

BOOK OF ABSTRACTS

Symposium on Advanced Photonics (SAP-2025)

16th-18th November 2025



Organized by:

Optoelectronic Nanodevice Research Laboratory (ONRL),
Centre for Advanced Electronics (CAE),

In association with IIT Indore Optica Student Chapter,
with Madhya Pradesh Section and Student Chapter,

IEEE Photonics Society, IIT Indore

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About the Symposium-

The Symposium on Advanced Photonics (SAP 2025), is designed to bring together researchers, academicians, industry professionals, and students to explore the latest advancements in photonics and its diverse applications. The program scheduled for November 16–18, 2025, will feature keynote addresses, invited talks, technical sessions, and networking opportunities, fostering a collaborative environment for knowledge exchange and innovation.

This symposium offers multifaceted benefits to its participants, focusing on the following key aspects:

Lecture Sessions- Engage with distinguished Scientists, Professors, and Industry Experts as they share insights into cutting-edge research and emerging trends in Advanced Photonics.

Interactive Sessions- Benefits from interactive discussions with leading experts in photonics.

Oral Presentations and Poster Sessions- Participants will have the opportunity to present their research in oral or poster formats, organized into thematic tracks for focused discussions. Best presentations will be recognized with awards to encourage excellence and innovation.

Networking and Discussions- Dedicated sessions for networking with peers, industry professionals, and invited experts will enable collaborations across research areas. These discussions will address future directions, challenges, and opportunities in advanced photonics, bridging academia and industry.

Inaugurated by

Prof. Samit Kumar Ray

Professor, Department of Physics
IIT Kharagpur, India



Born on 1961, Prof. Ray obtained his M.Sc., Physics (1982), M.Tech., Materials Science (1984) and Ph.D. (1991) from IIT Kharagpur. He worked as a Scientist-B for a brief stint in 1984-85 at Solid State Physics Laboratory, Delhi. He joined IIT Kharagpur as a Lecturer in 1991 and rose to the position of Full Professor in 2004 and Professor (HAG) in 2010. He has served as the Head of the Department of Physics (2011-2014), founder Head of the School of Nanoscience and Technology (2014-2016) and Dean, Postgraduate Studies and Research (2015 – 2016) at IIT Kharagpur.

Prof. Ray's research interest in the broad area of experimental condensed matter physics focusses on semiconductor nanostructures, epitaxial growth of quantum structures, nanophotonics and physics of nanodevices. His research has run the gamut from very practical fields such as pseudomorphic strained SiGe/SiGeC alloy heterostructures for high mobility MOSFETs to low dimensional quantum structures. His studies on Ge quantum dots and strained Ge to achieve light emission from an indirect bandgap semiconductor are useful to realize Si based lasers in future. His research results on floating-gate flash memory, 2D/3D heterostructures, quantum dot infrared photodetectors and nanowire heterojunctions are considered as significant breakthroughs for future nanodevice applications. Prof. Ray has supervised twenty six Ph.D. students (another twelve continuing at S. N. Bose Centre and IIT Kharagpur) and more than fifty dissertations in UG and PG levels. He has completed 16 sponsored research projects worth over Rs. 18 crore as a PI/Co-PI.

Plenary Speaker

Title of Talk: Organic semiconductors for photodetectors and bioelectronics

Abstract :

Organic semiconductors enable a variety of novel applications for flexible, lightweight, and environmentally friendly electronics. In this talk, I will first discuss recent work at IAPP on organic photodetectors, having a performance which matches or exceeds the best detectors based on crystalline semiconductors. As second topic, I will report on recent work on organic electrochemical transistors (OECT) suitable for bioelectronic applications. We have recently shown that the detailed working principle of these devices differs significantly from classical FET. Finally, an outlook is given on a new form of neural networks based on organic semiconductors, allowing highly efficient neuromorphic computing approaches.

Prof. Karl Leo

Dresden Integrated Center for
Applied Physics and Photonics (IAPP)
Technische Universität Dresden
D-01062 Dresden, Germany



