-level interactions significantly influence device behavior. This field encompasses transistors, memories, interconnects, and sensors constructed with novel materials and architectures beyond traditional silicon. It is these innovations—miniaturization, quantum-based devices, and new materials—that continue to fuel progress in computing, communications, energy, and sensing technologies.

Faculty members in CeNSE whose core expertise is in electronic devices include Professors Sreetosh Goswami, Aditya Sadhanala, Digbijoy Nath, Sushobhan Avasthi, and Navakanta Bhat. Together, they cover the full spectrum of device research, from understanding the fundamental physics to designing, fabricating, packaging, integrating, and testing advanced systems.

At CeNSE, electronics research bridges fundamental science and real-world applications. Researchers explore new semiconductors and nanostructures, design circuits and systems, and integrate them into practical platforms. This



work spans power electronics, sensors, optoelectronics, and brain-inspired computing. Through collaborative, interdisciplinary efforts, CeNSE translates cutting-edge device research into innovations that impact areas such as renewable energy, healthcare, safety, communication, and next-generation computing.

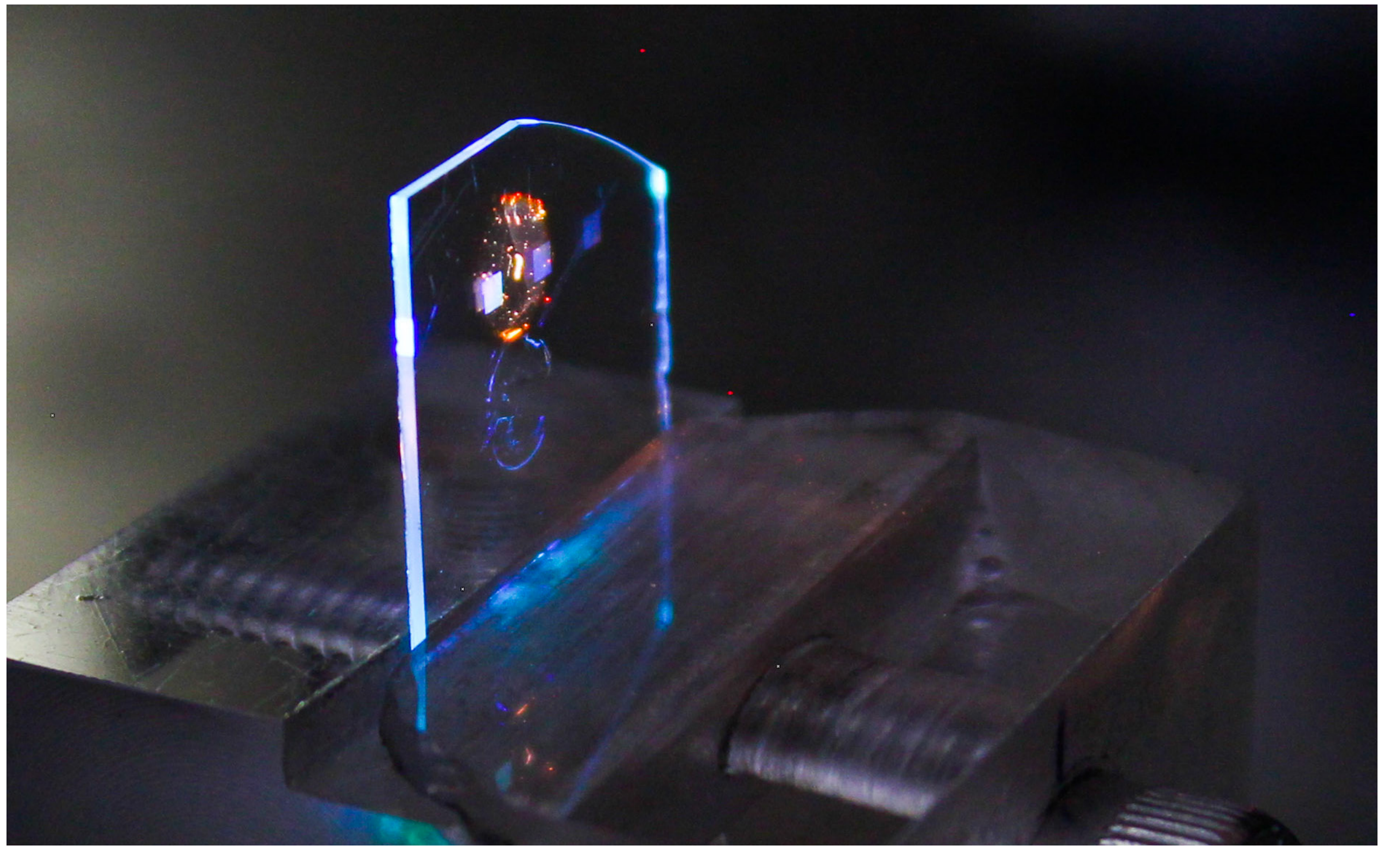
Current research in electronics at CeNSE covers a wide range of exciting directions. Wide-bandgap materials like gallium nitride (GaN) and gallium oxide (Ga_2O_3) are being developed for high-performance power devices—such as those used in electric vehicle charging—and for radio frequency (RF) electronics critical to 5G communication and radar systems. Oxide-based devices are also a major focus, with researchers building sensors for hazardous gases, electrochemical sensors for detecting biomarkers relevant to healthcare, and infrared detectors based on oxides and 2D materials for safety applications like fire alarms. In parallel, photovoltaics research explores solar cells made from silicon, organics, and hybrid organic–inorganic perovskites to create highly efficient and scalable renewable energy solutions. Thin-film transistors are being developed for integration into CMOS backends, enabling new classes of flexible and multifunctional electronics. Another key thrust is brain-inspired computing, where researchers design neuromorphic devices and architectures that mimic the brain's information processing. These systems promise enormous improvements in energy efficiency and reconfigurability, enabling advances in artificial intelligence, machine learning, cybersecurity, and big-data applications.

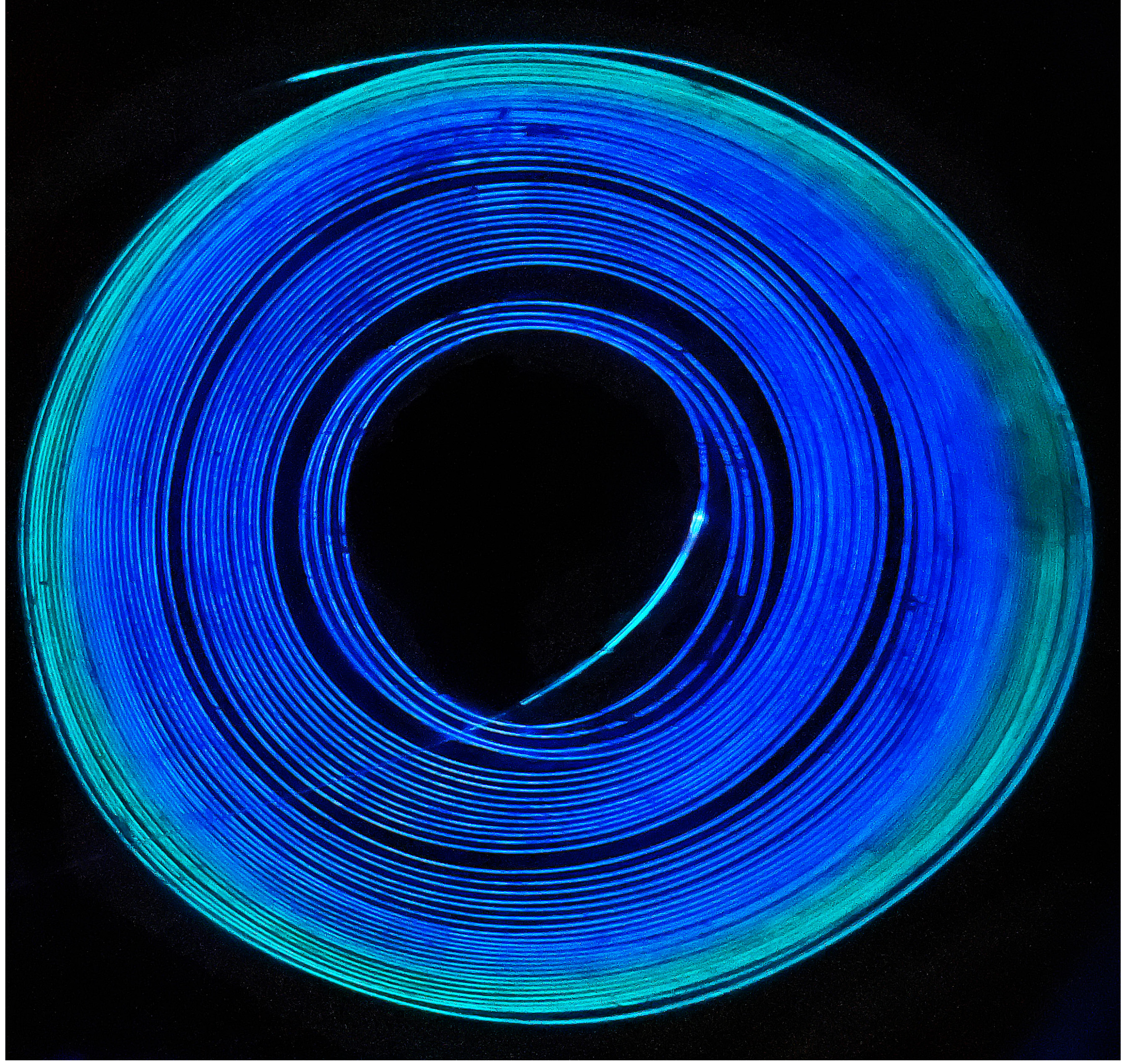
Photonics

While electronics has shaped the modern world, the future promises to be equally defined by photonics—the science and technology of generating, controlling, and detecting light. Photonics underpins fiber-optic communication, high-speed internet, and advanced imaging systems. Beyond communication, light-based technologies are transforming healthcare (through biomedical imaging), industry (through precision lasers), and computing (through photonic processors that promise unprecedented speeds and efficiency). By exploiting light–matter interactions at scales ranging from nanometers to full systems, photonics is poised to disrupt traditional electronics and open new frontiers in science and technology.

At CeNSE, research in photonics is led by Professors V. R. Supradeepa and Shankar Kumar Selvaraja, whose expertise spans nonlinear optics, high-power lasers, and silicon photonic integrated circuits.

Photonics research at CeNSE bridges fundamental studies and real-world applications. Researchers investigate how light interacts with different materials and structures, and then engineer devices that harness these interactions. This ranges from building chip-scale devices that guide and process light for computing and communication, to designing powerful laser systems that cut, sense, or process materials. By combining nanoscale device engineering with system-level integration, CeNSE develops technologies that impact global challenges in data communication, quantum science, and healthcare.



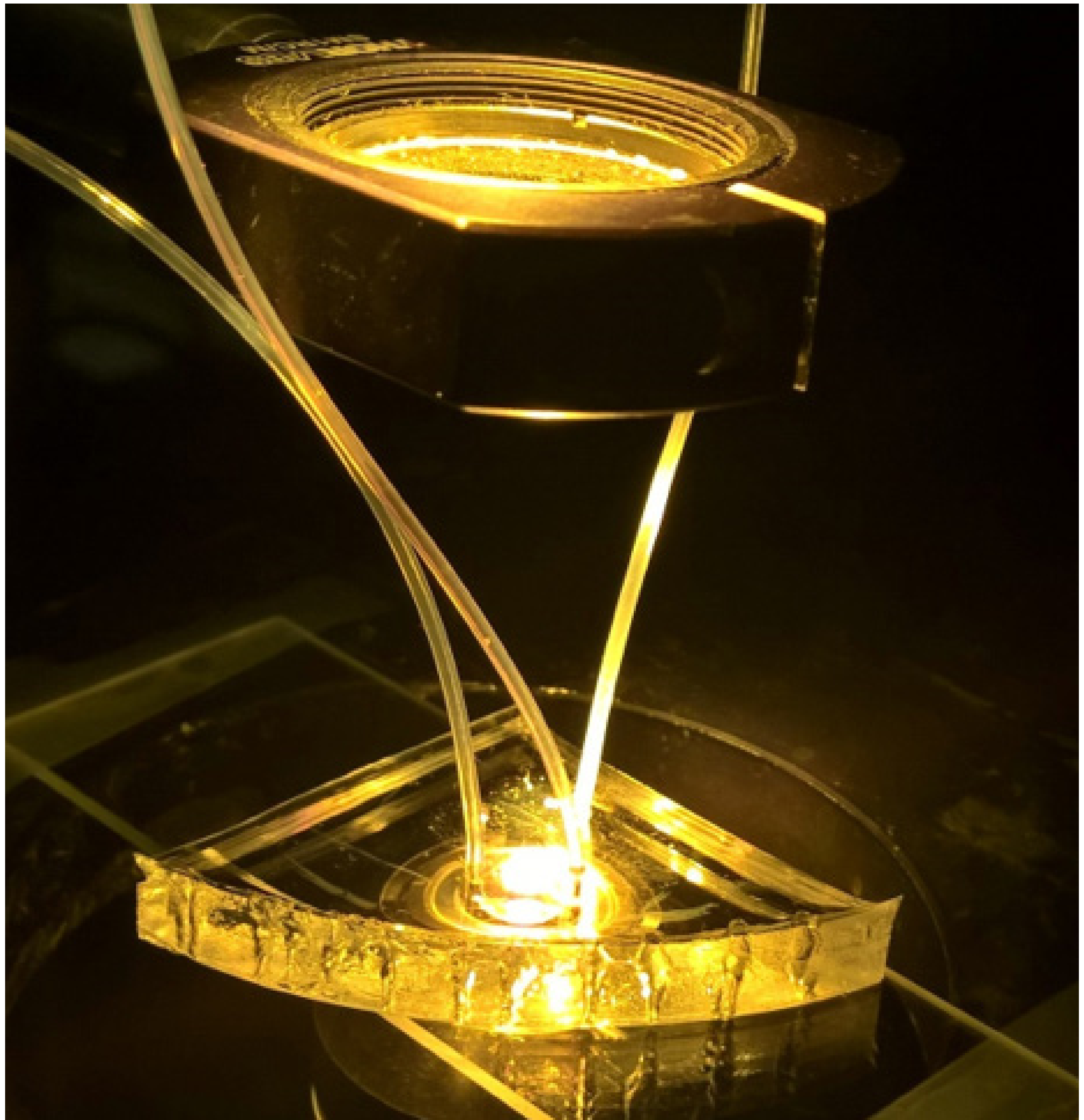


Ongoing research in photonics at CeNSE covers a wide spectrum of activities. At the nanoscale, the focus is on developing photonic integrated circuits (PICs) that can handle tasks in high-speed communication, advanced computing, sensing, and even photonic neuromorphic architectures. These circuits leverage silicon photonics and novel materials to realize compact, scalable platforms for information processing. On the other end of the spectrum, CeNSE is pioneering high-power fiber and solid-state laser systems, spanning output powers from milliwatts to kilowatts and wavelengths from the visible to the mid-infrared. These lasers are crucial for applications in the semiconductor industry, precision materials processing, advanced communication, biomedical imaging, and sensing. In addition, nonlinear optics research enables new techniques for wavelength conversion and optical signal processing, while photonic device innovations support emerging fields like quantum technologies and on-chip sensing. Together, these research threads position CeNSE at the forefront of shaping the light-powered technologies of the future.

Micro and Nano Electro Mechanical Systems and Microfluidics:

Micro-Electro-Mechanical Systems (MEMS) and their nano-scale equivalent, Nano-Electro-Mechanical Systems (NEMS), encompass the comprehensive technology involved in designing, fabricating, and utilizing micro and nano-scale mechanical structures that are closely integrated with the necessary electronics and/or optical components for sensing and actuation purposes. Micro-Nano fluidics is concerned with the distinct behaviour of fluids at the micro-nanoscale, where surface forces are predominant, resulting in phenomena such as insects being able to walk on water.

For practical applications, MEMS/NEMS and microfluidics systems require integration and packaging. The team at CeNSE is also engaged in developing 3-D integration and encapsulation technologies. 3D integration involves vertical layering of integrated circuits and other components, which enhances functionality, increases device density, boosts power efficiency, and minimizes signal delays, all within a compact space. Wafer-scale encapsulation simultaneously safeguards entire wafers, improving reliability and simplifying the manufacturing process.



Professors Gayathri Pillai, Saurabh Chandorkar, Prosenjit Sen, Akshay Naik, and Rudra Pratap are faculty members at CeNSE who specialize in MEMS/NEMS and microfluidics.

At CeNSE, the work on MEMS/NEMS and microfluidics covers everything from device design and materials growth to fabricating them in a cleanroom. It also includes comprehensive testing of materials, devices and packaged systems to ensure quality and reliability. The research work at CeNSE spans both fundamental studies and practical applications. The technologies created here are highly beneficial in the areas of biomedical science, space exploration, and defense.

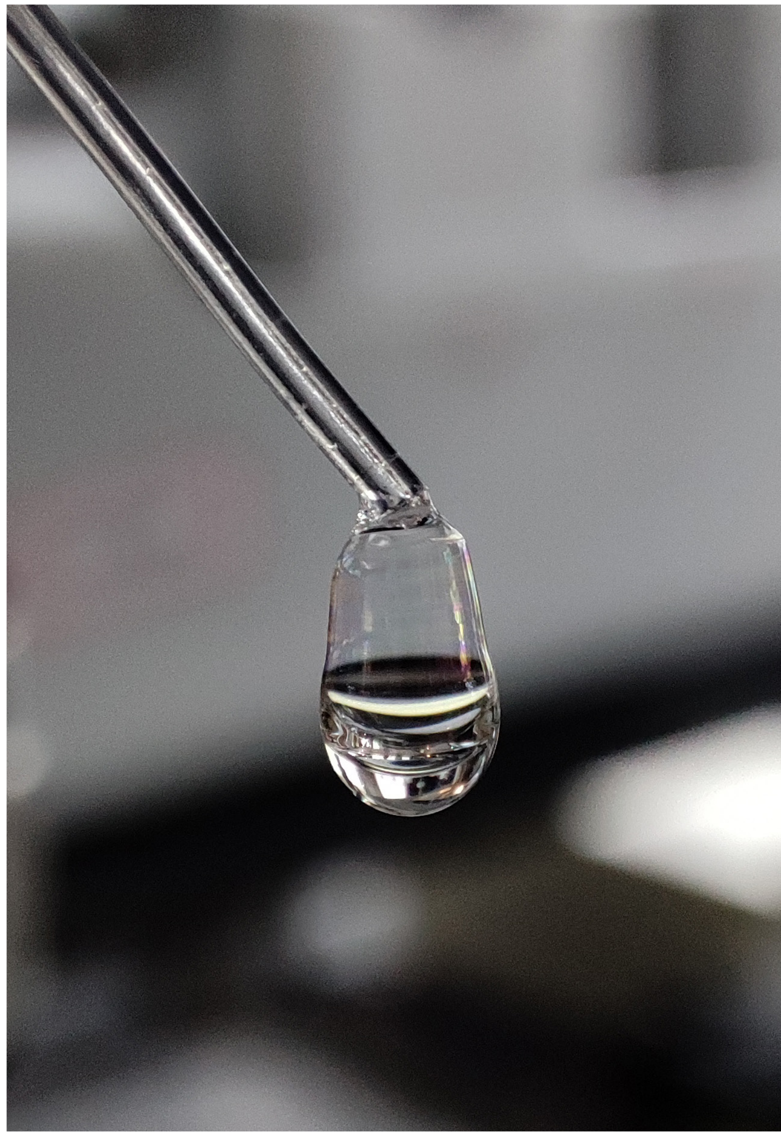
Current focus is on optomechanical systems, Piezo and RF MEMS, and NEMS fabricated using 2D materials, oxides, nitrides, and niobates. Research threads currently being pursued include sensing, signal processing, photonics, and quantum sensing and metrology. We also study surface and bulk acoustic wave devices and energy loss in NEMS/MEMS. Additionally, we are engaged in integrating two-dimensional materials and superconducting devices with MEMS/NEMS to develop novel quantum sensors and transducers. These devices serve as excellent tools for investigating fundamental aspects of nonlinear dynamics and quantum phenomena.

On the microfluidics front, we develops solutions for healthcare applications, including biosensing, nanoswimmers, cell cytometry, sorting, and DNA sequencing. We pioneer drop-on-demand printing and advance organ-on-chip platforms to mimic human organs, enabling disease and drug response studies.

CeNSE's research in 3D integration and encapsulation technologies supports the development of next-generation MEMS/NEMS devices with applications across various sectors, including healthcare, defense, and industrial automation. Research themes include interfacial microfluids, artificial nano-swimmers, droplet-based devices, and lab-on-a-chip platforms. These efforts have led to innovations such as pressure sensors, gyroscopes, microfluidic cytometry platforms, and organ-on-a-chip technologies.

CeNSE has also developed advanced devices using traditional and cutting-edge materials, like a multilayered paper-based pressure sensor made from corrugated cellulose and 2D SnS material, as well as a chemiresistive H_2S sensor based on an $MoSe_2$/ZnO nanocomposite. This research integrates MEMS, NEMS, packaging, and microfluidics to advance technology in fluid behavior, energy mechanisms, and active matter, paving the way for new solutions in diverse fields.

These devices are not only important for practical applications but are also of immense importance in fundamental research. MEMS business worldwide is currently estimated to be close to Rs 5 lakh crores. These include sensors, accelerometers, actuators which form critical components in a range of products including cars, cell phones and inkjet printers. Current research efforts at CeNSE in the area of NEMS/MEMS include MEMS and NEMS Sensors, Vibratory Mechanobiology, Materials for MEMS/NEMS and Fundamental research in NEMS/MEMS



Nano-Bio-Medical Interface:

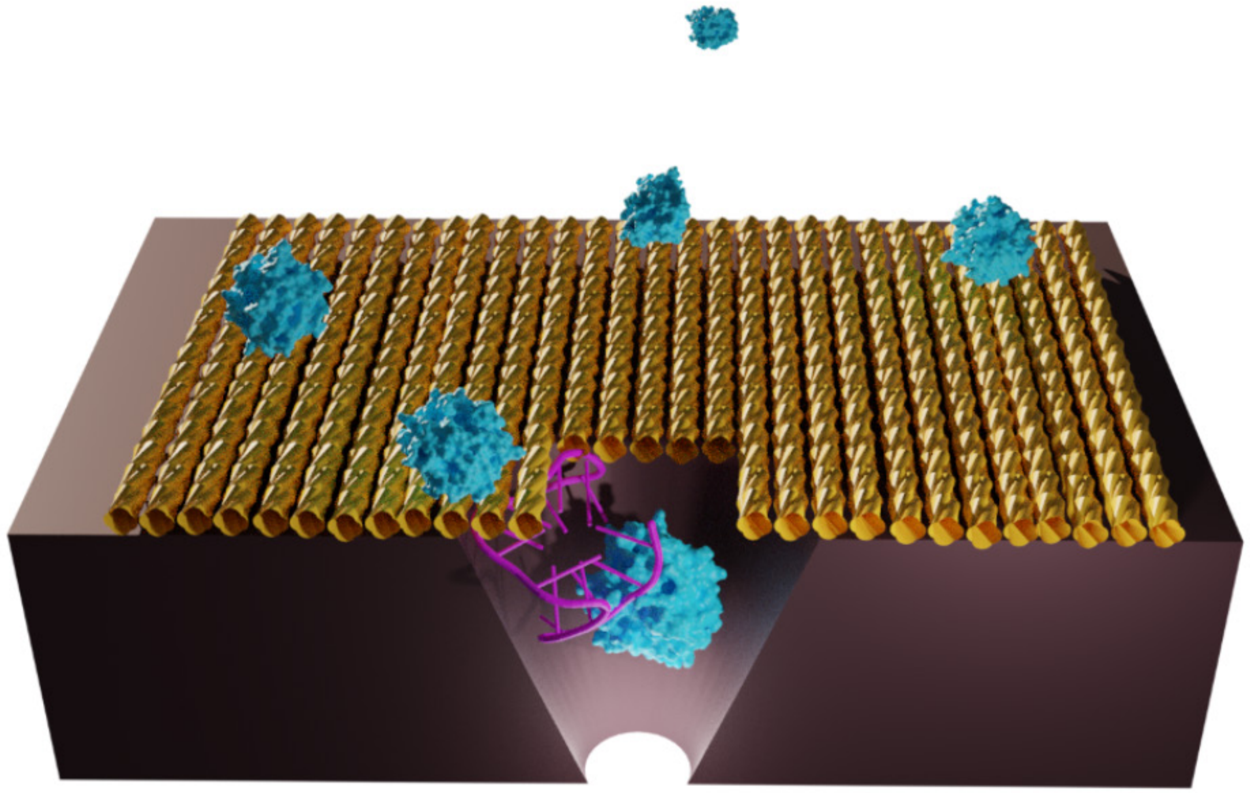
Improving human health and well-being is one of the most important challenges of our time, and nanoscience is uniquely positioned to make transformative contributions. At the nano–bio–medical interface, researchers explore how nanomaterials and devices can be used to sense, diagnose, and treat disease, as well as to probe and better understand the complexities of biological systems. By designing tools at the scale of molecules and cells, nanotechnology enables early diagnosis, targeted therapies, and new ways of interfacing electronics with biology. This interdisciplinary field combines physics, engineering, chemistry, and biology, paving the way for next-generation healthcare solutions.

with clinicians and startups, including PathShodh and Theranautilus, help translate these advancements into real-world applications.

At CeNSE, research in nano-bio-medicine is led by Professors Vini Gautam and Manoj Varma, who bring expertise in neuroengineering, biomaterials, bioelectronics, and molecular sensing technologies.

CeNSE researchers work at the cutting edge of biomedical innovation, developing nanoscale devices and systems that can both monitor and influence biological processes. These efforts include building sensors that detect molecular biomarkers for disease, engineering nanoscale probes that interact with neurons and tissues, and fabricating devices that mimic the environment of human organs on chips. By bridging nanotechnology with medicine, CeNSE's work is helping to create practical solutions for healthcare—from diagnostics and regenerative therapies to precision treatment platforms.

Ongoing work at CeNSE in nano-bio-medicine spans several pioneering directions. Researchers are designing nanostructured devices for neuro-regenerative therapies, which support nerve growth and enable the monitoring and stimulation of neuronal activity. Solid-state nanopores are being developed for highly sensitive single-molecule sensing and DNA sequencing, opening possibilities for rapid and accurate genetic diagnostics. Nanorobots capable of navigating inside the human body are being explored for targeted diagnosis and therapy applications, embodying the future of minimally invasive medicine. In parallel, electrochemical sensors are advancing health management for conditions like diabetes, offering affordable and accessible diagnostic tools. Microfluidic devices are also being engineered for biomedical applications such as organ-on-a-chip platforms, which provide realistic models of tissues and organs for drug testing and personalized medicine. Together, these projects demonstrate how CeNSE's expertise at the nano-bio interface is shaping the future of healthcare.

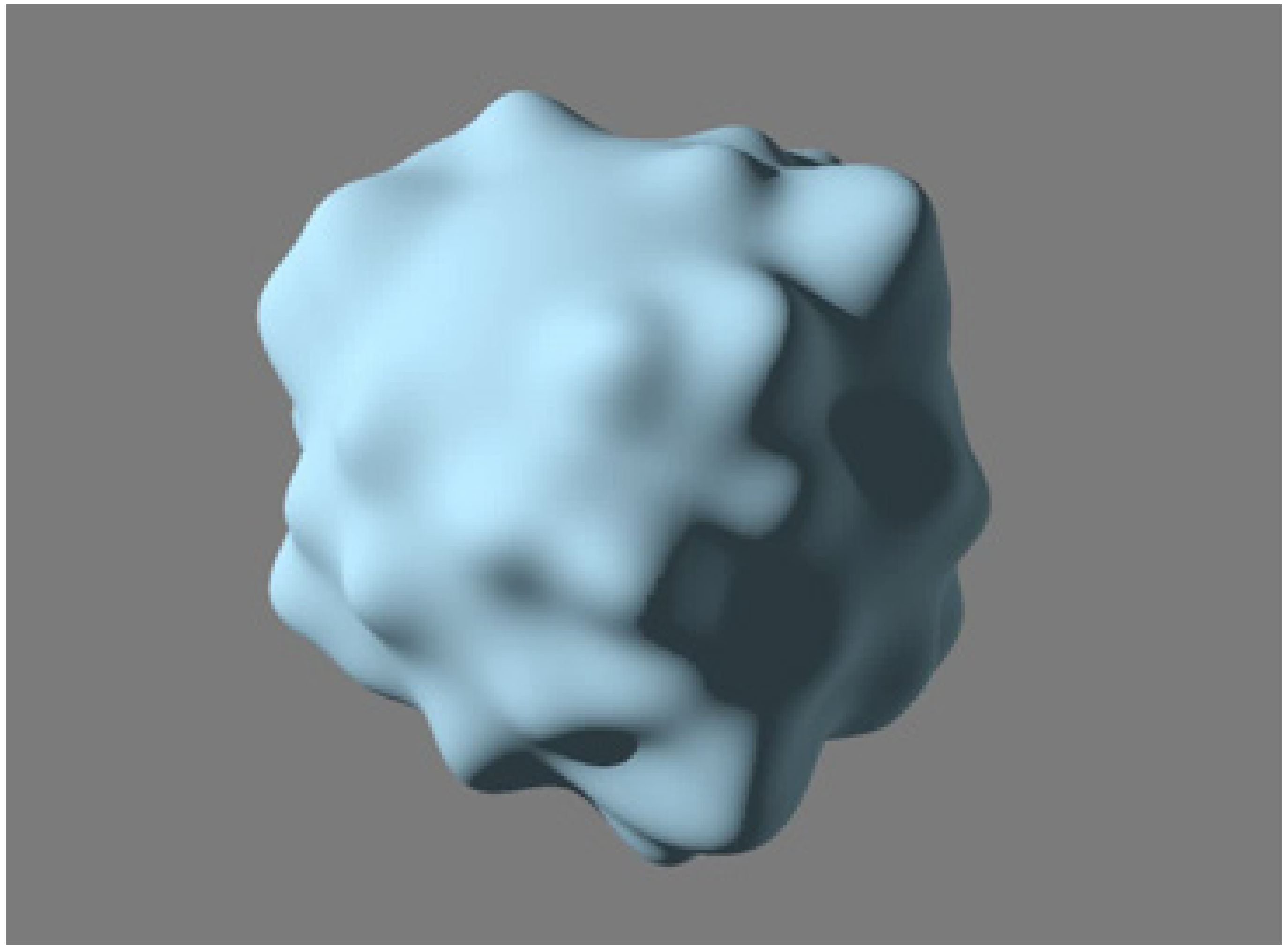


Physics and Quantum Science and Technologies

At the heart of modern physics is quantum science, which explores how objects behave at the smallest scales and coldest temperatures, often in ways that defy our everyday experience. Quantum technologies use these unique properties to build powerful computers, ultra-sensitive sensors, secure communication systems, and advanced materials. Together, physics and quantum science not only deepen our understanding of the universe but also drive innovations that shape the future.

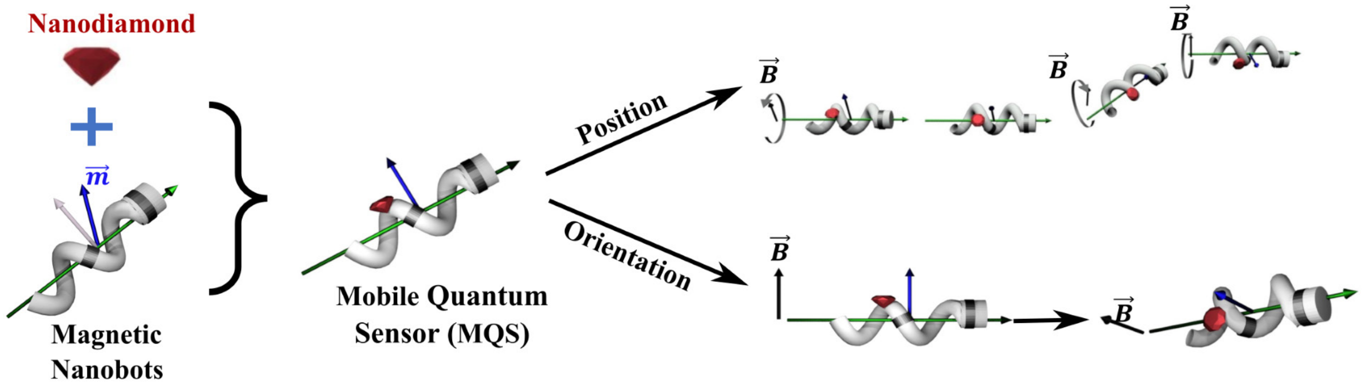
Faculty members in CeNSE whose core research area is centred around physics and quantum science and technologies include Dhavala Suri, Chandan Kumar and Ambarish Ghosh.

At CeNSE, researchers are exploring the frontiers of quantum science and technology through diverse and interdisciplinary efforts. Our work spans the development of novel quantum materials, such as topological insulators, superconductors, and van der Waals heterostructures, as well as advanced quantum devices like ultra-small atomic clocks and nanoscale magnetic field sensors. We study quantum fluids, design mechanical systems for quantum information storage, and engineer materials for future quantum computing platforms. These activities combine cutting-edge experiments, innovative fabrication techniques, and collaborations across disciplines, with the aim of deepening our understanding of quantum phenomena and creating technologies that can benefit society.



CeNSE conducts cutting-edge research in quantum science and technology, integrating advances in quantum materials, devices, and sensing platforms. Our work on quantum materials focuses on engineering and studying systems with novel electronic and magnetic properties — including topological insulators, high-temperature superconductors, van der Waals heterostructures, and oxide-based materials exhibiting skyrmions for spintronic and memory applications. Researchers design and control band structures for quantum computing platforms, explore proximity effects at the interfaces of topological, magnetic, and superconducting materials, and develop phase-change materials. These studies leverage sophisticated fabrication and characterization techniques such as molecular beam epitaxy, cryogenic low-temperature transport measurements, and custom-developed instrumentation and automation systems.

In quantum devices and sensing, CeNSE groups are advancing nanoscale systems capable of operating at or near quantum limits. This includes optomechanical resonators with on-chip optical cavities for displacement sensing and quantum information storage across multiple mechanical modes, as well as integrated quantum sensors combining NV-center nanodiamonds with magnetic nanosrobots for nanoscale magnetometry and NMR. Researchers also investigate quantum fluids, such as electron bubbles in superfluid helium, to study quantum melting and turbulence. Efforts in ultra-small atomic clock development, advanced microfabrication, and heterogeneous integration tackle the complex engineering challenges of quantum technology realization. CeNSE's work is deeply interdisciplinary, with strong collaborations across IISc and external partners, and a focus on translating discoveries into practical technologies through licensing and start-ups.



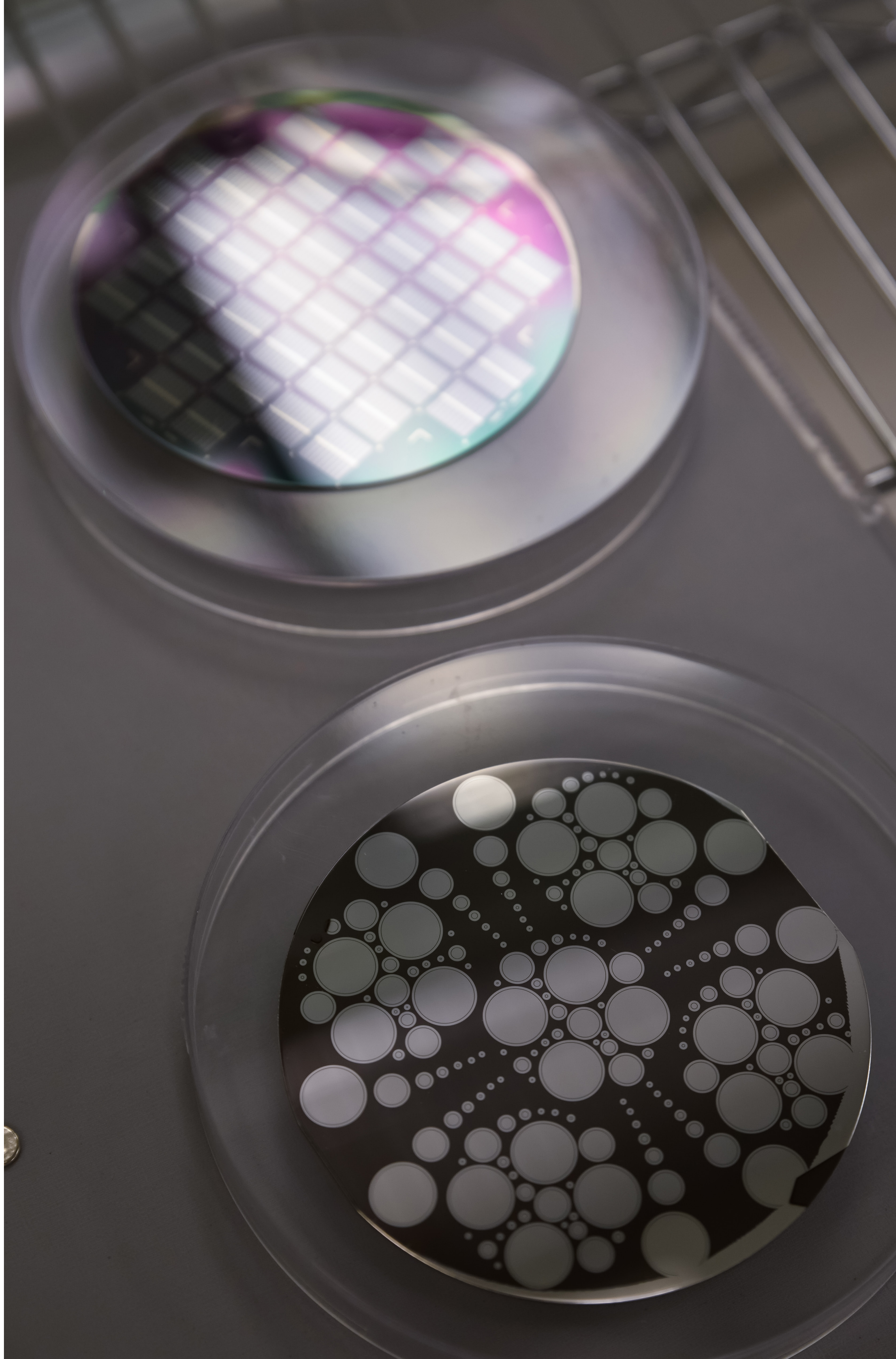
Brain-inspired computing

The human brain remains the most sophisticated computing system known, capable of learning, cognition, and decision-making with remarkable energy efficiency. Traditional computing systems, based on silicon CMOS technology, struggle to match this efficiency, especially as the demands of artificial intelligence (AI), machine learning (ML), and big data continue to rise. Brain-inspired, or neuromorphic computing, seeks to replicate the brain's architecture and functionality using novel devices and circuits. By mimicking the way neurons and synapses communicate, these systems promise to deliver powerful computation at a fraction of the energy consumed by conventional computers, offering the foundation for the next generation of AI hardware.

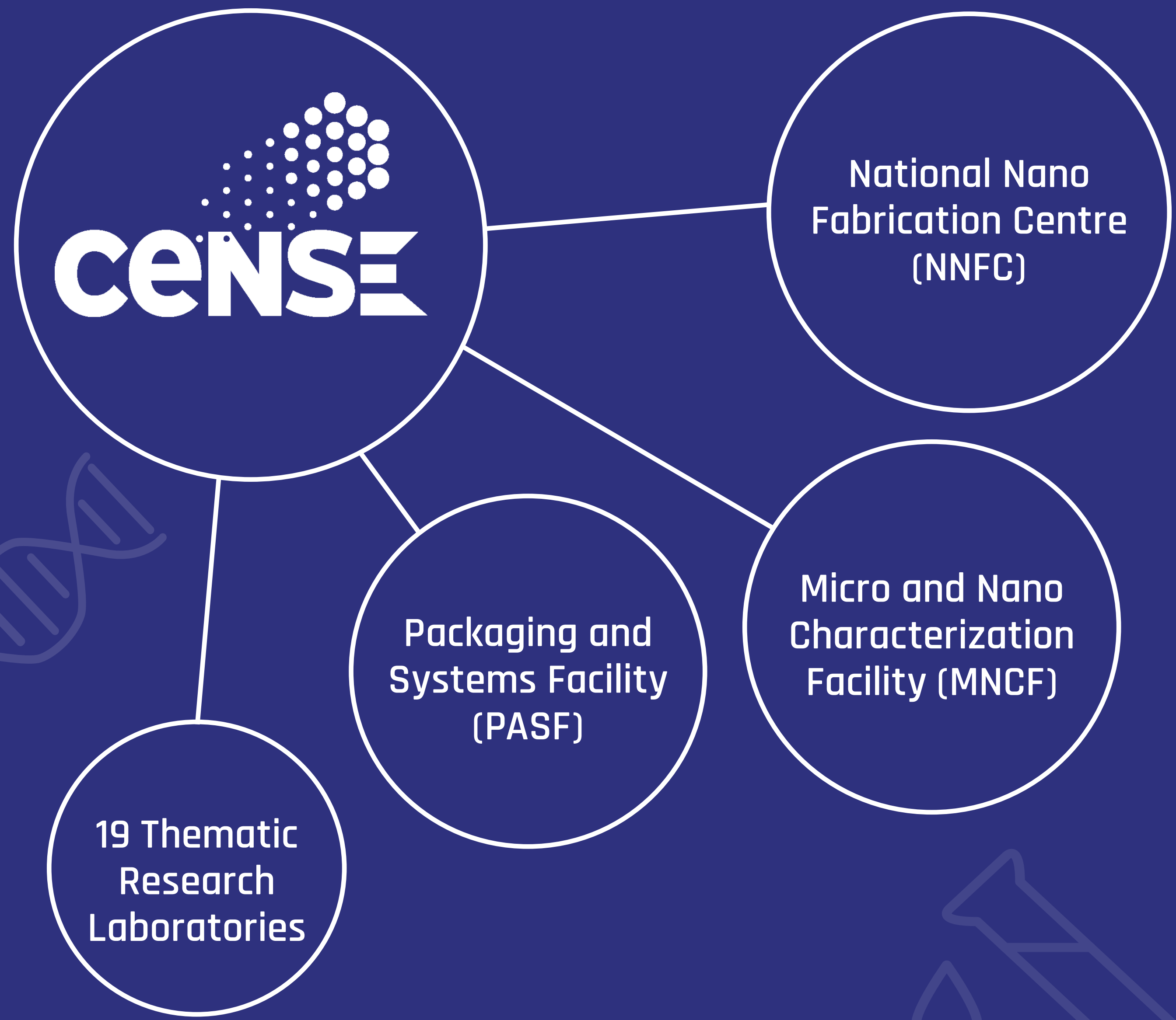
At CeNSE, brain-inspired computing research is driven by a multidisciplinary team, including Professors Sreetosh Goswami, Navakanta Bhat, and Pavan Nukala who bring expertise in materials science, nano-patterning, device physics, and system-on-chip integration.

Researchers at CeNSE are engineering computing platforms that function more like the human brain, rather than conventional digital machines. Their work integrates materials innovation, nanoscale fabrication, and circuit design to build devices that can process information in parallel, adapt dynamically, and consume vastly less power. By creating analog, neuromorphic hardware, CeNSE aims to go beyond current artificial and deep neural networks, developing computing systems capable of tackling complex real-world problems such as image recognition, motion detection, and real-time decision-making.

Research in brain-inspired computing at CeNSE spans materials, devices, and system architectures. One key thrust is the development of spiking neural networks and circuits tailored for applications in cybersecurity and bioinformatics, where rapid and adaptive data processing is critical. Another focus is on materials with multiple thermodynamic transitions, which enable logic parallelism and reconfigurability—essential for efficiently handling the vast scale of modern data. Researchers have also designed robust molecular memristors, based on a ruthenium complex of an azo ligand, which provide tunable transformation characteristics and enhanced flexibility for neuromorphic devices. These efforts collectively aim to build analog computing platforms that achieve a million-fold improvement in energy efficiency compared to conventional computers, while addressing NP-hard problems and powering the future of AI, ML, and IoT applications.



Research
- State of the art Facilities



National Nano Fabrication Centre – NNFC

NNFC houses a 14000 sq. ft. state-of-the-art class 100 and class 1000 clean room facility with micro- and nano-fabrication facilities. It is a 24x7 operating and ISO certified facility that has a dedicated staff of nearly 50 engineers and technicians who maintain the process tools and develop unit process modules to support complex process integration for research and prototyping. Research efforts at NNFC are being taken to the next level by development of more complex process flows and final device or module prototyping. NNfC is also home to GEECI a low volume production foundry for GaN devices. The capabilities of GEECI can also be availed by contacting NNfC.

The mission of this facility is to support research and educational objectives of CeNSE, IISc and offer state of the art fabrication facilities and services to nanoscience academic (through INUP), related industries and national laboratories across the nation and the world.

Its capabilities include

• Photolithography: Critical dimensions of 1 µm by optical and down to 10 nm by e-beam lithography. Wafer scale, 250 nm through a stepper, and down to 10 nm through a 100 kV ebeam are now available through the GEECI line.

• Deposition: Chemical & physical vapour deposition (CVD) of most commonly used semiconductors and dielectrics, such as Si, SiGe, Ge, SiO_2, SiNx, Al_2O_3, TiO_2, and metals by LPCVD, PECVD, e-beam and sputtering.

• Etching: Wet and dry etching of the most commonly used semiconductors and dielectrics.

• Process Development and Integration: Developing new and customized processes for MEMS/NEMS devices, microfluidic structures, and semiconductor devices for industries and other laboratories.

• Inline characterization: Using various metrology tools involved in device fab.

NNfC now houses Gallium Nitride Ecosystem Enabling Centre and Incubator (GEECI), a prototype GaN fab being setup under the aegis of SID (Society for Innovation and Development), IISc.

Services offered by NNFC:

• Wafer Processes: Films, lithography, annealing, doping & diffusion, wafer bonding, and dicing.

• Consultation: Fabrication and characterization.

• Training: Microfabrication (theory and hands-on), equipment training, custom trainings (vacuum, etching, lithography and MEMS/NEMS)

• Project and product development: So far gas sensors, pressure sensors and CVD reactor have been developed.

For a list of all resources, services provided, how to become a user of the facility visit, and more information please visit http://nnfc.cense.iisc.ac.in/.

Micro and Nano Characterisation Facility – MNCF

ISO certified, operating 24x7 and spread over an area of 7000 sq. ft. the Micro and Nano Characterization Facility (MNCF) at CeNSE, IISc, offers a comprehensive range of material and device characterization services through over 50 state-of-the-art instruments and a team of 20+ skilled staff.

Its capabilities include

• Electrical Characterization: Multiple probe stations for current-voltage (I-V), capacitance-voltage (C-V), conductance-frequency (G-?) measurements, measurements at temperatures from 4 K to 400°C and RF testing up to 67 GHz.

• Mechanical Characterization: Tools to probe mechanical properties at micro and nano scales like atomic force microscopes with capabilities to measure functional properties for piezo MEMS, optical profilometer, micro-system analyzer, scanning acoustic microscope, piezo nano displacement systems and laser Doppler vibrometer.

• Material Characterization: In-depth analysis of micro and nano structure and chemistry of materials using FESEM, CL, FIB, XPS, and TEM with multi-modal capabilities.

• Optical Characterization: Comprehensive characterization of bulk materials and thin films using Raman spectroscopy, FTIR, XRD, UV-Vis-NIR, and more. MNCF also houses optical microscope for material analysis, stereo microscope, and fluorescence microscope.

Visit for further detailed information, http://mncf.cense.iisc.ac.in/

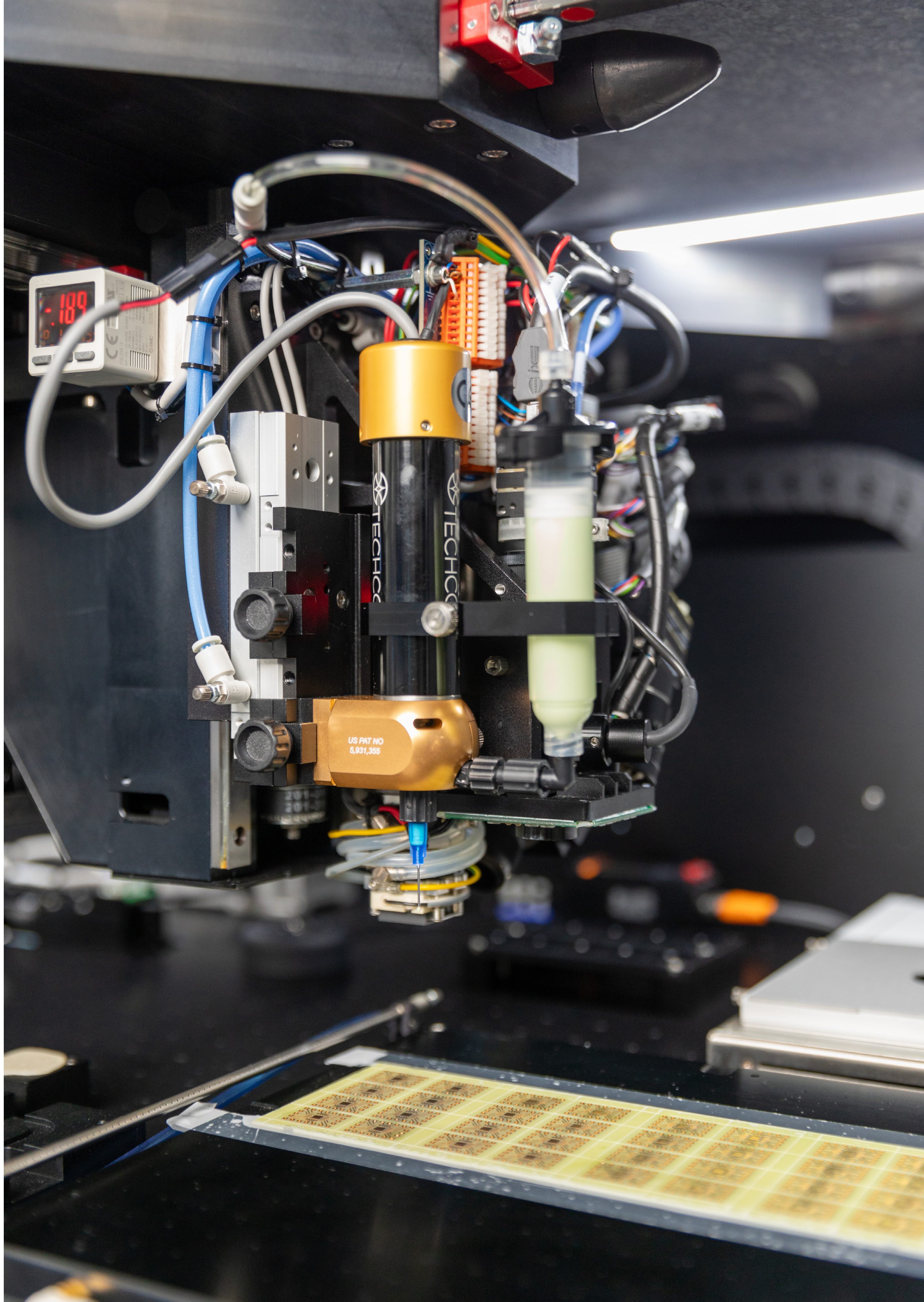
Packaging and Systems Facility- PASF

Spanning over an area of 2500 sq.ft. with 1000 sq.ft. semiclean room of Class 10K PASF provides embedded design services, advanced semiconductor packaging services using a suite of 20 tools and over 20 design services and 12 staff members. A sister facility set up as part of GEECI offers more services that can be availed through PASF.

Packaging facility provides all the infrastructure required to build a packaged device using a fully processed wafer.

- Testing services: Pressure sensor calibration and test services of various types and ranges including reliability testing using thermal chamber, shock test based on customized fixture for high reliability applications.
- semiconductor packaging services: Wafer dicing and grinding, wire bonding, die attach, die inspection, parylene coating, plasma cleaning, flip chip bonding, laser welding and many more.
- Design services: Embedded hardware and firmware, mechanical design, analog product design, PCB Design and modelling, prototype hardware assembly and testing.
- Key equipment and tools: Wafer dicing machine, semi automatic wire bonder, flip chip bonder, laser welding, sensor testing and calibration, thermal chambers for reliability testing, 3D printing including carbon fibre filament

To know more visit: https://sysefandpackagingfacility.cense.iisc.ac.in/



Thematic Research Groups

Advanced Opto-nano-Electronics (A-OnE) Lab

PI: Aditya Sadhanala

This group has a wide range of interests from material development, device engineering, testing and development, photo-physical and optoelectronic studies and optoelectronic applications. Their next gen photovoltaics and solar cell research include development of thin-film optoelectronics using organic, perovskite and other semiconductors.

NEMS@CeNSE Lab

PI: Akshay Naik

This research group focuses on physics and applications of nanomechanical devices. Activities in this lab include fabrication of resonant nanomechanical devices with frequencies in the very high and ultra-high frequency range, novel transduction and actuation schemes, study of noise processes that govern the frequency stability and the utility of these devices for various applications.

QuAN2M Lab

PI: Ambarish Ghosh

This lab focusses on quantum fluids, active nanoswimmers and 2D metamaterials. They design and develop active nanoswimmers for studying soft matter physics, quantum sensing and in applications like nanorobotics for targeted drug delivery and microsurgery. They study electron bubbles in quantum fluids like super He4 and study plasmonics & 2D metamaterials for quantum sensing.

Quantum Device Engineering Lab

PI: Chandan Kumar

state of art National Nano Fabrication facility. They employ different characterization and measurement techniques to address the open questions in these low dimensional quantum materials.

INOX Quantum Materials Lab

PI: Dhavala Suri

This lab synthesizes materials using the technique of molecular beam epitaxy (MBE) and sputtering. They engineer materials and their interfaces, in which properties of the interface are significantly different from that of the materials constituting the interface. They fabricate nano & micro devices out of these materials so that they are useful for technological applications. They study their properties - electronically, structurally and magnetically, at low temperatures in the presence of magnetic / electric fields.

Wide Bandgap Devices Lab

PI: Digbijoy Nath

They work on wide band gap materials and devices, including Gallium nitride based transistors for power switching and RF applications. They develop and study deep-UV photodetectors based on III-nitrides, gallium oxide and their heterojunctions. Additionally they work on 2D layered materials for memristive and synaptic devices.

Multidisciplinary Micro and Nano Systems Laboratory

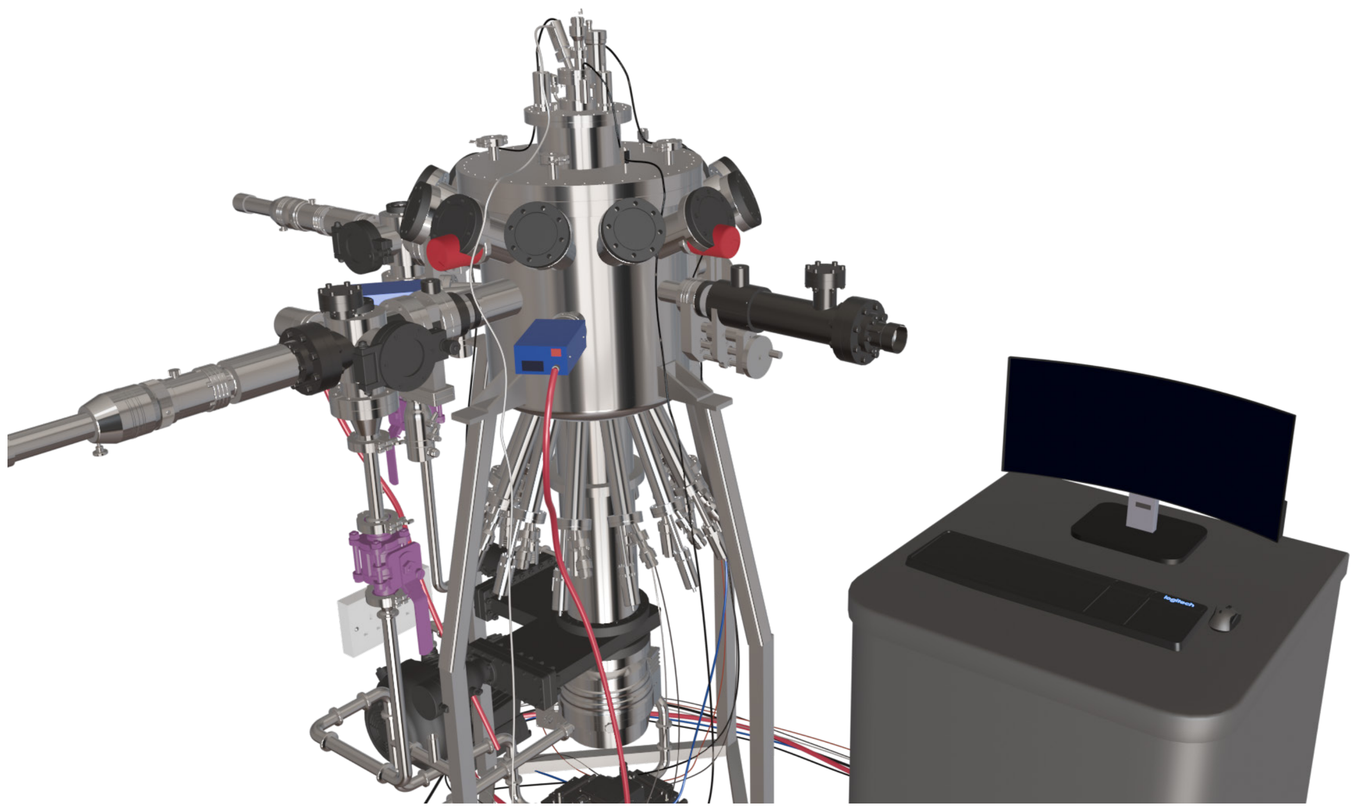
PI: Gayathri Pillai

This lab focuses primarily on the fabrication, design, and characterization of Micro and Nano Electromechanical Systems (M/NEMS). They work on Radio Frequency communication, nonlinear device physics, piezoelectric material investigations, and acoustic sensors/actuators.

Nanopore Research Group

PI: Manoj Varma

They seek to develop nanopore-based sensing and sequencing techniques for biomedical and healthcare applications. Their current research activities look at several aspects of nanopore technology such as, micro and nano-fabrication techniques, biochemical functionalization, novel read-out methods, computational modeling and molecular dynamics simulations.



Nanodevices and Sensors Lab

PI: Navakanta Bhat

They conduct in depth research on various aspects of Nanoelectronics, MEMS and sensors. They work on electrochemical biosensors, SERS & lab-on-a-chip devices, gas sensors, AlGaN/ GaN HEMTs, 2D nanoelectronics with MoS2 & graphene and 2D nanoelectronics for ISFETs and BIOFETs

Functional Thin Films and Electron Microscopy Lab

PI: Pavan Nukala

The lab conducts investigations on influence of process parameters on the structure and properties of functional thin films, leading to the development of micro and nano sensors and actuators. Facilities include evaporation, sputtering and ion beam systems, designed and fabricated for specific requirements.

Microfluidic Devices and Heterogenous Systems Laboratory

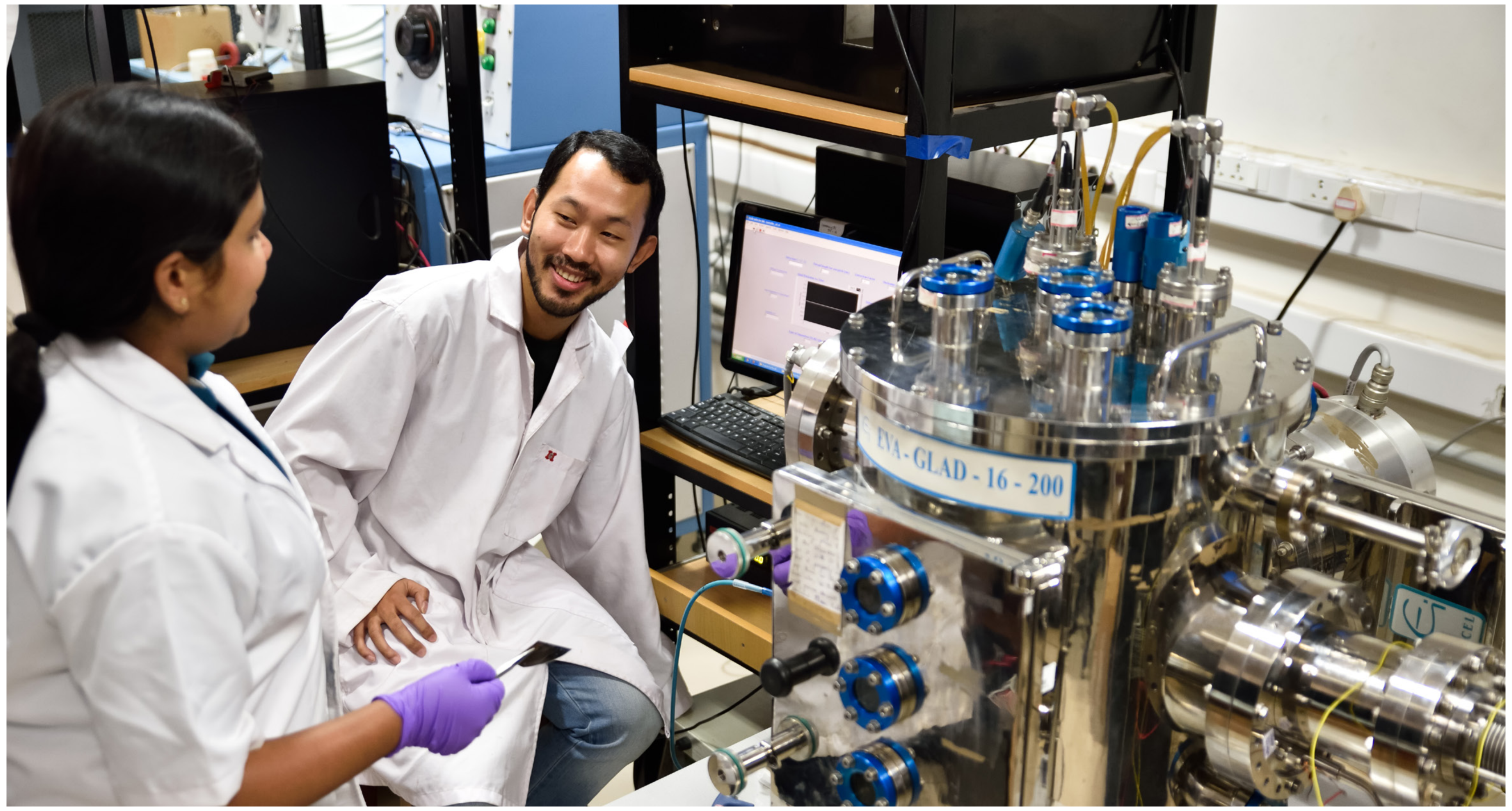
PI: Prosenjit Sen

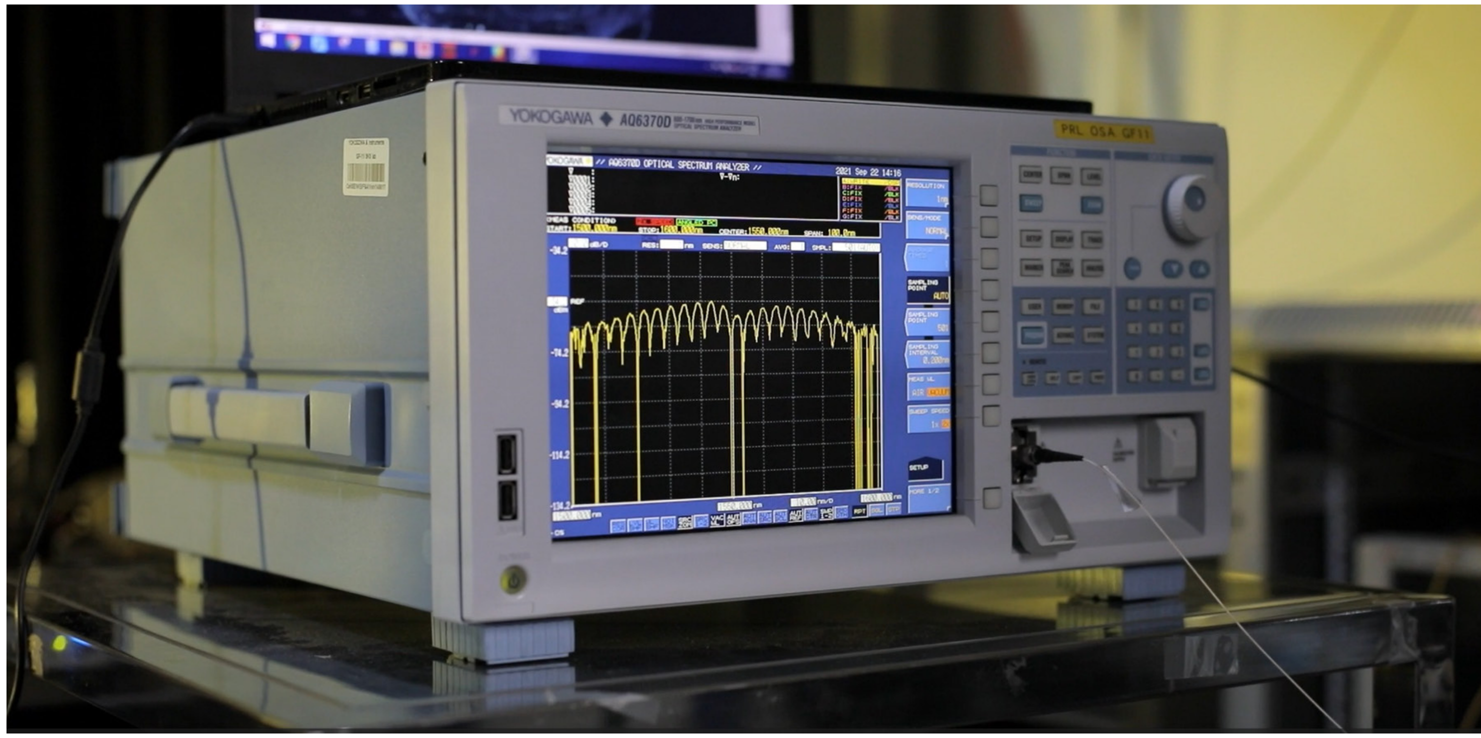
This lab works on Interfacial Microfluidics for Lab-on-Chip & other applications. They synthesise nanostructures for Self-Cleaning and Anti-Microbial Surfaces and they investigate Cells for Cytometry and Separation of CTC's using interfaces. They also perform 3D Heterogeneous Integration of Micro-Nano Scale Devices for System Scaling.

MEMS Laboratory

PI: Rudra Pratap

Design and development of MEMS inertial sensors, MEMS microphones, capacitive and peizoelectric ultrasound transducers (CMUTs and PMUTs), suspended gate FET-coupled MEMS sensors, all-optical actuation and sensing MEMS, study of energy dissipation in micro and nanoscale structural vibrations, study of microscale biosensors in insects, haltere dynamics, and cell dynamics. Facilities include experimental measurement tools for subnanoscale vibrations, angular rate measurements, ultrasound transmitters and receivers, and optical imaging, including high speed videography.





Microsystems and Fluctuation Dissipations Laboratory

PI: Saurabh Chandorkar

This lab studies various physical phenomena through MEMS resonator configuration and explores the possibility of use of MEMS/NEMS for various engineering applications. They work on studying the energy loss mechanisms in micro/nano scaled resonators, wafer scale packaging for MEMS, human-computer modality enhancements and low cost system development for IC fabrication and characterization

Photonics Research Laboratory

PI: Shankar Kumar Selvaraja

Photonics Research Laboratory is a dedicated characterization facility for integrated photonic devices and circuits. The primary focus of the lab is to develop high-speed integrated photonic devices for next-generation computing and communication. The lab houses a comprehensive high-speed electro-optic testbed for characterizing bandwidth of discrete devices such as Wavelength filters, light modulators, photodetectors, and amplifiers in the O, C, and L bands. The device and circuits developed are tested using a custom developed vertical and horizontal optical probe station. Research in the lab is also aimed at exploiting the photonic circuit for on-chip gas and biosensors. Spectrometers spanning from visible to Near-IR are used to develop such on-chip sensors.

Molecular Neuromorphic computing and Cognitive Systems Lab (MoNCS)

PI: Sreetosh Goswami

This group works on design of brain inspired computing devices, electronic and ionic non-linear dynamics in molecular memristors, ultralow energy electrical switching devices, nano-optoelectronics using molecular thin films, low T transport in electronic devices, in-situ Raman and absorption spectroscopy, heterostructures: oxide-molecular films, 2D-molecular films and magnetism in redox active transition metal complexes

Crystal Growth Lab

PI: Srinivasan Raghavan

The crystal growth lab houses capabilities to deposit thin film of oxides by pulsed laser deposition and sputtering, chemical vapor deposition of 2D materials and III-nitrides (GaN and AIN). They work on establishing correlation between the synthesis conditions, the microstructure of the film deposited, the functional properties and performance of devices made with these materials.

FALCON Lab

PI: V R Supradeepa

This laboratory focuses on development of novel optical sources and processing technologies for varied applications from optical communications, sensing and biomedical imaging to high power industrial and defense lasers. Fundamental research on non-linear optics in guided-wave devices, an enabler for many of the novel laser technologies, is also undertaken.

Heterojunction Lab

PI: Sushobhan Avasthi

This laboratory conducts research in design, fabrication and characterization of novel electronic devices. The focus is on integrating different semiconductor materials with each other, e.g. silicon with metal-oxides or germanium to silicon. Such heterogenous integration introduces novel functionality and improves performance for the next generation of electronic devices.

Neuro Electronics Laboratory

PI: Vini Gautam

The research emphasis is on interfacing neurons of the brain with electronic devices. The broad aim is to understand how learning takes place in biological neuronal networks using electrical and optical recording and stimulation, and to utilize it for robotic control. Facilities available are: nanofabrication of multi-electrode arrays, tissue culture laboratory for neuronal culture, electrophysiology rigs for multi-electrode array recording with feedback control, an electronics lab bench, high-end microscopes with fast fluorescence imaging and optical stimulation of neurons using a femto-second laser.

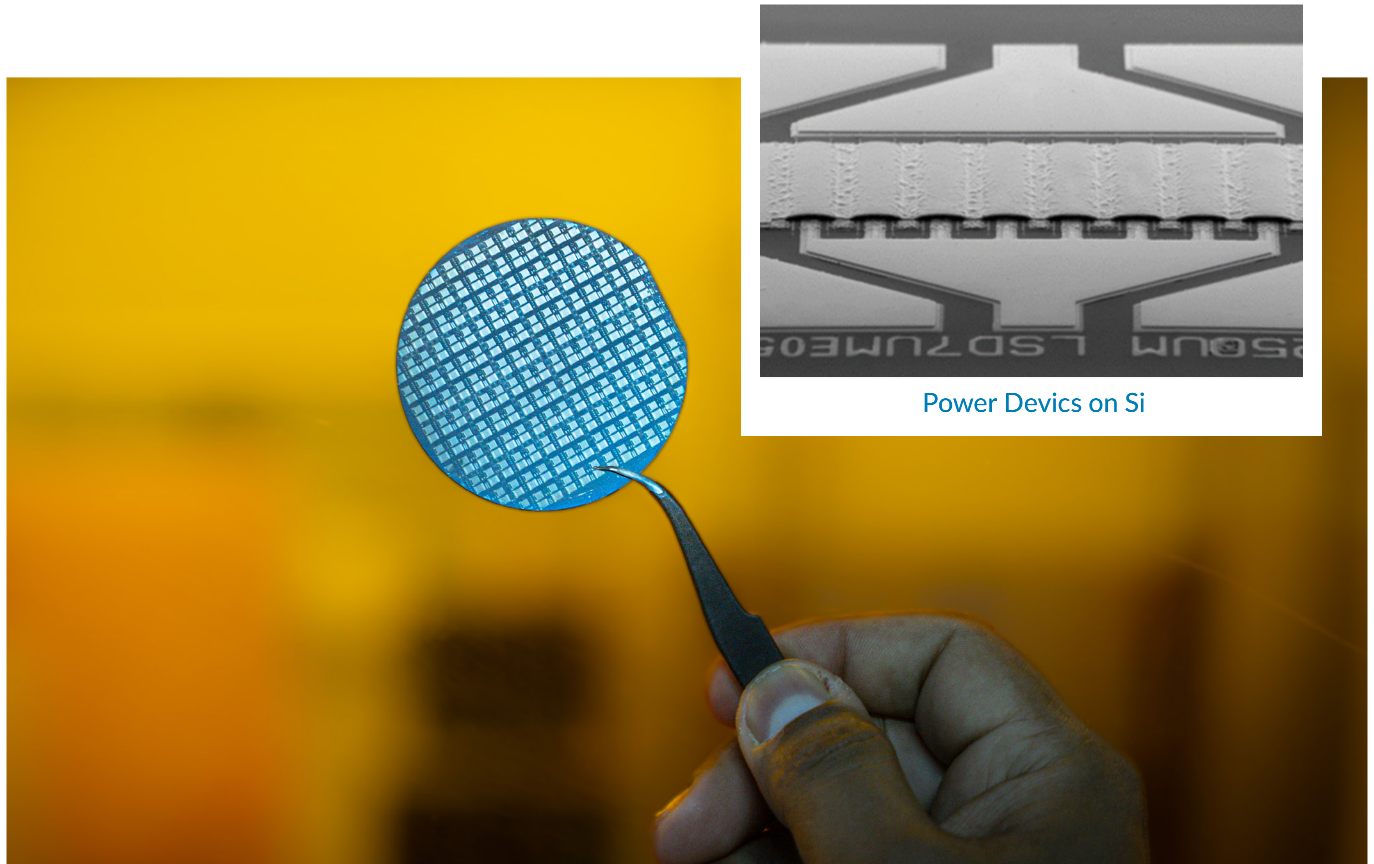
Technology Development

The primary goal of CeNSE is to translate cutting-edge research and technological innovation into the development of products, services and to help commercialize them successfully. CeNSE works with industry and government labs to develop new technology and is able to transfer production-ready technology. Even though a young department, CeNSE has already developed and transferred several technologies. We list a few of them below:

GaN Transistors for power and RF applications

PI: Srinivasan Raghavan and Digbijoy Nath

GaN could be considered to be the most important semiconductor after Si. GaN optoelectronics, light emitting diodes and laser diodes, is very well commercialized. GaN electronics based on HEMTs (High Electron Mobility Transistors) for power, such as in EV charging, and high frequency and RF, for 5G and radars, electronics is currently gaining traction. In CeNSE, post many years of establishing the material and growth technology, a low volume production foundry, GEECI has been set up to enable indigenous capability in GaN electronics. A startup AGNIT semiconductors pvt. limited has been incubated by IISc faculty members and is in the process of commercializing this indigenous GaN technology.



Power Devics on Si

GaN RF Transistor fabricated on the low volume production line GEECI location in NNfC

High Power Fiber Laser Module

PI: V R Supradeepa

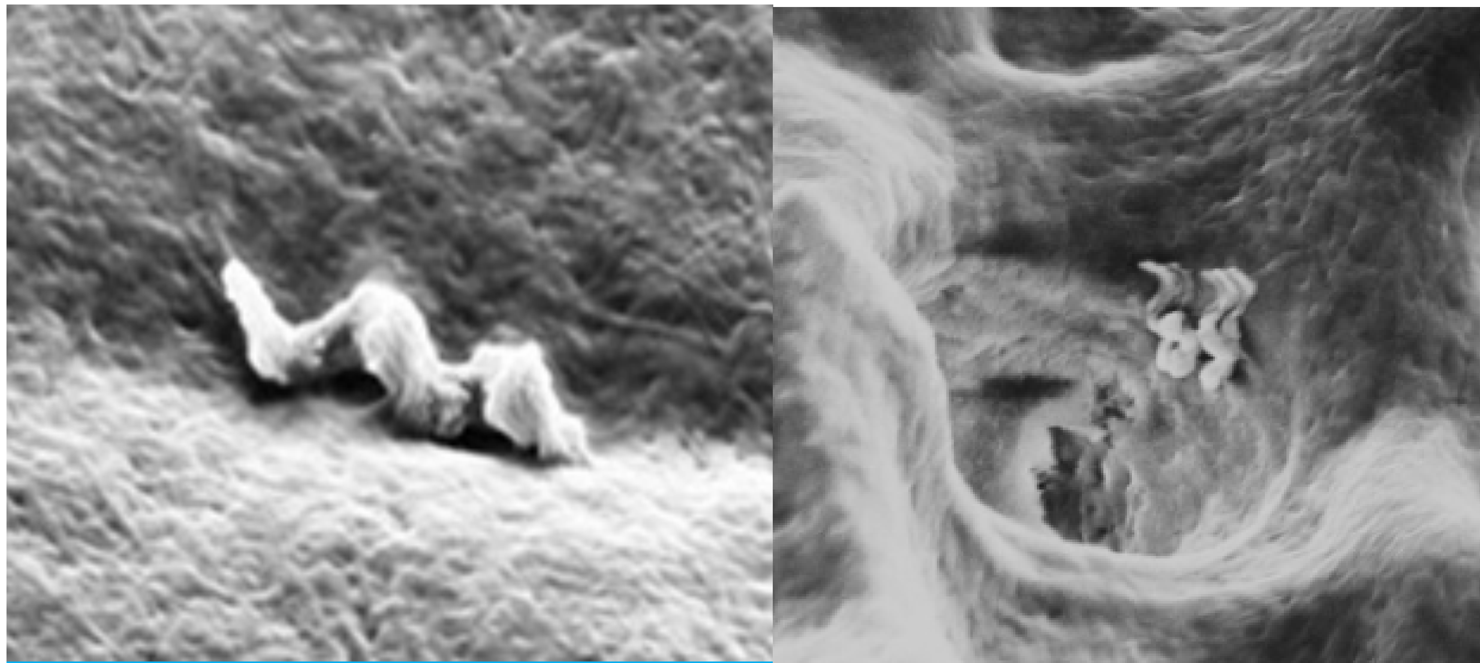
High-power fiber lasers have become essential across industrial, defense, medical, sensing, and scientific domains due to their effectiveness in applications such as cutting, welding, drilling, and directed energy systems. However, challenges like maintaining beam quality and managing optical nonlinearities persist at higher power levels. CeNSE's NNetra project addresses these issues by developing indigenously designed fiber laser modules in collaboration with BEL. Two prototypes—a 400W air-cooled and a >1kW water-cooled module—were created for portable and vehicle-mounted defense applications. In prototype demonstration 2kW level lasers were developed, both in the conventional version and its advanced counterpart, the narrow-linewidth version used for beam combining of lasers, Such lasers form a critical component of directed energy systems. These systems aim to replace imports, ensuring enhanced reliability and cost-effectiveness.

High power fibre laser

Remote magnetic navigation of multifunctional nanoprobes in biological tissues: towards spatially targeted cancer theranostics

PI: Ambarish Ghosh

Developed multifunctional micron-sized helical probes that can be guided magnetically in biological tissues (ex vivo) with optical feedback control and studied their feasibility as futuristic cancer theranostic vehicles. The main aim is to remotely guide and image a system of multifunctional magnetic nanoprobes in biological tissues under ex vivo conditions. This is based on a magnetic guidance system with active optical feedback control. They have also integrated multiple imaging and therapeutic modalities within these probes **to achieve targeted delivery of drugs in cancer patients. Ultimately, this approach would enhance the local availability of drugs while reducing the toxicity associated with chemotherapy.**

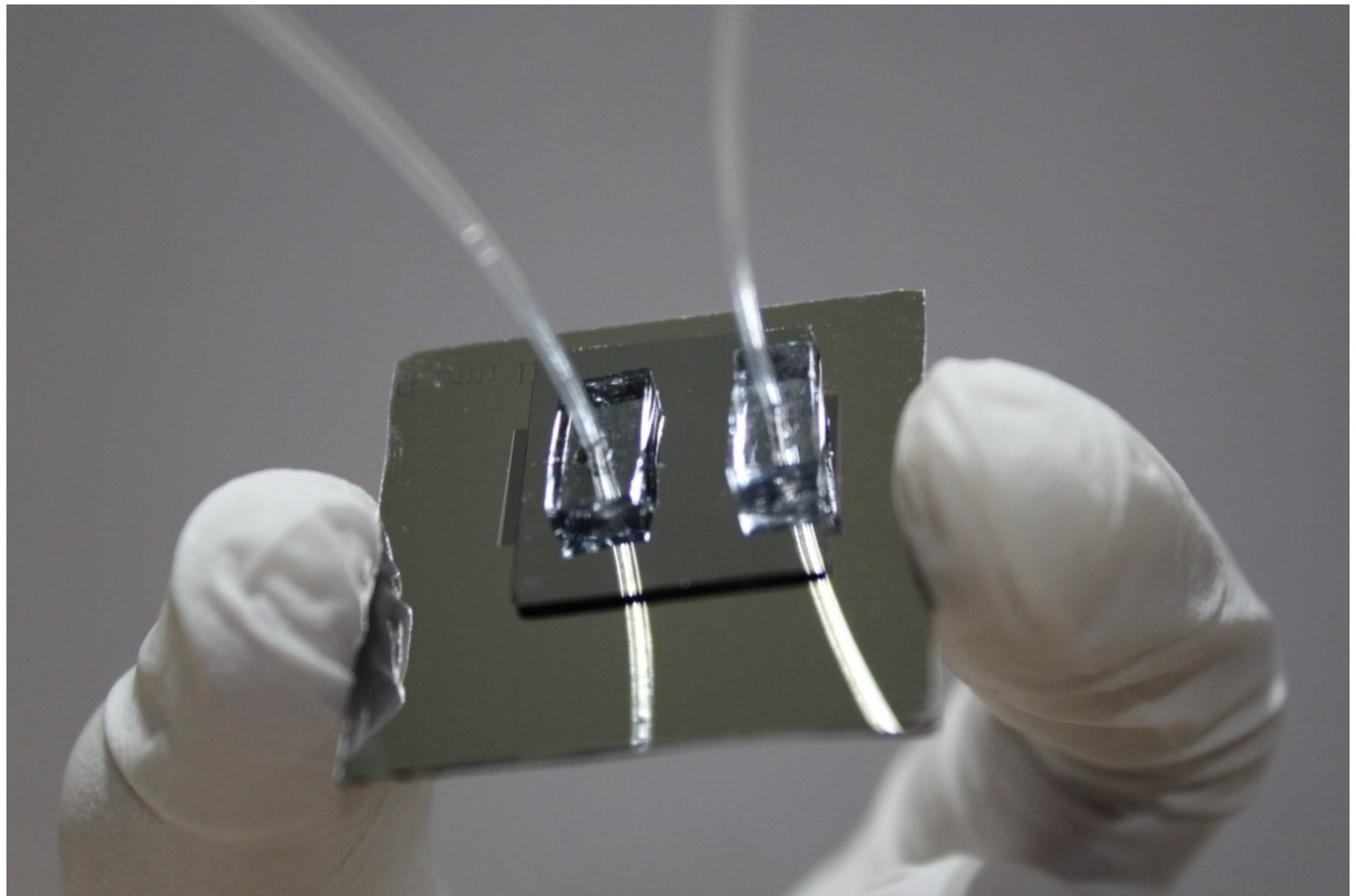


Nano robots for oral health

Integrated Photonic Sensor Technology for Ethylene gas monitoring

PI: Shankar Kumar Selvaraja

Designed, developed and demonstrated a Mid-IR gas sensor using on-chip photonic integrated circuit. In addition to this, developed a portable on-chip mid-IR photonic sensor system to reduce the post-harvest loss of fruit through Ethylene gas monitoring.

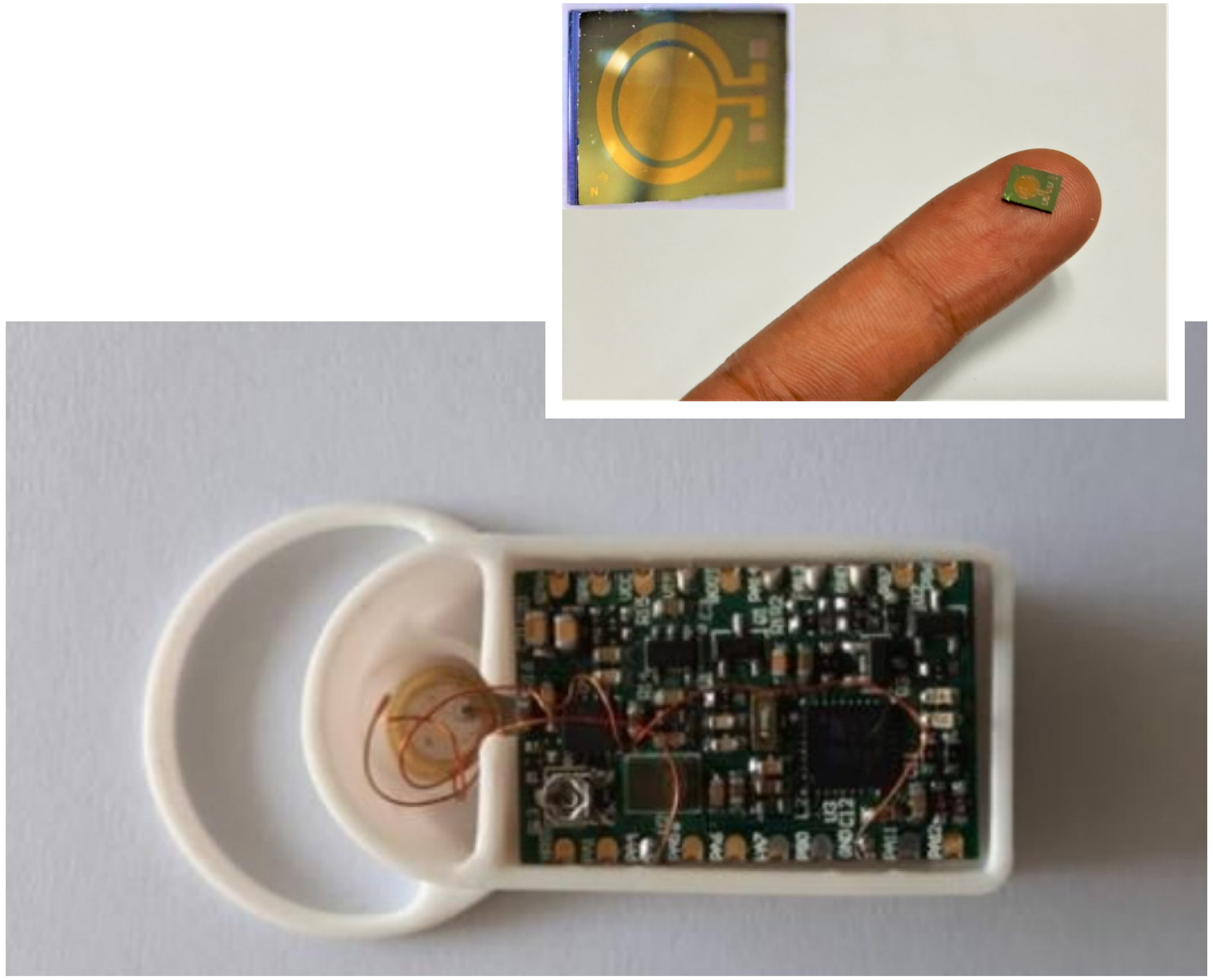


On-chip Mid - IR sensor

CriSpeakers- miniature MEMS acoustic transducers inspired by crickets.

PI: Rudra Pratap

These highly efficient 2D MEMS speakers are advancing toward commercialization. Key achievements include improved deposition processes for piezoelectric thin films, fabrication of diaphragm-type near-ultrasound µ-speakers, and the development of integrated electronics, firmware, and hardware for Data-over-Sound transceiver modules. The technology has reached TRL 7, with deliverables including two types of MEMS acoustic transducers, passive acoustic amplifiers using cavity resonators and horns, and an ultra-low-power electronic transceiver module—ready for technology transfer and product development.



Gas Sensor Technology

PI: Navakanta Bhat and M M Nayak

The research team has successfully scaled up metal oxide gas sensor technology to wafer-scale production, completed long-term reliability assessments, and finalized calibration methods. The sensors have been field-tested in collaboration with user agencies, with technology transferred to a production foundry. The work has achieved TRL 9, making the sensors ready for commercial deployment.

Nurturing Startups

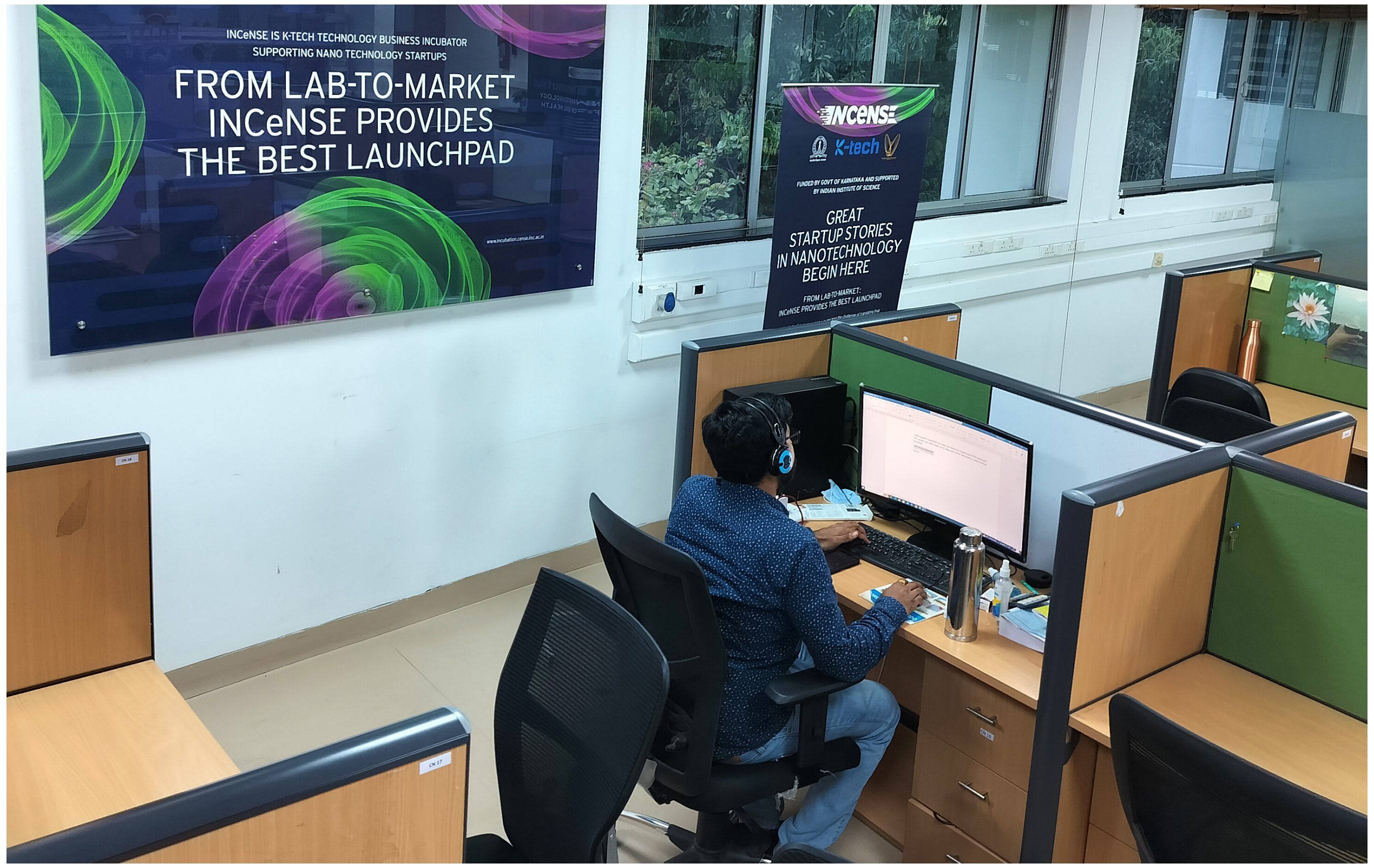
9 of the 19 faculty members of CeNSE are founders of startups. InCeNSE our inhouse incubator has helped incubate 13 deep tech startups over the last many years as of December 2024.

INCeNSE - DeepTech Technology Business Incubator

INCeNSE, a specialty incubator within FSID at IISc and funded by the Government of Karnataka, supports entrepreneurs and startups focused on deep-tech hardware innovation. Located at CeNSE, it provides access to advanced facilities and expertise in areas like semiconductors, 2D materials, electronic devices, sensors, MEMS/NEMS, photonics, nano-biotechnology, quantum technology, and more.

Startups benefit from independent access to state-of-the-art equipment at the Nanofabrication (NNFC), Micro- and Nano-characterization (MNCF), and Systems Engineering & Packaging Labs, alongside office space, mentoring, and industry connections. INCeNSE also offers support in business, legal, IP, and financial aspects necessary for early-stage startups.

Since its inception in 2019, INCeNSE has screened over 100 applications, selecting 23 for incubation, with more than 13 startups receiving support and utilizing thousands of hours on advanced equipment.



INCeNSE incubatees

Startups founded by CeNSE Staff and Students:

Molecular Semiconductor Pvt Ltd is a pioneering company specializing in the synthesis of electronic-grade π-conjugated organic molecules for printable and flexible electronics. They are known for offering high-quality, proof-of-concept solutions at highly competitive prices. Their extensive material portfolio includes tunable bandgap, redox-active, and photoactive polymers, photoresists, and small molecules, which are widely used in applications such as redox-flow batteries, solar cells, photodetectors, and electrochromic windows. With a strong commitment to innovation and contributing to India's semiconductor self-reliance mission, Molecular Semiconductor is making significant strides in the development of sustainable organic electronics technologies.

ABX3 PV Pvt Ltd is at the forefront of sustainable and environmentally friendly technology for the manufacturing of hybrid perovskite solar cell panels. The company is focused on the early commercialization of hybrid perovskite modules, utilizing an advanced, indigenously developed manufacturing process. With a strong commitment to innovation, ABX3 PV is driving the future of perovskite technology, aiming to revolutionize the solar energy industry with efficient and eco-conscious solutions.

External Startups incubated in 2024:

Meerkats World Pvt Ltd is dedicated to extending the lifespan of electronic devices through cutting-edge technology, while reducing waste and promoting sustainability. The company delivers high-performance thermal management solutions that are key to supporting a greener future. By enhancing device efficiency and longevity, Meerkats World is helping to drive eco-friendly innovation within the electronics industry.

Gyrfalcon IntelliEdge Solutions India Pvt Ltd is a startup working on cloud enabled intelligent edge devices, gateways and sensor based IoT solutions that enable long-term sustainability, savings and predictive analytics through data driven decision-making application and solutions

Other startups that are currently incubated at INCeNSE

Startups founded by CeNSE Staff and Students:

AGNIT Semiconductors Pvt Ltd: Design and manufacture GaN semiconductors in Karnataka for the world. AGNIT Semiconductors is a deep-tech startup from IISc, offering Gallium Nitride (GaN) components for next generation communication networks for 5G and efficient power switches for electric vehicle fast charging, etc. The AGNIT team has more than 100 years of experience in developing GaN solutions from materials-to-device-to-systems. Only Indian GaN device company and one of a handful world-wide with patent protected GaN technology.

Theranautilus Pvt Ltd: Theranautilus is a hardware company specializing in instruments for fabricating nanorobots, safe deployment of nanorobots in living systems, and mechanism to maneuver them to their target inside the body remotely. Our system would be capable of reaching greater depths within the dentinal tissues to target bacterial colonies that are out of reach with the current state of the art tools.

External Startups incubated at INCeNSE:

INFAB Semiconductors Pvt Ltd: INFAB is a foundry service aimed at making MEMS-based devices available for everyone – from students to a practicing engineer to research labs to startups/MNCs engaged in MEMS-based activities. Their vision is 'MEMS for everyone" and motivated to benefit their users by providing microfabrication of MEMS and microfluidic devices at affordable cost with quick turnaround time. The services help the users with technical support including design feasibility, characterization, and packaging.

International Centre for Nano Devices (ICeND) Pvt Ltd. The first of its kind disruptive device that can handle biological and material science problems in fluid in real time at the single molecule level. This device called UNanoD – Universal Nanofluidic devices will be a standard like USB that will be established with existing specifications for various optical microscopes, electron microscopes to interface between one nanoscopic measurement device to another.

SuperQ Technologies Pvt Ltd: High Temperature Superconducting Technology. SuperQ is a next-generation research and product development company that aims to build and deploy commercial scale applications in superconducting device technology.

Densepower Pvt Ltd.: Microstructural engineering of materials for power and medical oxygen separation. Densepower focuses on tailoring the microstructure to multiply the performance of the re-engineered materials for (a) making zeolite materials for gas separation including medical oxygen concentrators (b) High density power conversion device using solid-oxide-membrane electrolyte by engineering triple phase boundary.

Meukron Technologies Pvt Ltd. is helping Semiconductor and Biomedical companies developing MEMS and Microfuidic devices to accelerate their Product Development Cycle and Market Entry, using Innovative Manufacturing Solution.

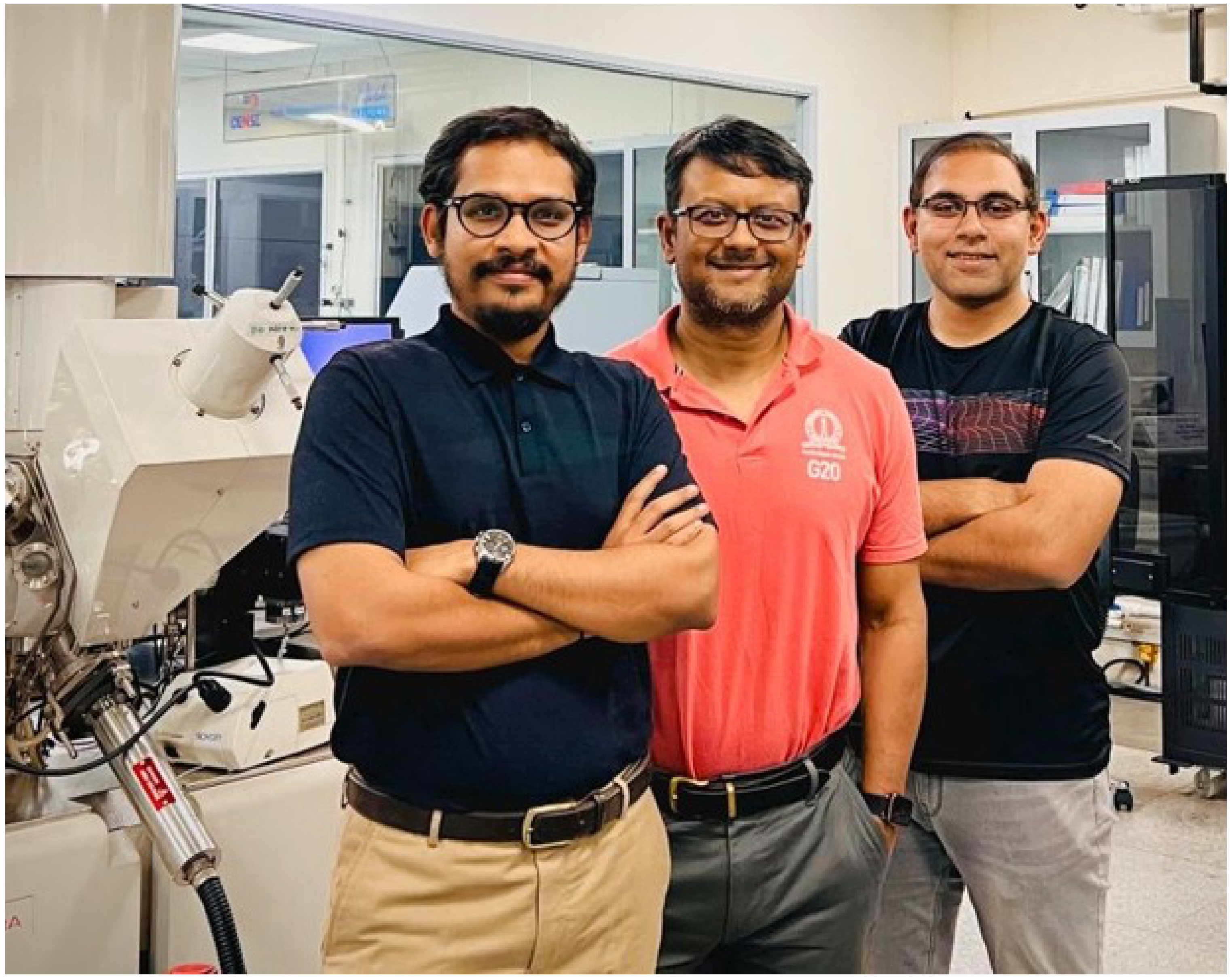
14 Si Solutions Pvt Ltd.: With expertise in Applications Engineering, Materials, Metrology, & Manufacturing combined with their holistic, data-driven approach provides a critical insight into contamination - its causation, mitigation, and control. They leverage their expertise to improve products from and process at component, chemical, and tool suppliers to further enable semiconductor device manufacturers.

News from Startups Incubated by CeNSE faculty and Students

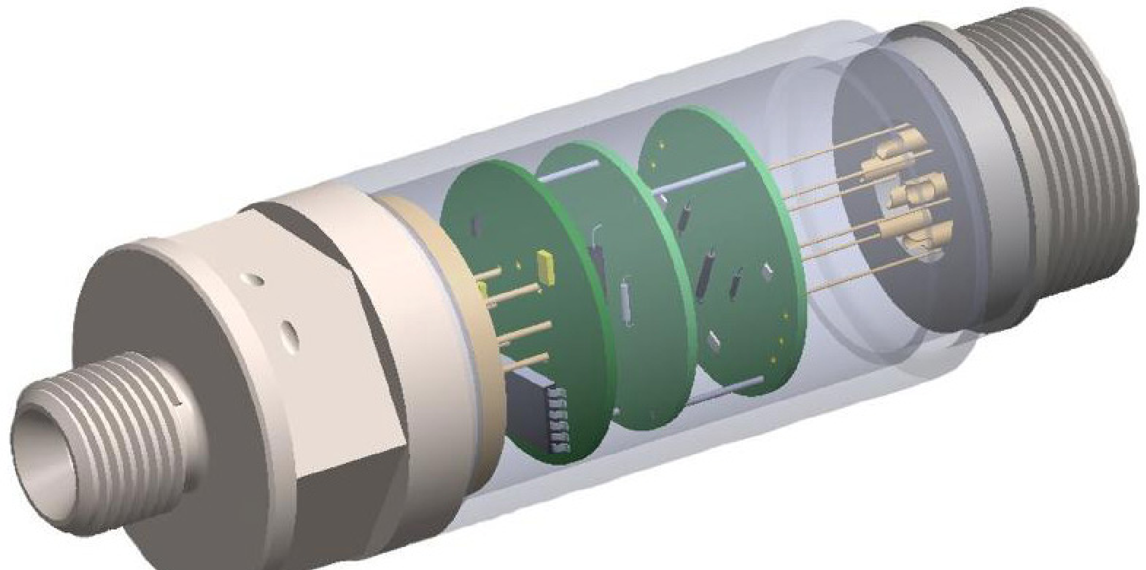
AGNIT Semiconductors Pvt. Ltd. co-founded in 2019 along with CeNSE faculty members Digbijoy Nath, Shankar Kumar Selvaraja and Srinivasan Raghavan now employs 15 people and is in the process of putting down Indian made indigenous GaN RF devices in the hands of Indian Companies.

AGNIT Semiconductors is India's first and only GaN integrated device manufacturer, delivering advanced GaN solutions for RF and power electronics. From GaN HEMT wafers on Si and SiC substrates to high-performance packaged devices, Agnit powers next-generation telecom, defence, and power applications, including 5G networks, satellite communications, radar, electronic warfare, software-defined radios (SDRs), remote space connectivity, electric vehicles, data centres, and telecom power supplies. Led by Hareesh Chandrasekar, CEO, AGNIT raised $3.5 million from 3one4 Capital with participation from Zephyr Peacock India.

Theranautilus Pvt Ltd. is transforming the future of medicine with cutting-edge nanorobotics, bringing sci-fi innovations to real-world healthcare! Co-founded in 2022 by Prof. Ambarish Ghosh, Dr. Debayan Dasgupta, and Dr. Peddi Shanmukh Srinivas, this DeepTech startup is pioneering nanorobots for drug delivery, biofilm sterilization, and cancer theranostics. Their breakthrough solutions include nanorobots that eliminate antibiotic-resistant bacteria during root canal procedure, treat tooth hypersensitivity by deep dentine mineralization, and even detect and destroy cancer cells with unprecedented accuracy. With a bold vision to revolutionize precision medicine, Theranautilus is turning laboratory innovations into life-saving clinical applications, reshaping the future of healthcare. In 2024, Theranautilus has raised $1.2 million in seed fund from pi Ventures with participation from Golden Sparrow and angel investors Abhishek Goyal and Lalit Keshre.



i2N Technologies Pvt Ltd is a MEMS based Product Development Company, one of the earliest startups incubated in 2012 by a CeNSE faculty member Prof. Rudra Pratap is now delivering products, pressure transducers, to the strategic sector for aerospace applications. This product line has been used on several helicopters in all kinds of flying conditions and is being qualified for other strategic platforms. i2n plans to build different transducer systems around various MEMS sensors developed at CeNSE, IISc, for other sectors, including Industrial and civilian Applications.



Pathshodh Healthcare Pvt Ltd another early CeNSE startup incubated in 2015 and co-founded by CeNSE faculty member Prof. Navakanta Bhat and CeNSE student Vinay Chauhan is now hires 27 people, has revenue exceeding 2Cr in current financial year and has been selected to be an instrument of choice for BBMP namma clinics for about a million diabetes screening tests.

Born from the PhD research of Vinay Kumar under Prof. Navakanta Bhat at CeNSE, IISc, PathShodh's handheld device is the first of its kind, capable of detecting multiple biomarkers for diabetes, kidney disease, anemia, malnutrition, and liver ailments. With a strong foundation in deep science and multiple patents, PathShodh is committed to making healthcare diagnostics affordable and accessible. Despite the challenges of COVID-19, it has emerged as a leading startup, delivering innovative technologies to medical professionals, institutions, and partners worldwide, shaping the future of precision diagnostics.

Industry Associations at CeNSE

Industry Affiliate Program

Industry Interface at CeNSE (I2CeNSE) aims to seed and nurture interactions between Centre for Nano Science and Engineering (CeNSE) and Industry towards a long term, mutually beneficial relationship.

IAP FEATURES

1. ACCESS TO STUDENT INTERNSHIPS
2. OPPORTUNITY OF CREATING NEW JOINT PROJECTS
3. ACCESS TO CURRENT RESEARCH VIA CENSE ANNUAL SYMPOSIUM/ SEMINARS
4. DEDICATED WORKSHOPS FOR INDUSTRIES
5. ACCESS TO CENTRALIZED FACILITIES ON PRIORITY

Our flagship Industry Affiliate Program (IAP) serves as a platform to engage with industry with leading companies as its members.

Current CeNSE IAP members are

- *Applied Materials*
- *Lam Research*
- *Gleam Innovations*
- *Yield Engineering Services BEL*
- *Bharat Electronics*

Past CeNSE IAP members are

- *ASM-HHV, a joint venture between ASM Technologies Ltd and Hind High Vacuum Company Pvt Ltd*
- *Centum Electronics*
- *CMTI (Central Manufacturing Technology Institute)*
- *L & T Technology Services*
- *Rakon*

Our IAP members form a critical component of CeNSE innovation eco-system and get handheld privileges of facility usage, consultancy & research projects with faculty, training, student internships, networking, distinguished lectures, and visits to CeNSE and IISc.

Industry Sponsored fellowships for 2nd Year MTech Students

MTech Fellowship instituted at CeNSE, IISc is aimed at attracting highly talented students to the areas of Semiconductor Manufacturing Supply Chain (Equipment/ Materials/ Services), Semiconductor wafer fabrication equipment (WFE), Advanced Materials, Semiconductor Fabrication & packaging and Materials Engineering Solutions.

This fellowship includes an enhanced fellowship for a period of 12 months, and conference attendance is supported.

Our current Sponsors include:

Foundational and Advanced Workshops on Semiconductor manufacturing

Foundational Workshop on Semiconductor Manufacturing

The online foundational program (60 hours) equips participants with essential knowledge of semiconductor fabrication and characterization. It covers unit processes, contamination control, yield optimization, metrology, MEMS, packaging, and wafer tape-out flows. Designed for professionals and academics, it provides a solid grounding in cleanroom operations and the economics of chip manufacturing.

Advanced Workshop on Semiconductor Manufacturing

The advanced program (90 hours) offers hands-on training using CeNSE's cleanroom and characterization facilities. Participants work with tools for lithography, etching, thin-film deposition, SEM, AFM, XRD, Raman spectroscopy, and probe stations. The course also includes MOSFET fabrication, expert lectures, and research proposal development, providing a comprehensive experience in semiconductor R&D.

Summary table

PROGRAM	FORMAT	DURATION	KEY COVERAGE
Foundational Workshop	Online	60 hours	Core fabrication processes, metrology, cleanroom protocols, wafer tape-out flow, MEMS, yield control
Advanced Workshop	Hands-on	90 hours	Practical fabrication & characterization (lithography, deposition, SEM/AFM/XRD), MOSFET process, research skills

Industry Training Programs at CeNSE

CeNSE offers specialized industry-focused training programs tailored to the needs of professionals at different stages of their careers. These programs leverage CeNSE's advanced cleanroom and characterization infrastructure, ensuring participants gain both theoretical grounding and practical, hands-on experience relevant to semiconductor and nanotechnology industries.

Experienced Professionals Training

Targeted at mid-career professionals, this program helps participants upskill or transition across domains. With a focus on practical knowledge, it equips participants to adapt to emerging technologies and take on new roles in semiconductor design, fabrication, and characterization.

New Graduate Training

Designed for fresh hires entering the semiconductor industry, this program provides a comprehensive overview of the field. It combines eyes-on and hands-on modules in process integration, helping participants understand how different fabrication steps come together to build complete devices and systems.

Specialist Training

This advanced program is tailored for professionals seeking expert-level mastery of specific tools or techniques. Candidates can choose from a variety of verticals across fabrication and characterization, gaining deep, tool-specific knowledge that directly enhances their technical expertise and workplace performance.

Industries that have opted training services from CeNSE, IISc:

TATA ELECTRONICS

Lam RESEARCH

intel

ANALOG DEVICES

GlobalFoundries

APPLIED MATERIALS make possible

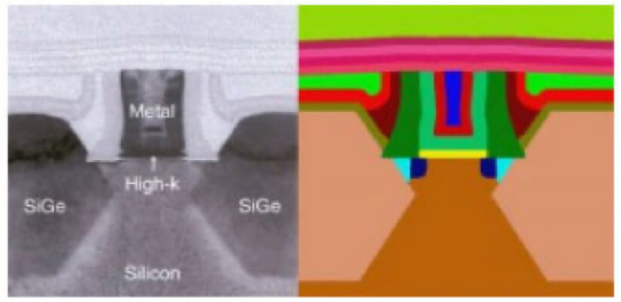
Quest global

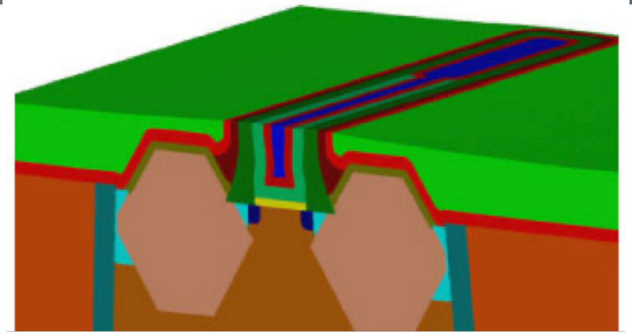
इसरो isro

mks | Atotech

DRDO

L&T Technology Services





SEMulator3D® Training Program

CeNSE, in collaboration with Lam Research India, ISM, and MeitY, launched a nationwide training initiative using the SEMulator3D® virtual fabrication platform. The one-month hybrid program follows a "train-the-trainers" model for faculty from UG/PG engineering colleges. It combines two weeks of hands-on fabrication and characterization at CeNSE with two weeks of online SEMulator3D® sessions.

The program will help scale semiconductor education to over 60,000 engineers, bridging academia and industry while accelerating India's semiconductor workforce development.

Impact so far:

- Unprecedented industry–academia collaboration to create course content
- 40 institutes onboarded to launch new semiconductor courses
- 500 students trained in the first semester

Overall Industry Collaborations:

Outreach at CeNSE

Industry Affiliate Program

Industry Interface at CeNSE (I2CeNSE) aims to seed and nurture interactions between Centre for Nano Science and Engineering (CeNSE) and Industry towards a long term, mutually beneficial relationship.

Services from facilities offered at CeNSE

TRAINING
- Introductory Courses
- Hands-on fab training
- Custom-designed training
- Tool training

PROJECT EXECUTION
- Standard & Custom patterning
- Micro heaters and IDE's
- On-chip Gas sensor devices
- Cantilevers & AFM tips
- Microfluidic channel

PRODUCT DEVELOPMENT
- Gas Sensors
- Pressure Sensors
- CVD Reactor
- KW Class Lasers
- Soil moisture Sensor

WAFER PROCESSES
- Films
- Lithography
- Annealing
- Doping & Diffusion
- Wafer bonding
- Dicing

CONSULTANCY
- Fabrication
- Characterization

INUP - Indian Nanoelectronics Users Program

The Indian Nanoelectronics Users Program (INUP) is a pioneering initiative jointly run by CeNSE, IISc and IIT Bombay, and funded by the Ministry of Electronics and Information Technology (MeitY), Government of India. Launched in 2008, the program provides training and research access in nanoelectronics to scientists and engineers across the country, including those from institutions with limited research infrastructure.

INUP has grown into a nationwide network of 700+ institutions, democratizing access to world-class facilities at IISc and IITB. Through lectures, hands-on workshops, and project-based training, researchers gain exposure to advanced fabrication and characterization tools, supported by expert technologists and faculty.

Building on its success, INUP-i2i now expands the program to six premier institutes—IISc, IITB, IITD, IITG, IITM, and IITKGP—broadening its reach and impact. Training is offered in three levels:

Level 1 – Familiarization workshops, introducing nanoelectronics concepts and infrastructure.

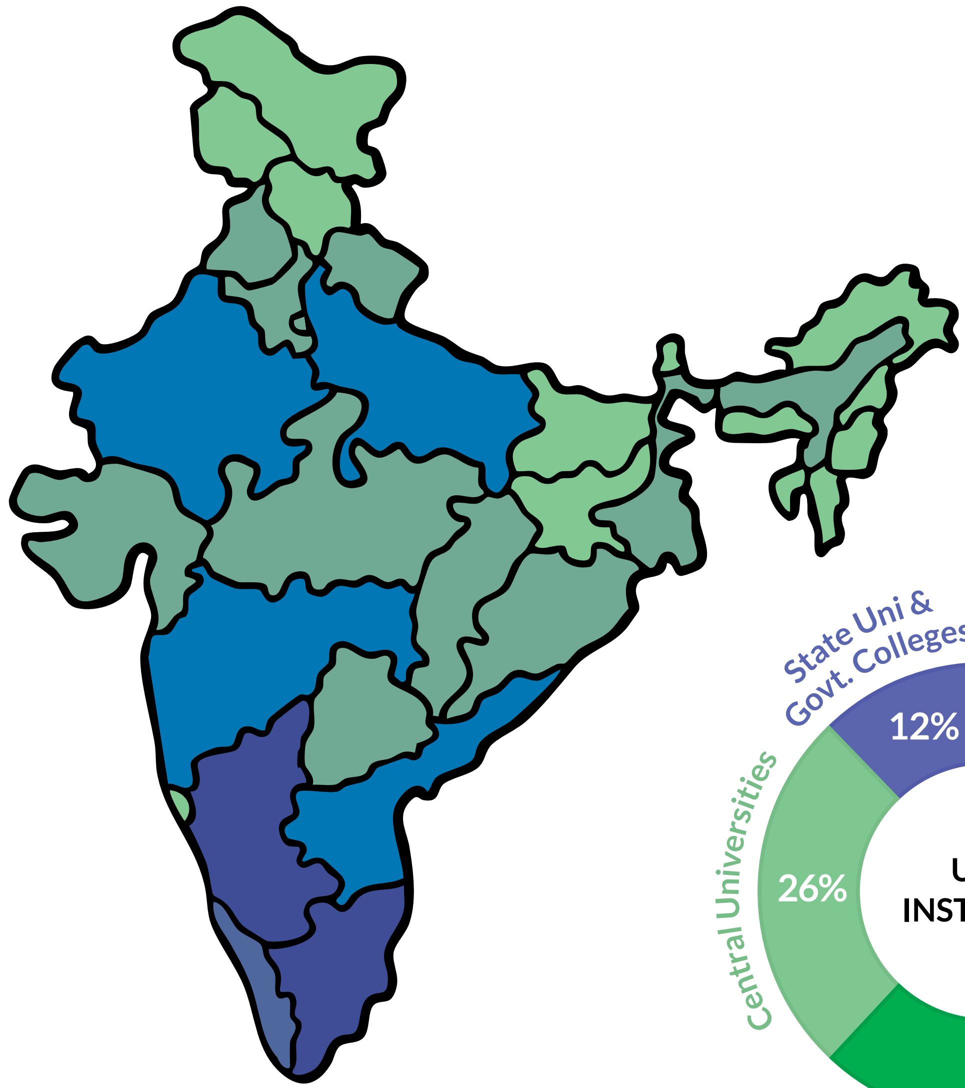
Level 2 – Hands-on training, offering 10–15 days of intensive experience in fabrication and characterization.

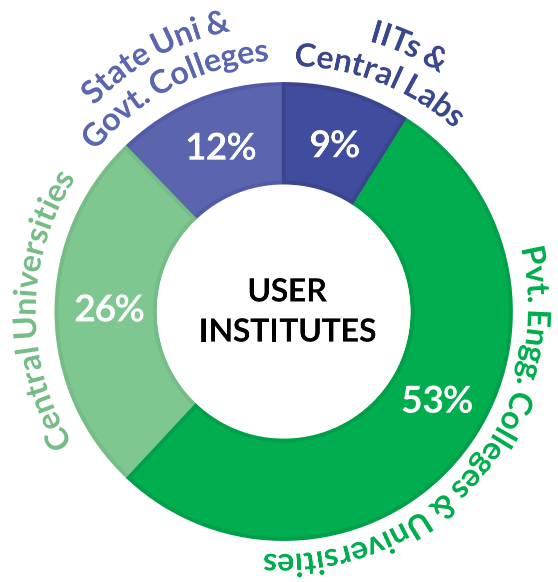
Level 3 – Project Execution, enabling selected participants to carry out their research at Nanocenters.

Through INUP and INUP-i2i, researchers from across India can engage in cutting-edge R&D, strengthening the nation's capabilities in nanoelectronics.

INUP i2i

User Institutes





Users from

Assisted in these outcome for external users

6100+ Manpower trained

800+ Organizations

390+ Publications

650+ Thesis

25+ Patents

News Highlights

Centre of Excellence for PiezoMEMS transducers:

Funded by Department of Science and Technology, this CoE aims to establish a vibrant scientific-industrial ecosystem focusing on the development of piezoelectric thin-film material synthesis/characterization and #MEMS design/fabrication technologies on a 4-inch Silicon-on-Insulator wafer. This CoE (i) will cater to the exploratory study (materials and devices) demands of academia (ii) enable device and technology development for the strategic sector and (iii) build a roadmap for large-scale piezoelectric MEMS device fabrication in India. The thin-film deposition and transducer fabrication technologies developed by the researchers at Centre for Nano Science and Engineering (CeNSE), Indian Institute of Science (IISc) and CSIR - National Aerospace Laboratories (NAL) for 4-inch wafers under Phase-1 of the CoE will serve as a guideline for industries to set up and up-scale MEMS design and fabrication houses in India.

Meet the team :

Dr. Gayathri Pillai, CeNSE, IISc – Principal Investigator

Dr. Pavan Nukala, CeNSE, IISc

Dr. Saurabh Chandorkar, CeNSE, IISc

Prof. Srinivasan Raghavan, CeNSE, IISc

Dr. Soma Dutta, Material Sciences, CSIR-NAL

Dr. Milind Acharya, Exec. Director, Milman Thin Film Systems Pvt Ltd (Industry Partner)






11th CeNSE student Research Symposium

The 11th CeNSE Student Research Symposium was held on September 21st and 22nd, 2023, at Centre for Nano Science and Engineering (CeNSE), Indian Institute of Science (IISc), this event was an absolute triumph.

For two action-packed days, our department's talented students showcased their cutting-edge research through captivating oral and poster presentations. It was an excellent opportunity for them to gain insights into their peers' work and foster potential collaborations that could spark ground-breaking innovations in the future.

Moreover, the symposium had the privilege of hosting distinguished speakers from various sectors, including industry, start-ups, and strategic fields.

Kusuma N CMTI - Central Manufacturing Technology Institute

Nitin Singh Malik - Applied Materials

Ravikumar Patil - Lam Research

Mahesh Lunavath - Bharat Electronics Limited

Sudhanshu Shekhar - INFAB Semiconductor Pvt Ltd

Ashutosh Bhabhe – 14Si Solutions Pvt Ltd

Paired with the networking luncheon, this event served as an invaluable platform for our students to immerse themselves in the latest industry developments, gain a deeper understanding of the current market landscape, and explore promising career prospects.

Knowledge Sharing Workshop by INUP at CeNSE, IISc

CeNSE, IISc, Bangalore conducted a knowledge sharing workshop along with Indian Institute of Technology, Bombay, Indian Institute of Technology, Guwahati, Indian Institute of Technology, Madras, and Indian Institute of Technology, Kharagpur to share knowledge on fabrication and characterization labs and their operations.

Nanobiotechnology: Beyond the conventional

CeNSE, IISc Bangalore, and STARS jointly organized an international conference on 'Nanobiotechnology: beyond the conventional' from 27-29, Sep 2023 which consisted of interesting and insightful talks from various academic speakers, startups, and practicing medical professionals on emerging topics in nanobiotechnology, including quantum sensing, nanorobotics, AI/ML in bio, novel biomaterials, and current challenges. There was also enthusiastic participation from the CDNA participants and IISc students.

Akanksha Training at CeNSE

"Akanksha" is a program designed to provide meritorious girl students with an opportunity to learn the potential of micro/nanotechnology. Particularly, the program aims to attract girl students from rural Karnataka. The program aims to motivate girl children to pursue a science and engineering career. Considering India's planned leap in electronics and semiconductor manufacturing, we must ensure that the ecosystem offers equal opportunity to women, making up ~50% of the population in that age group actively participate and contribute to this endeavour. "Akanksha" seeks to increase girl child participation in engineering and science, especially in the world of nano and micro dimensions and opens a world of possibilities to be pursued by interested students.

The program is designed for 11th standard school students. The students will make a device and understand their working, like a motion sensor. The students will spend time on the Indian Institute of Science campus, giving them ample opportunities to interact and learn from the students, researchers, professors, and scientific staff.

Thankful to our sponsors

- Honeywell Hometown Solutions India for sponsoring sessions in Nov 2023 for 30 students from Ekalavya Model Residential Schools in Tumkur, Chamrajnagara, and Kodagu districts
- Infineon for sponsoring sessions in August 2024 for 30 students from Ekalavya Model Residential Schools in Chikkamagalur, Belagavi and Ballari

During their 5-day stay on the Indian Institute of Science (IISc) campus, these bright minds engaged with researchers, scientific staff, and faculty. They immersed themselves in hands-on nanotechnology experiments at NNFC and MNCF, garnering valuable insights and knowledge.

Their feedback speaks volumes - a program that not only educated but also captivated young minds. We're thrilled to have provided such a rewarding experience for these aspiring students.

CeNSE hosts Shri. S. Krishnan, Secretary, MeitY, GoI

We were privileged to welcome Shri. S Krishnan, Secretary, Ministry of Electronics and Information Technology (MeitY), Government of India, along with other distinguished dignitaries from MeitY, to CeNSE, IISc, on January 23rd and 24th, 2024.

During the visit, Shri Krishnan was presented with an overview of our cutting-edge research initiatives, technological advancements, and product development efforts. The visit also included a detailed tour to our recently established Neuromorphic Computing Lab and state-of-the-art national facilities, including the National Nano Fabrication Centre (NNFC), and the Micro and Nano Characterization Facility (MNCF).

A significant highlight of the visit was the inauguration of the Packaging and Systems Facility (PASF) by Shri Krishnan. This national facility marks a crucial step in enhancing our capabilities in nanoelectronics, enabling advanced research and innovation to support India's growing semiconductor ecosystem.

Hands-on Training for northeast region institutions

INUP-CeNSE, IISc Bengaluru organised Indian Nanoelectronics Users' Programme - Idea to Innovation (INUP - i2i) Hands-on Training on Nanofabrication and Characterization Techniques, supported by Ministry of Electronics and Information Technology, GoI for North-East Region Institutes and Collaborating Institutes from 16th to 25th January 2024.

Open Day 2024

What an incredible day - The Open Day at CeNSE was an enriching experience, blending fun, education, and inspiration! CeNSE at IISc opened its doors to the public on February 24, 2024, welcoming a vibrant crowd of enthusiastic school students, college students, researchers, and parents.

The event was brimming with energy as CeNSE members showcased an array of exciting activities, including live demos, hands-on experiments, interactive live streams, and an exclusive cleanroom tour. The audience's curiosity and enthusiasm brought the event to life!

Conference on Semiconductor Ecosystem in India 2024

The Conference on Semiconductor Ecosystem in India (COSEIn) brought together key stakeholders from semiconductor fab builders, IC chip industries, OEMs, consumable suppliers, and representatives from strategic and academic fabrication facilities in India. The event supported by sponsors including ThermoFisher Scientific, Raith Nanofabrication, BeST Cluster, LabIndia Instruments, and Applied Materials featured four dynamic panel discussions:

Upcoming Packaging and Testing Facilities: With 70% of semiconductor revenue in design and fabrication, packaging, despite lower margins (10-15%), presents significant growth opportunities. India could attract 10% of the global $150 billion packaging market by 2030. Synergies with India's established solar manufacturing and bio-pharma ecosystems can aid this growth through transferable skills and supply chain integration.

Training and Upskilling: Addressing the projected demand for 28,000 skilled professionals in five years and 55,000 in ten years, efforts must focus on aligning academic capabilities with industry needs. Initiatives like training fabs, short-term certifications, and digital tools can bridge the gap. Coordination among entities like ESCII, AICTE, and MeitY is critical.

Supply Chain and Consumables: Policy reforms can enhance ease of business, including reconsidering bans on importing refurbished equipment, which can lower costs and foster local repair ecosystems. While India excels in chemical manufacturing, fostering innovation and patenting capabilities is essential.

Encouraging Deep-Tech Startups: Startups should focus on modularizing technology into commercially viable components and leverage balanced funding strategies. Achieving key milestones within 18 months and creating robust data rooms can attract mainstream investors.

Advancing collaborations with ISRO

CeNSE, IISc, continues to strengthen its partnership with the Indian Space Research Organization (ISRO). In a recent meeting at ISRO headquarters, CeNSE researchers engaged with ISRO Chairman Shri. Somanath S and senior scientists to review ongoing projects and explore future collaborations.

This partnership has led to the development of advanced sensor technologies, fabricated at CeNSE's cutting-edge facilities and delivered to ISRO for testing. The collaboration exemplifies the successful integration of academic research with the technological needs of the space sector.

Future initiatives aim to leverage India's startup ecosystem for device production, enhance specialty foundry and packaging technologies, and develop next-generation sensors for space applications. Together, CeNSE and ISRO continue to drive innovation, contributing to India's self-reliance under the Atmanirbhar Bharat initiative.

Semiconductor Skills Development through SEMulator3D

In alignment with the India Semiconductor Mission, Lam Research has aimed to train over 60,000 engineers to make them skilled in semiconductor technology. CeNSE, IISc is glad to be a part of the MoU to help develop this semiconductor manufacturing workforce for the country.

The pilot training using LAM's SEMulator3D® for 32 MTech and PhD students was a great success and we are looking forward to train many more and make India semiconductor ready!!

Training program on semiconductor fabrication – Tata Electronics

We are thrilled to have hosted over 100 engineers from Tata Electronics at CeNSE, IISc for a comprehensive training program from 1st July to 31st July 2024.

During this month-long program, these talented engineers engaged in a series of training sessions, including classroom lectures and hands-on experience in semiconductor fabrication and characterization.

This initiative is a significant step in aligning with the India Semiconductor Mission, preparing our workforce for the promising ventures ahead.

Training on Semiconductor Fabrication and Characterization – by Ministry of Tribal Affairs

In a collaborative initiative between the Ministry of Tribal Affairs, Government of India, and CeNSE, IISc, a series of training programs have been launched to leverage advanced technology for the holistic development of tribal communities. With 48,000 hours of training planned over three years, this initiative is poised to create a significant impact in building job-ready talent for the semiconductor industry.

Key highlights of the initiative include:

Eligibility Criteria: Students from tribal community, pursuing (or rising) 4th year of UG Engineering (B.Tech / B.E.) OR pursuing (or rising) 2nd year of M.Sc in the relevant field. Faculty from tribal community are also eligible.

NSQF-Certified Training Programs:

Advanced Programme in Nano Science and Technology: Aimed at job readiness, this program will train 600 candidates over three years and facilitate industry placements through collaboration with companies.

Foundation Programme in Nano Science and Technology: Designed for 1500 students to provide foundational knowledge in the field.

Exposure Programmes: Targeted at school and diploma students, with 100 participants annually, to introduce them to the semiconductor sector.

With a very successful 1st batch this year, we look forward to more in the upcoming years.

IISc Convocation 2024

CeNSE, IISc congratulates all its graduating students of the year 2024 and wishes them the very best and great success at their future endeavours.

INUP-i2i Users Meet 2024

The first Indian Nanoelectronics Users' Programme - Idea to Innovation (INUP - i2i) Users' Meet was organized in association with Ministry of Electronics and Information Technology, GoI on August 10, 2024, at IIT Bombay and CeNSE, IISc was honored to be a part of this meet.

This event was organized to celebrate INUP's success, share the experiences, and shape the future of India Semiconductor Mission. This special event was a platform for the users from academics and industry to showcase the achievements as well as to participate in special sessions, lively discussions, and fantastic networking opportunities!

The event highlighted some of the most promising startups in India's semiconductor industry, showcasing their innovative R&D projects and the resulting patents and publications.

A key feature was the panel discussions focused on shaping the future of India's Semiconductor Mission, NSQF Certificates with insights into upcoming projects and strategic plans to further enhance the country's capabilities in nanoelectronics research and development.

CeNSE Participates in Semicon India 2024

We had an fantastic experience filled with valuable insights and connections at SemiconIndia 2024, held at IEML, Greater Noida from September 11-13, 2024!

It was great to connect with so many passionate students, current and aspiring entrepreneurs, as well as reconnect with old friends, collaborators, and industry partners.

Welcoming Yield Engineering Systems (YES) to CeNSE's Industry Affiliate Program

We are delighted to announce Yield Engineering Systems (YES) as the newest member of our Industry Affiliate Program (IAP) at CeNSE, IISc.

YES is a global leader in differentiated technologies for materials and interface engineering, serving markets like AI and HPC Advanced Packaging, Memory Systems, and Life Sciences. Known for state-of-the-art, cost-effective equipment, YES specializes in vacuum cure, coat & anneal tools, fluxless reflow tools, through-glass via and cavity etch systems, and electroless deposition tools for semiconductor applications.

Headquartered in Fremont, California, YES has a growing presence worldwide, including R&D and engineering teams in Bengaluru and Coimbatore, India. Their expertise aligns seamlessly with CeNSE's mission to drive innovation and technology in semiconductor and nanotechnology.

Visit by Shri Tarun Kapoor, Advisor to the Prime Minister of India

On October 11, 2024, Shri Tarun Kapoor, Advisor to the Prime Minister of India, was welcomed by IISc Director Prof. Govindan Rangarajan, Dean Prof. Navakanta Bhat, and other esteemed faculty members, alongside Dr. Sangeeta Semwal from MeitY at CeNSE, IISc

During his tour, Shri Kapoor explored the MeitY-nucleated fabrication and characterization facility, commending its contributions to the India Semiconductor Mission and workforce training. He expressed keen interest in projects including large-area solar panels, medical diagnostic devices by PathShodh Healthcare, nanorobotics by Theranautilus, quantum-integrated photonics, high-power lasers, and advancements in gallium nitride (GaN) technologies at the GEECI facility.

His visit reinforced the pivotal role of CeNSE in shaping India's technological future and strengthening government-academia collaboration.

INOX Quantum Materials Lab to Drive Quantum Computing Research

CeNSE, IISc has partnered with INOX Air Products to establish the INOX Quantum Materials Lab. This state-of-the-art facility will focus on developing topological semiconductors, essential for fault-tolerant quantum computing.

A key goal of the collaboration is to build an indigenous Molecular Beam Epitaxy (MBE) unit, reducing reliance on imported equipment and making advanced semiconductor and quantum technologies more accessible in India. The initiative also aims to nurture local talent and promote technology transfer to benefit both industry and society.

Siddharth Jain, Director of INOX Group, expressed pride in supporting India's quantum leadership, while Prof. Srinivasan Raghavan, Chair of CeNSE, highlighted the collaboration's alignment with CeNSE's mission to drive innovation from science to society.

Science in Action: Research Journeys at CeNSE

Two Nature Publications in One Year!

CeNSE celebrates a remarkable achievement with two research breakthroughs featured in Nature this year by the groups of Dr. Pavan Nukala and Dr. Sreetosh Goswami. Dr. Pavan's team discovered that passing electric current through wires made of indium selenide—a 2D ferroelectric material—caused long stretches of it to spontaneously transition into glass, opening up new possibilities in materials science. Meanwhile, Dr. Sreetosh's team unveiled a neuromorphic computing platform capable of storing and processing data in over 16,500 distinct states within a molecular film. This innovation promises to transcend the binary constraints of conventional systems, heralding a new era of ultra-efficient AI hardware.

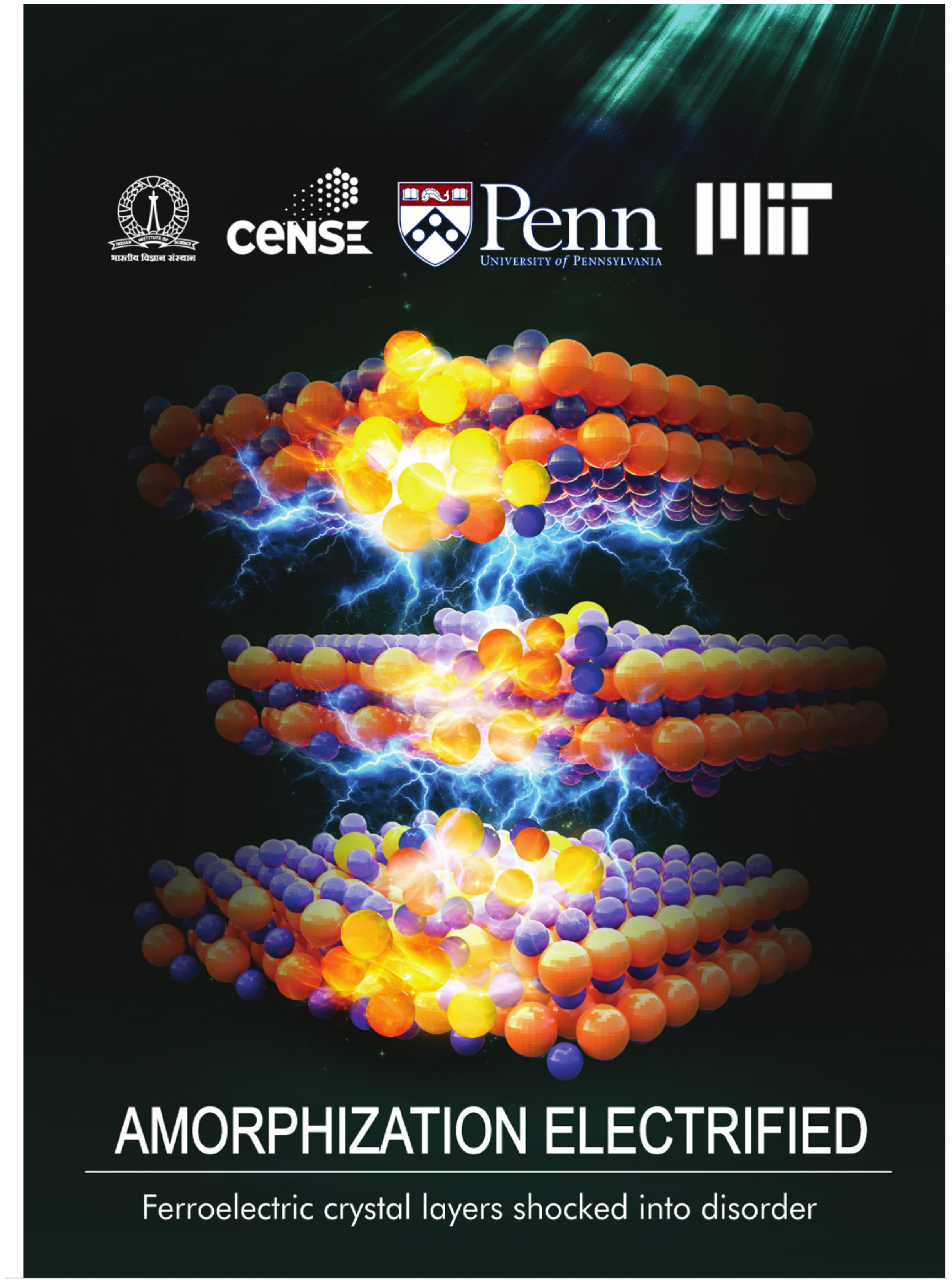
nature

Article | Published: 11 September 2024

Linear symmetric self-selecting 14-bit kinetic molecular memristors

Deepak Sharma, Santi Prasad Rath, Bidyabhusan Kundu, Anil Korkmaz, Harivignesh S, Damien Thompson, Navakanta Bhat, Sreebrata Goswami, R. Stanley Williams & Sreetosh Goswami

Nature **633**, 560–566 (2024) | Cite this article



nature

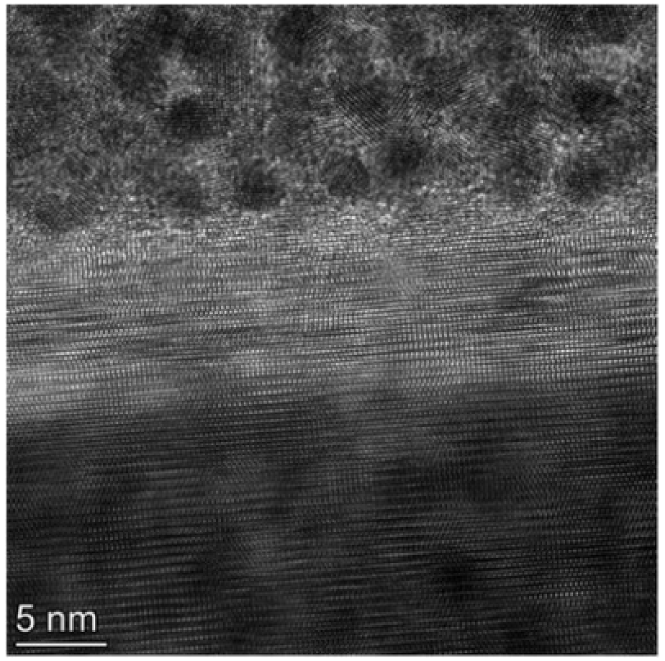
Article | Published: 06 November 2024

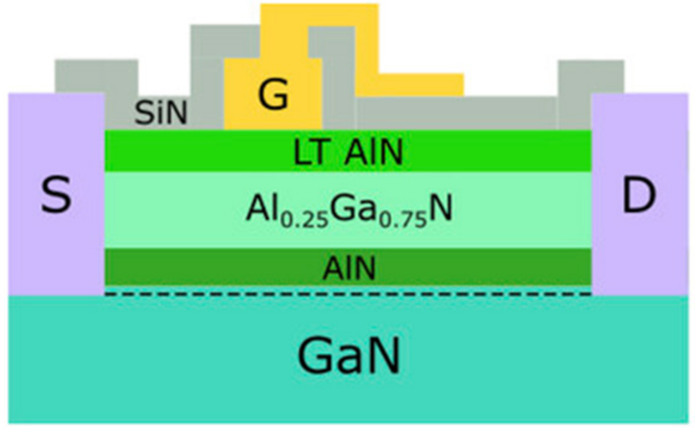
Electrically driven long-range solid-state amorphization in ferroic In_2Se_3

Gaurav Modi, Shubham K. Parate, Choah Kwon, Andrew C. Meng, Utkarsh Khandelwal, Anudeep Tullibilli, James Horwath, Peter K. Davies, Eric A. Stach, Ju Li, Pavan Nukala & Ritesh Agarwal

Materials:

Low-Temperature AlN Gate Dielectric for GaN-on-Si HEMTs
Researchers have demonstrated a low-temperature (460 °C) MOCVD-grown aluminum nitride (AlN) gate dielectric for GaN-on-Si high electron mobility transistors (HEMTs). This 10 nm AlN cap forms a clean, oxide-free interface and delivers an order of magnitude lower gate leakage compared to GaN-capped devices, while retaining higher channel charge and comparable resistance stability. The study highlights AlN's promise as a reliable, energy-efficient dielectric for next-generation GaN power electronics, with further optimization expected to enhance device performance.





RESEARCH ARTICLE
www.pss-a.com

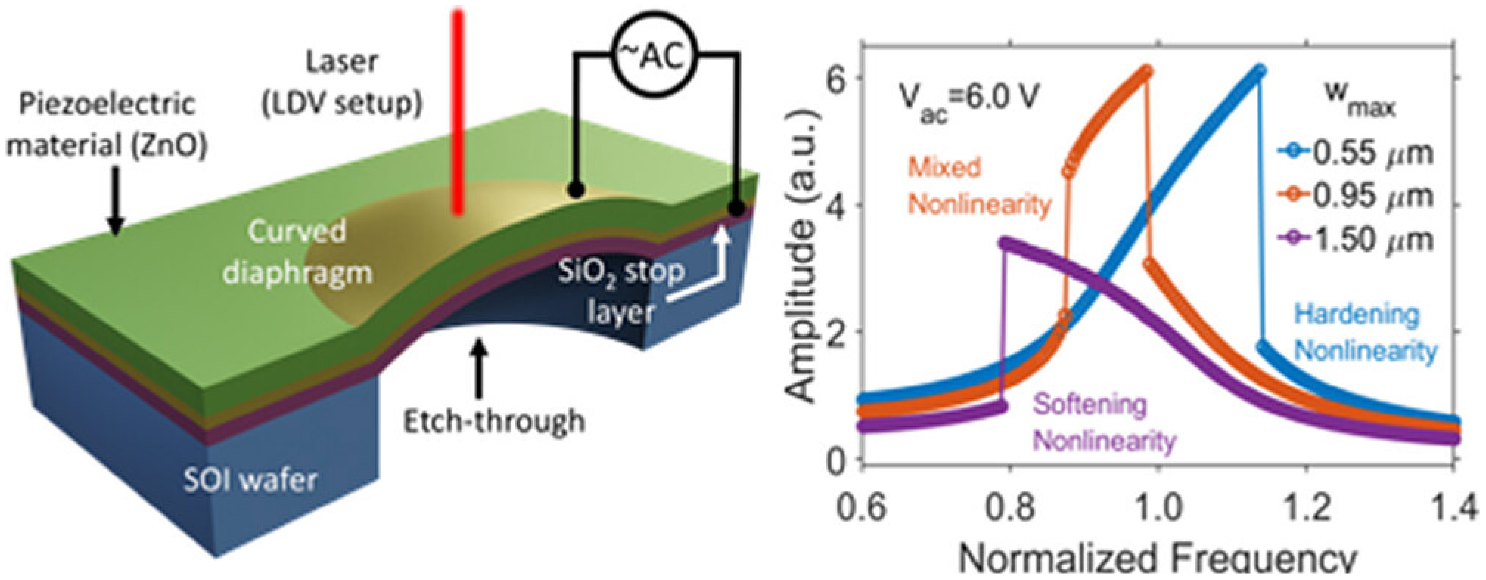
Metal-Organic Chemical Vapor Deposition Grown Low-Temperature Aluminum Nitride Gate Dielectric for Gallium Nitride on Si High Electron Mobility Transistor

Anirudh Venugopalarao, Shantveer Kanta, Hareesh Chandrasekar, Aniruddhan Gowrisankar, Muralidharan R. Rengarajan, Digbijoy N. Nath, and Srinivasan Raghavan**

MEMS/ NEMS/ Microfluidics:

Engineering Nonlinearities in ZnO PMUTs

This study shows how fabrication-induced curvature influences the nonlinear dynamics of zinc-oxide-based piezoelectric micromachined ultrasonic transducers (PMUTs). Devices with flat diaphragms exhibit hardening nonlinearity, curved ones show softening, and intermediate curvatures lead to mixed responses. A theoretical model links these behaviors to quadratic and cubic nonlinear effects. The findings highlight how static displacement can be tuned to control PMUT nonlinearities, opening new opportunities for optimized sensors, filters, and signal processing applications.



ACS APPLIED ELECTRONIC MATERIALS

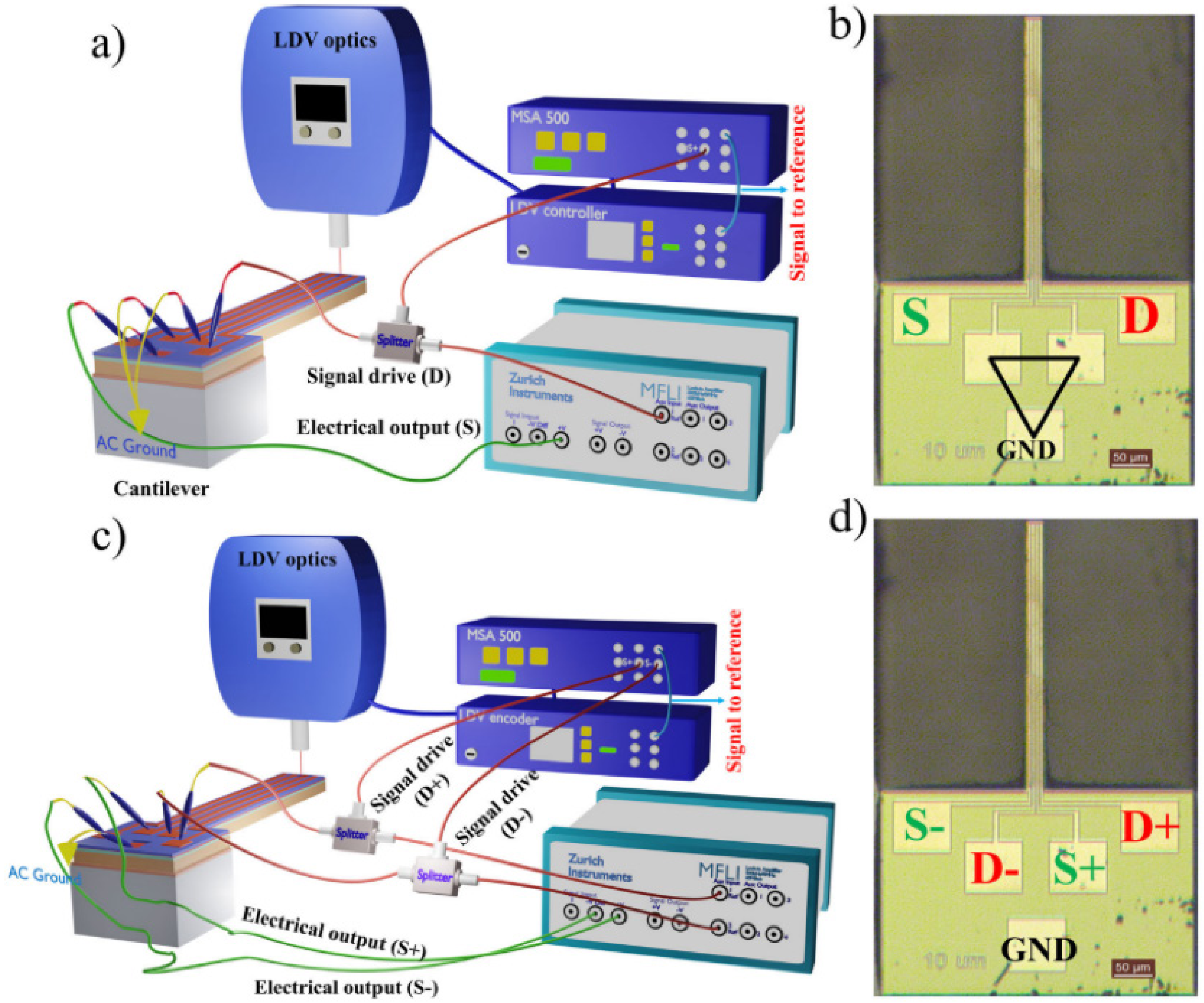
pubs.acs.org/acsaelm Article

Mixed Nonlinear Response and Transition of Nonlinearity in a Piezoelectric Membrane

Nishta Arora,[§] Priyanka Singh,[§] Randhir Kumar, Rudra Pratap, and Akshay Naik*

New Method to Estimate Energy Dissipation in Piezoelectric MEMS/NEMS

This work introduces a synchronized opto-electro-mechanical measurement technique for thin-film-piezoelectric-on-substrate (TPoS) devices, addressing long-standing challenges in quantifying energy losses. By combining optical (LDV) and electrical (LIA) measurements with a physics-based model, the method extracts all key parameters—including piezoelectric coupling, capacitances, and dielectric, piezoelectric, and mechanical loss tangents—using just two measurement points. Demonstrated on TPoS cantilevers and PMUTs, the approach overcomes the limitations of conventional resonance–antiresonance methods and enables accurate assessment of Quality Factor contributions without fabricating multiple device stacks. This provides a powerful tool for designing more efficient, high-performance piezoelectric MEMS/NEMS devices.



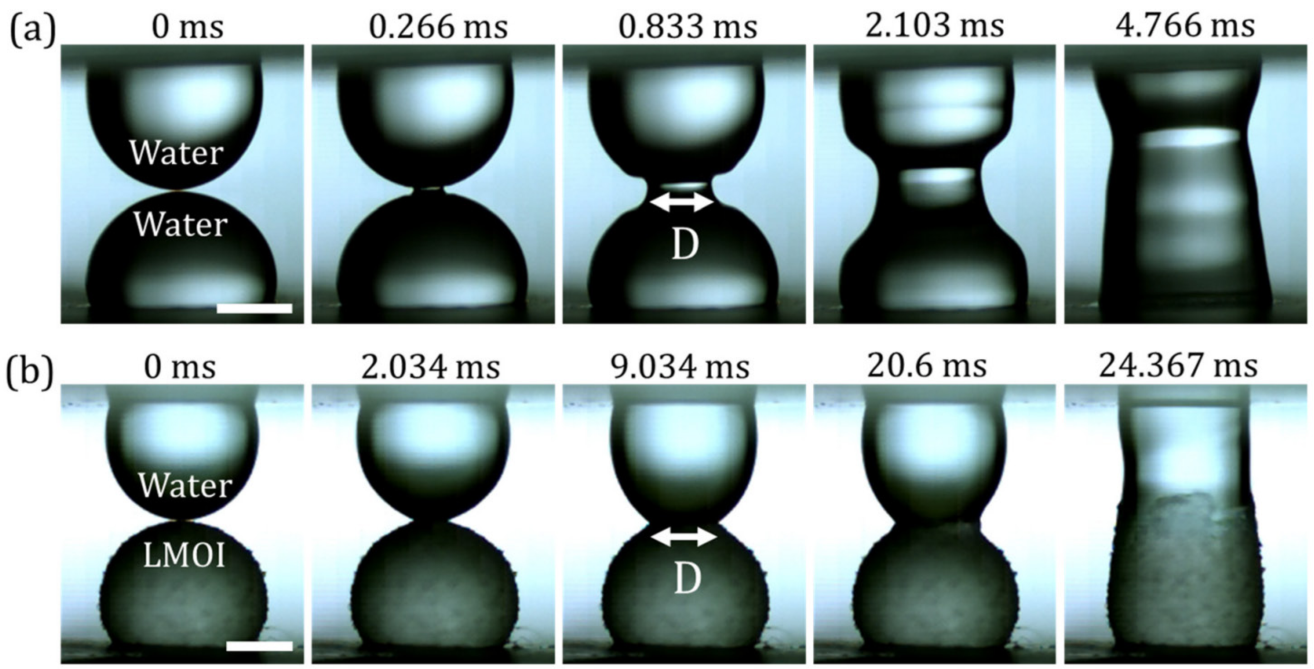
JOURNAL OF MICROELECTROMECHANICAL SYSTEMS, VOL. 33, NO. 6, DECEMBER 2024 793

Synchronized Opto-Electro-Mechanical Measurements for Estimation of Energy Dissipation in Thin-Film-Piezoelectric-on-Substrate MEMS/NEMS Devices

Vishnu Kumar, *Student Member, IEEE*, Sudhanshu Tiwari, *Student Member, IEEE*, Gayathri Pillai, *Member, IEEE*, Rudra Pratap, *Senior Member, IEEE*, and Saurabh A. Chandorkar, *Member, IEEE*

Coalescence Dynamics of Liquid Marbles on Oil-Infused Surfaces

This study uncovers how liquid marbles on oil-infused surfaces (LMOI) behave during droplet merging. Unlike bare droplets that merge in a single step, coalescence involving LMOI proceeds through three phases: spreading, depletion, and merging. Higher oil viscosity slows the process, while LMOI–LMOI coalescence resists merging altogether unless triggered by external stimuli like pressure or electric fields. These insights highlight the remarkable stability and tunability of LMOI, opening pathways for advanced microreactor systems, lab-on-chip devices, and applications in controlled reactions, co-culture, and diffusion barriers.



Physics of Fluids ARTICLE pubs.aip.org/aip/pof

Coalescence of liquid marbles on oil-infused surface

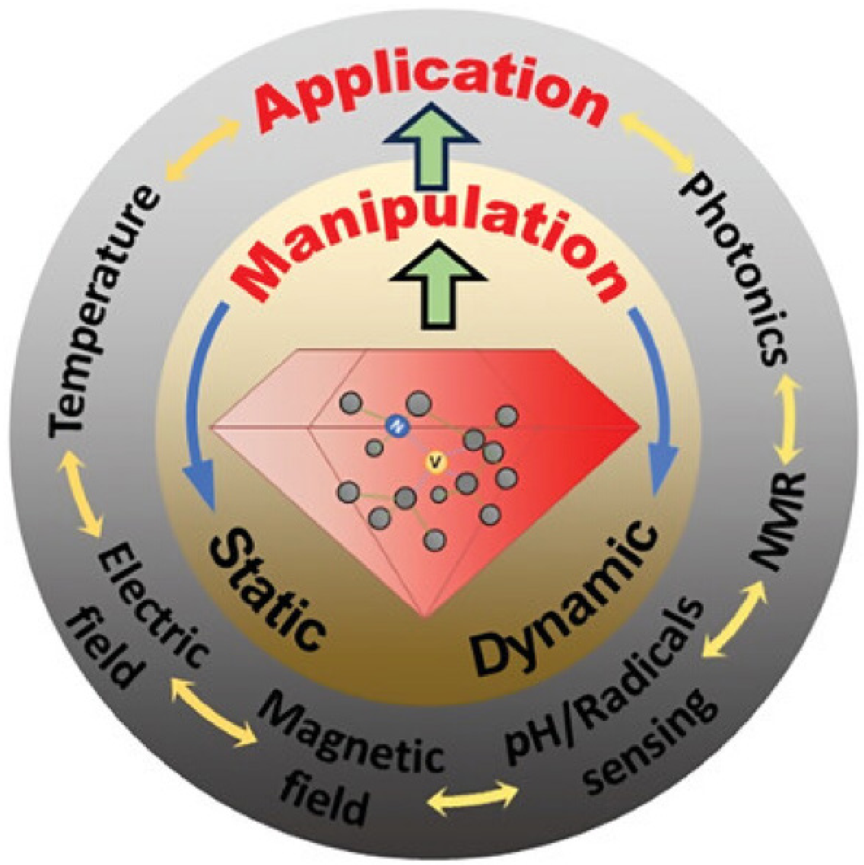
Cite as: Phys. Fluids **36**, 032110 (2024); doi: 10.1063/5.0196769
Submitted: 9 January 2024 · Accepted: 14 February 2024 ·
Published Online: 7 March 2024

Rutvik Lathia (ऋत्विक लाठिया),[1] Prerana Deshmukh (प्रेरणा देशमुख),[1,2] Vinaya (विनया),[1] and Prosenjit Sen (प्रोसेनजीत सेन)[1,a)]

Quantum Technology:

Manipulating Nanodiamonds for Quantum Sensing and Beyond

Fluorescent nanodiamonds (FNDs) with nitrogen-vacancy (NV) centers combine exceptional photostability, quantum spin properties, and biocompatibility, making them powerful tools for bioimaging, drug delivery, sensing, and quantum technologies. This review highlights recent advances in manipulating and positioning nanodiamonds—both statically and dynamically—in microfluidic and heterogeneous environments. Techniques ranging from optical trapping to hybrid control schemes enable precise integration of NDs into photonic, microfluidic, and biological systems, enhancing their utility in quantum sensing, spin control, and scalable quantum architectures. While challenges remain—such as motion control in biological environments and large-scale integration with photonics—active manipulation of nanodiamonds is poised to unlock next-generation applications in sensing, nanobiotechnology, and quantum information processing.



REVIEW
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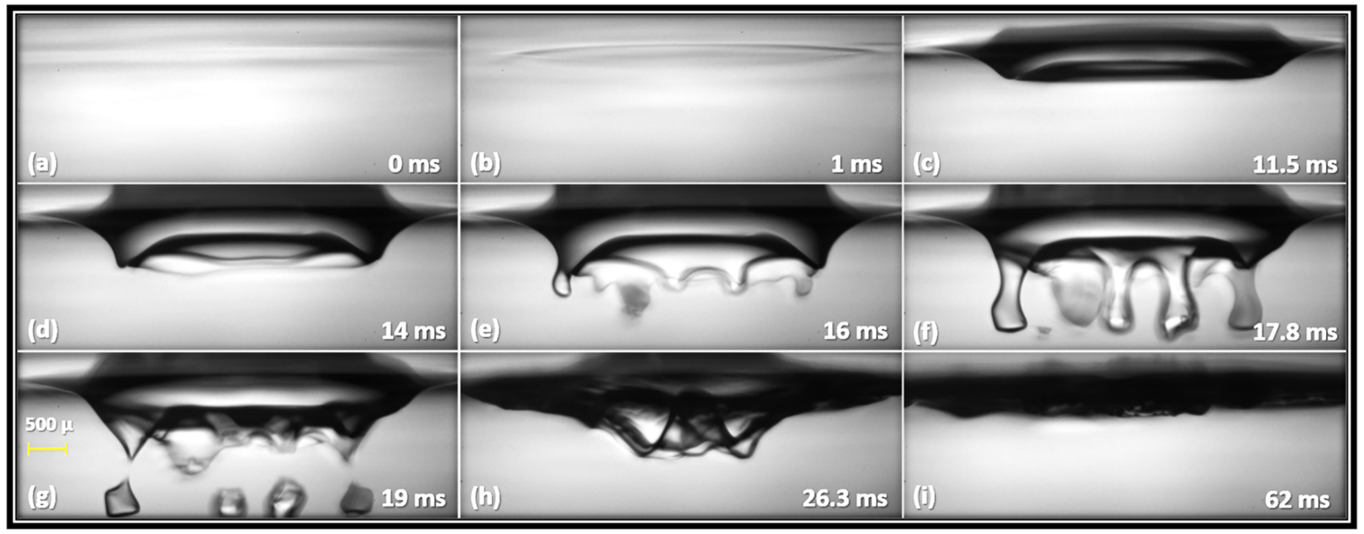
Spatial Manipulation of Fluorescent Colloidal Nanodiamonds for Applications in Quantum Sensing

Eklavy Vashist, Souvik Ghosh, and Ambarish Ghosh**

Kinetics of Electrohydrodynamic Instability in Liquid Helium

This study reports the first detailed experimental analysis of electrohydrodynamic (EHD) instability of a charged liquid helium surface—where excess electrons escape as multielectron bubbles. Using high-speed imaging, researchers captured the evolution of unstable wave vectors, finding strong agreement with theoretical predictions. Results show that kinematic viscosity limits the instability growth, while localized surface dimples can briefly sustain electron densities on the order of 10^{1}□ m□^{2}. These insights provide a pathway to engineer higher electron densities above liquid helium, opening opportunities to explore novel 2D quantum phases for future quantum technologies.



PHYSICAL REVIEW B **110**, 094510 (2024)

Kinetics of electrohydrodynamic instability of a charged liquid helium surface

Pranaya Kishore Rath,[1] Dillip Kumar Pradhan,[2] Paul Leiderer,[3] and Ambarish Ghosh[1,2]
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Nano-Bio-Medical Interface

Optimizing Aptamer-Based Sensors for Molecular Diagnostics

Aptamers—nucleic acid strands with high specificity and stability—are emerging as powerful alternatives to antibodies in biosensing, diagnostics, and therapeutics. This review highlights the performance of aptamer-based sensors (aptasensors), using thrombin as a representative target. It compares electrochemical, fluorescent, colorimetric, affinity-separation, and SERS-based strategies, emphasizing how optimization of parameters (pH, temperature, incubation time, aptamer concentration) dramatically improves sensitivity, specificity, stability, and reproducibility. While only a few aptasensors have reached commercialization, the study underscores that performance optimization can enhance detection limits by up to three orders of magnitude, paving the way for practical use in point-of-care diagnostics, biomedical research, and early disease detection.

BioNanoScience (2024) 14:1767–1779
https://doi.org/10.1007/s12668-023-01292-x

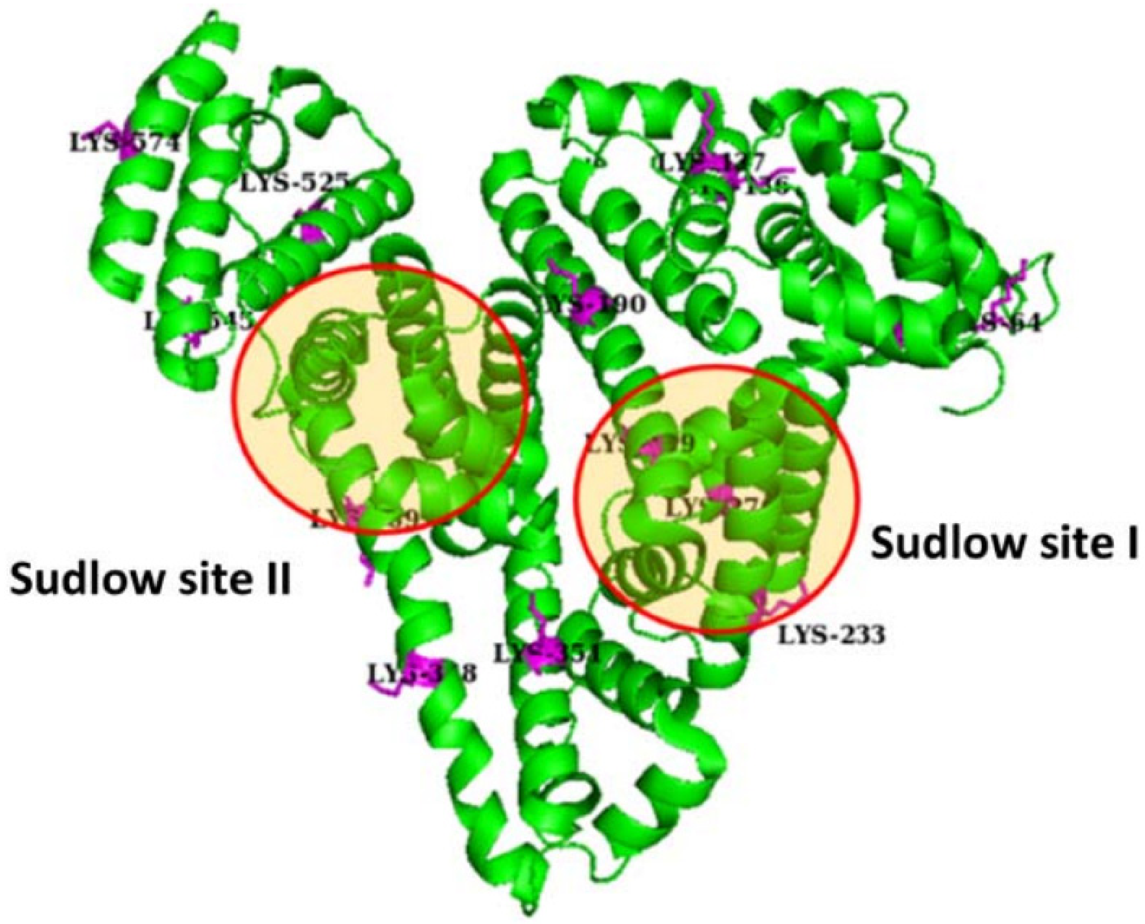
REVIEW

Performance of Aptamer-Based Sensing with Detection of Thrombin as a Representative Example

Manoj M Varma[1] · Shree Sumanas Badrinath[1]

Mapping Glycated Sites in Human Serum Albumin

This study provides a detailed analysis of protein glycation in human serum albumin (HSA) across samples from healthy individuals to severely diabetic patients. Using LC–MS/MS, researchers identified up to 14 distinct glycation sites, with glycation levels strongly correlating with HbA1c (5.7–18.1%) and glycated albumin (19.7–62.3%). By comparing direct serum digestion, SDS-PAGE isolation, and boronate affinity chromatography, they showed how sample preparation affects glycation site detection and relative abundance. Importantly, highly glycated fractions revealed sites more prone to modification, such as K-525. Enzymatic analysis demonstrated that trypsin outperformed Glu-C in sequence coverage and site identification. These findings deepen our understanding of albumin glycation in diabetes and highlight how processing methods impact detection, guiding better biomarker studies for disease monitoring.



Analytical Methods

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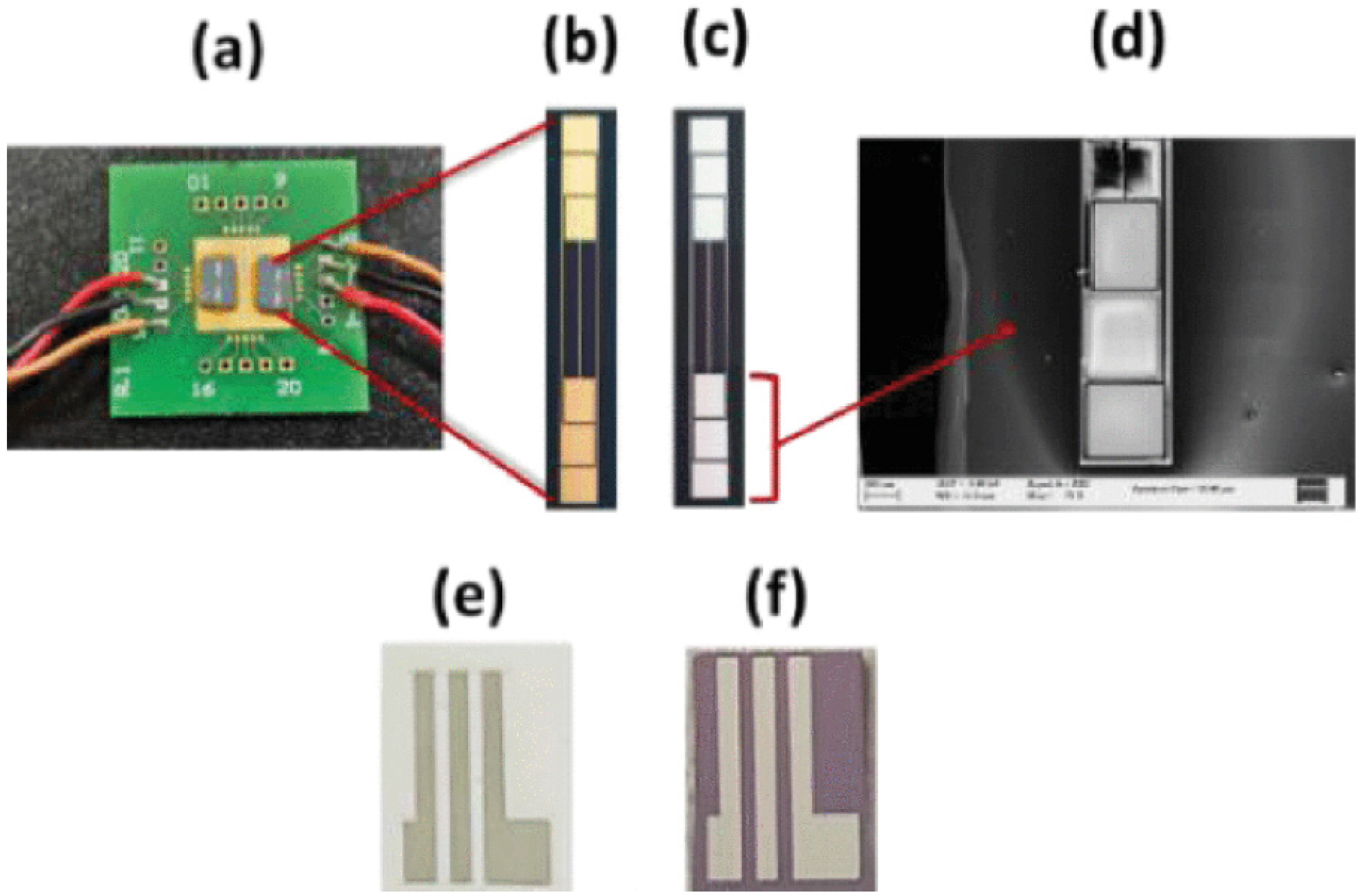
Cite this: *Anal. Methods*, 2024, **16**, 5239

Exploring glycated sites in human serum albumin: impact of sample processing techniques on detection and analysis†

Namita Kumari,*[a] Madhumati S. Vaishnav,[ab] Sathyanarayana Srikanta,[b] P. R. Krishnaswamy[a] and Navakanta Bhat[a]

Optimizing a Low-Cost Continuous Glucose Monitor

This study reports the development of a ferrocene carboxylic acid–based enzymatic glucose sensor for continuous glucose monitoring (CGM). The sensor, built on platinum electrodes and tested using a custom 3D-printed flow system, shows a wide detection range (50–400 mg/dL), high sensitivity, and stability—retaining 88% response after 7 days. Unlike commercial CGMs, this design uses a simplified fabrication process and a stable, readily available mediator, offering a scalable, cost-effective path for indigenous CGM devices. With minimal interference from common molecules and reproducibility across sensors, it provides a strong foundation for advancing affordable diabetes management.



IEEE Sensors Council IEEE SENSORS JOURNAL, VOL. 24, NO. 20, 15 OCTOBER 2024 33299

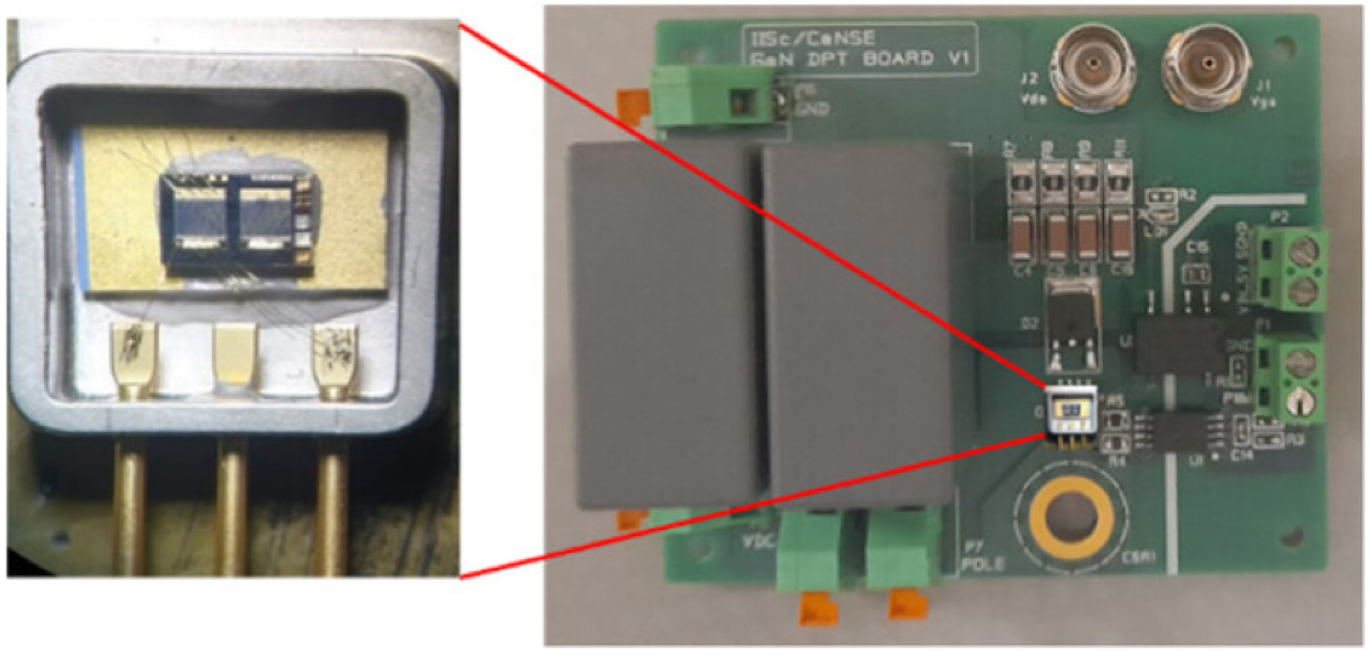
Optimization of a Ferrocene Carboxylic Acid-Based Enzymatic Glucose Sensor for Continuous Glucose Monitoring

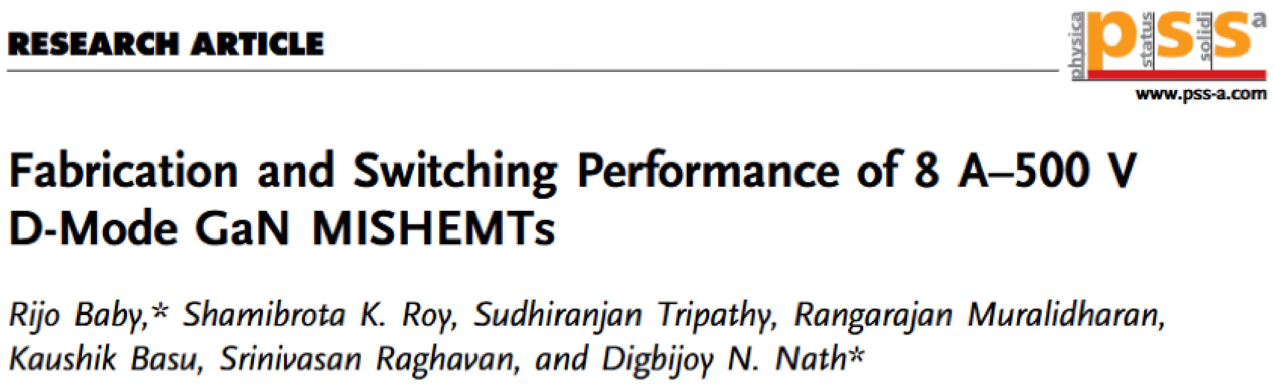
Kavya K. Nayak and Navakanta Bhat, *Fellow, IEEE*

Electronic Devices

Advancing GaN Power Devices: High-Current D-Mode MISHEMTs

This study demonstrates the design, fabrication, and switching performance of multi-finger D-mode GaN MISHEMTs on silicon. Using a superlattice buffer and optimized bilayer SiNx passivation, the devices achieved 8 A ON current, ~500 V breakdown, and reliable gate performance. Packaged and tested under double-pulse switching, they showed low energy losses (Eon = 14 µJ, Eoff = 27 µJ at 5 A, 50 V). These results highlight the potential of D-mode GaN MISHEMTs as scalable, efficient solutions for low-power switching applications in next-gen electronics.




RESEARCH ARTICLE

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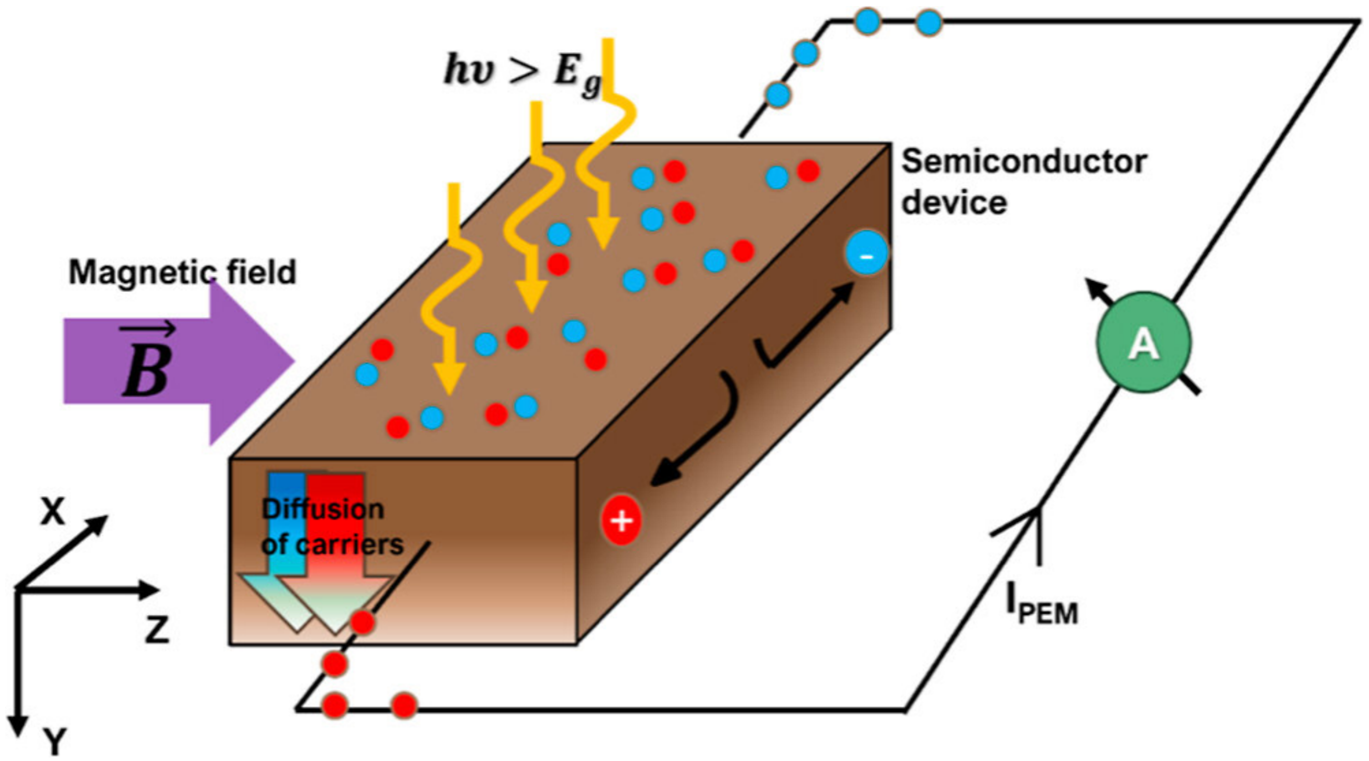
Fabrication and Switching Performance of 8 A–500 V D-Mode GaN MISHEMTs

Rijo Baby, Shamibrota K. Roy, Sudhiranjan Tripathy, Rangarajan Muralidharan, Kaushik Basu, Srinivasan Raghavan, and Digbijoy N. Nath**

First Observation of the Photoelectromagnetic Effect in Perovskites

This work reports the first-ever photoelectromagnetic (PEM) measurements in hybrid lead iodide perovskites, offering a new way to probe bulk carrier transport and recombination unaffected by surface effects. By combining PEM with photoconductance, the study provides lower bounds on carrier mobility, diffusion length, and bulk recombination lifetime in both single crystals and thin films. Results show that oversized acetamidinium cations can extend bulk lifetimes tenfold by passivating defects. Surprisingly, the bulk recombination velocity (BRV) is similar in single crystals and polycrystalline thin films—explaining why single-crystal perovskite solar cells don't outperform thin films. This work positions PEM as a straightforward tool to optimize perovskite materials for high-efficiency solar cells.




ACS APPLIED ELECTRONIC MATERIALS

pubs.acs.org/acsaelm Article

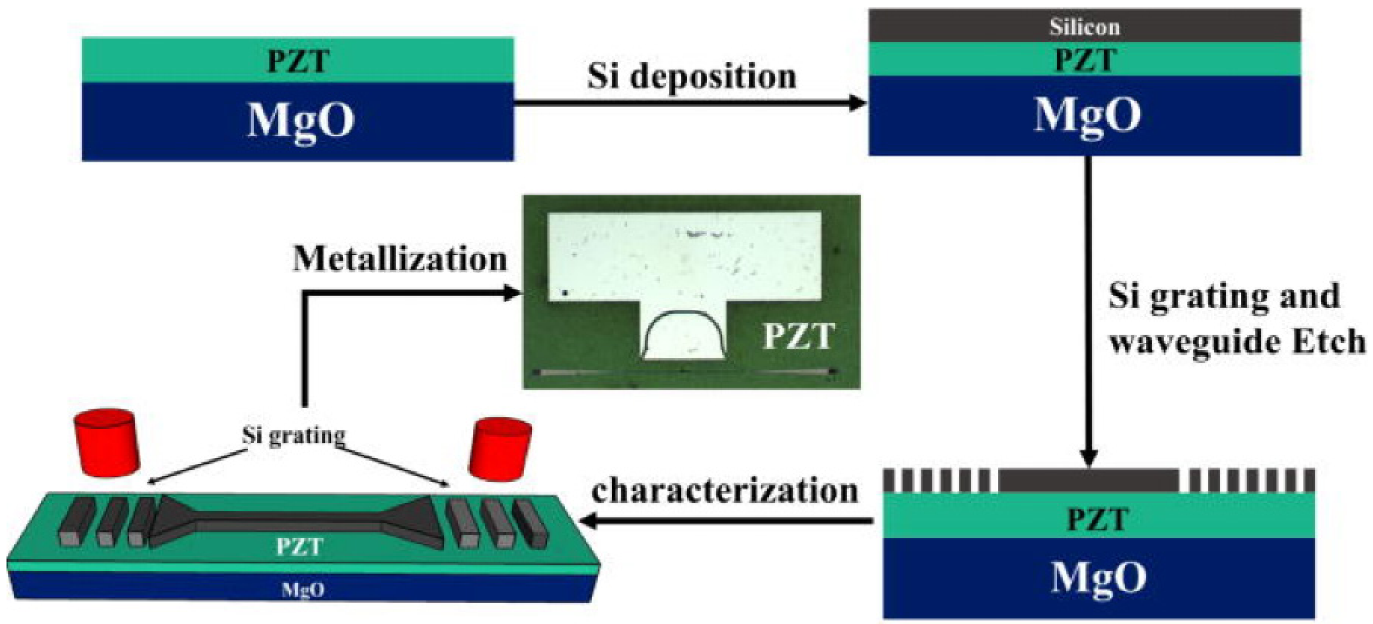
Photoelectromagnetic Effect in Hybrid Lead Iodide Perovskite

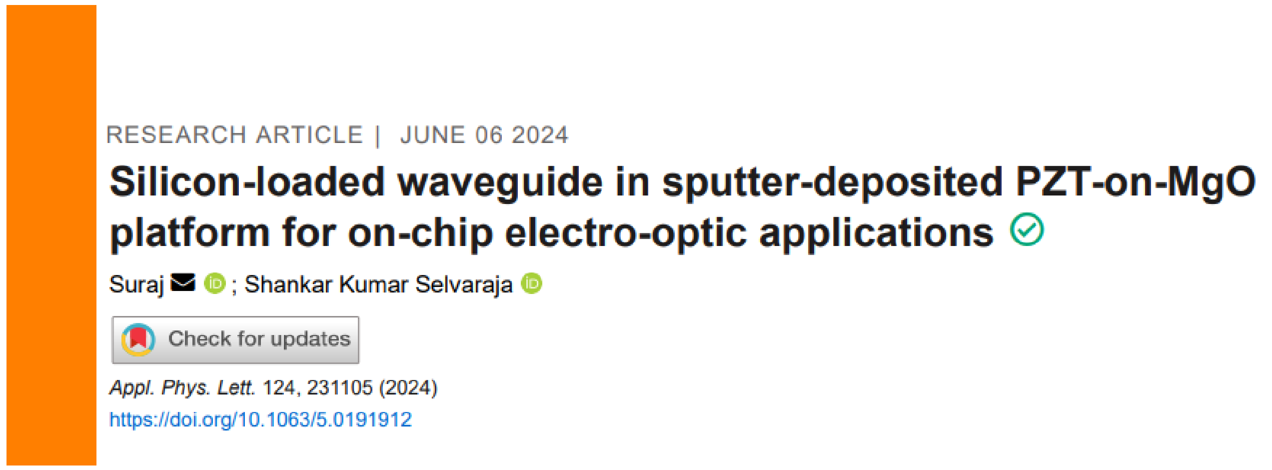
Amritha Anita Raj, Shubhangi Bhardwaj, Krishnamachari Lakshmi Narasimhan, and Sushobhan Avasthi*

Photonics

Silicon-Loaded Waveguides on PZT for Next-Gen Electro-Optics

Researchers at IISc have demonstrated a silicon-loaded waveguide platform built directly on sputter-deposited PZT films on MgO, enabling on-chip electro-optic devices such as modulators and interferometers. The optimized PZT films exhibit (100) orientation with <2 nm surface roughness, ensuring low-loss photonic integration. Compared to the conventional PZT-on-SOI approach, this architecture achieves a 400% enhancement in electro-optic response (71 pm/V vs 14 pm/V), attributed to improved film quality and stronger optical–electrical field overlap. The fabricated Si gratings show coupling efficiencies of −10 dB/coupler with ~14 nm bandwidth. This CMOS-compatible platform offers a promising route for programmable photonic circuits and neuromorphic computing, leveraging tunable PZT thin films for scalable, energy-efficient electro-optics.




RESEARCH ARTICLE | JUNE 06 2024

Silicon-loaded waveguide in sputter-deposited PZT-on-MgO platform for on-chip electro-optic applications

Suraj ; Shankar Kumar Selvaraja

Check for updates

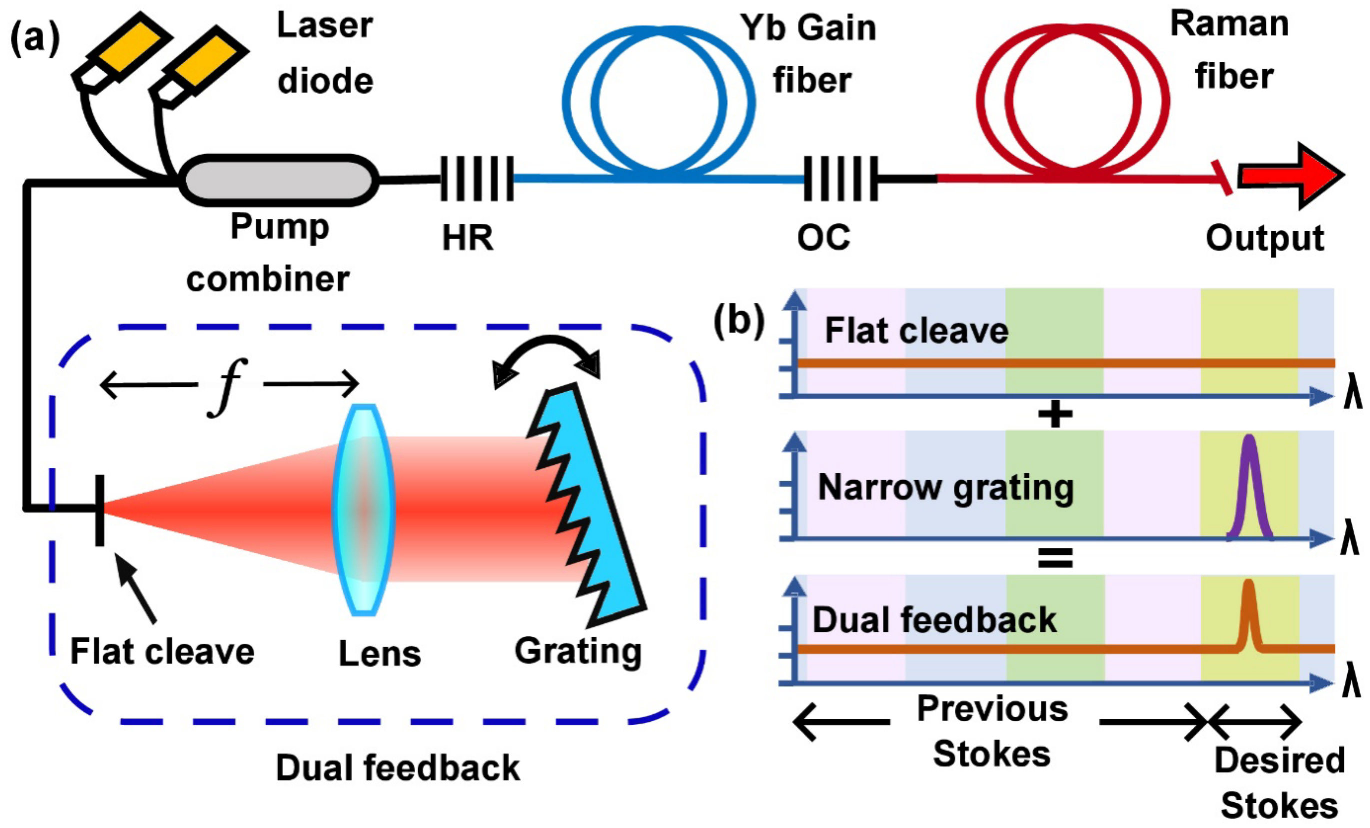
Appl. Phys. Lett. 124, 231105 (2024)

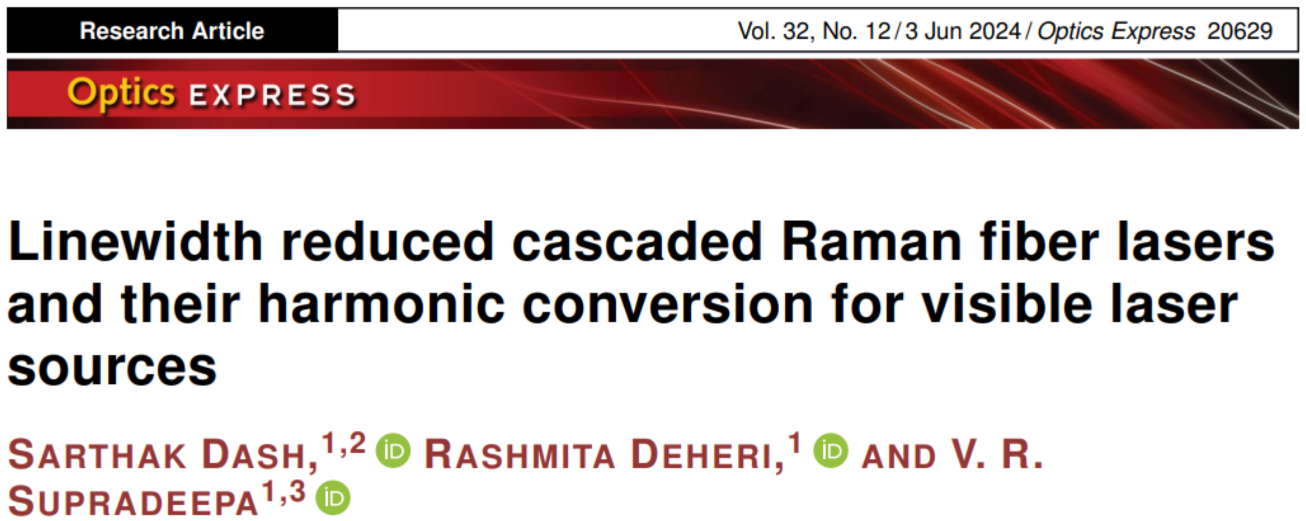
https://doi.org/10.1063/5.0191912

Linewidth-Reduced Cascaded Raman Fiber Lasers for Visible Light Generation

Researchers have demonstrated a new dual-feedback approach to narrow the linewidth of cascaded Raman fiber lasers (CRFLs) without sacrificing their wavelength tunability. By combining broadband flat feedback with a tunable grating-based narrowband filter, they achieved linewidth reduction from 4–5 nm to nearly 1 nm across multiple Raman shifts (1100–1500 nm).

This improvement enabled efficient frequency doubling, producing over 100 mW of tunable visible laser light in the green–yellow and yellow regions. The technique paves the way for scalable, wavelength-versatile fiber lasers that can bridge gaps in conventional rare-earth laser emission and provide compact, tunable visible sources for applications in spectroscopy, medicine, and optical communications.




Research Article | Vol. 32, No. 12 / 3 Jun 2024 / *Optics Express* 20629

Optics EXPRESS

Linewidth reduced cascaded Raman fiber lasers and their harmonic conversion for visible laser sources

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