Karl Leo obtained the Diplomphysiker degree from the University of Freiburg in 1985, working with Adolf Goetzberger at the Fraunhofer-Institut für Solare Energiesysteme. In 1988, he obtained the PhD degree from the University of Stuttgart for a PhD thesis performed at the Max-Planck-Institut für Festkörperforschung in Stuttgart under supervision of Hans Queisser. From 1989 to 1991, he was postdoc at AT&T Bell Laboratories in Holmdel, NJ, U.S.A. From 1991 to 1993, he was with the Rheinisch Westfälische Technische Hochschule (RWTH) in Aachen, Germany. Since 1993, he is full professor of optoelectronics at the Technische Universität Dresden. His main interests are novel semiconductor systems like semiconducting organic thin films; with special emphasis to understand basic device principles and the optical response. His work was recognized by a number of awards, including: Otto-Hahn-Medaille (1989), Bennigsen-Förder-Preis (1991), Leibniz-Award (2002), award of the Berlin Brandenburg Academy (2002), Manfred-von-Ardenne-Preis (2006), Zukunftspreis of the German president (2011), Rudolf-Jäckel-Prize (2012), Dr. techn. h.c. of the University of Southern Denmark (2013), Technology Transfer Prize of the DPG (2016), and the Lifetime Inventor Award of the European Patent Office (2021). He is cofounder of several companies, including NovaLED GmbH and HeliATEK GmbH.

Keynote Speaker

Title of Talk: Silicon Photonics Enabled Quantum Circuits and Systems (SPEQCS)

Prof. Bijoy Krishna Das

Professor
Dept. of Electrical Engineering
IIT Madras, India



Bijoy Krishna Das obtained his master degree in solid state physics from Vidyasagar University, Midnapore, India (in 1996) and PhD degree (Dr.rer.nat) in integrated optics from University of Paderborn, Germany (in April 2003).

Dr. Das started his research career in the area of photonics at the Microelectronics Centre, IIT Kharagpur nearly about two decades ago (in January 1996) when he was associated in a DRDO sponsored project. He was an FRC Postdoctoral Fellow in the Graduate School of Engineering, Osaka University, Osaka, Japan (2004-2005). He later joined as a postdoctoral researcher in the Center for Optical Technologies, Lehigh University, Bethlehem, PA, USA.. In April 2005, he rejoined the Integrated Optics Group in University of Paderborn as Wissenschaftlicher Mitarbeiter and continued his research on integrated nonlinear optical devices. He also worked for a while at Laboratoire Aime Cotton, CNRS, Orsay, France.

Since August 2006, Dr. Das has been associated with the Department of Electrical Engineering, IIT Madras, Chennai, India, where he is currently holding a full Professor position. He is also one of the core founding faculty members of the Centre for NEMS and Nanophotonics (CNNP) sponsored by the DeitY, Govt. of India. A number of projects sponsored by DRDO Labs (RCI Hyderabad, IRDE Dehradun), DST and DIT/MeitY have been executed by Dr. Das as a principal investigator. He has published more than 75 research articles in peer reviewed journals and conference proceedings. His present research focus is silicon photonics devices and circuits: optical interconnect and quantum optic application; integrated RF photonics signal processing; lab-on-chip biomedical applications.

Keynote Speaker

Title of Talk: Microring Resonators for Classical and Quantum Applications

Abstract

Optical waveguides made from silicon or silicon-compatible materials have garnered significant attention over the past few years due to their potential for high-speed connectivity within data centers, healthcare, defense, and chip applications. Microring resonators (MRRs) are one of the important building blocks for linear, nonlinear, and quantum computing applications. The microring resonator comprises a straight waveguide in close proximity to a circular waveguide. The MRR can be used as a filter, modulator, and to generate a frequency comb and entangled photon pairs for quantum computing applications.

In this talk, I'll discuss microring resonators and their potential applications in both classical and quantum information processing, as well as discuss other related works carried out in our group. I'll provide an insight and our contribution to achieving the objectives of the National Quantum Mission.

Prof. Shailendra Kumar Varshney

Professor, Dept. of E&ECE

IIT Kharagpur, India

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Dr. S.K. Varshney is recognized for his pioneering research in fiber optics and photonic technologies, encompassing integrated nanophotonics, metasurfaces, nonlinear optics, and quantum photonics. He is currently a professor in the Department of Electronics & Electrical Communication Engineering at IIT Kharagpur. He has made pioneering contributions to specialty fiber optics, microring resonators, linear and nonlinear devices, fiber-based sources, and optical and quantum communications.

He is the recipient of several fellowships UGC/CSIR JRF, the Monbukagakusho scholarship from the Government of Japan, the JSPS fellowship from Japan, and the Alexander von Humboldt fellowship and DAAD fellowship from Germany. He is the recipient of the Faculty Excellence Award (2019) by IIT Kharagpur and the G S Sanyal Faculty Excellence Award (2020) by the IIT Kharagpur Alumni Foundation USA. He is a senior member of IEEE and Optica. Currently, he is also serving as Dean's Student Affairs at IIT Kharagpur.

He is the author and co-author of over 110 research papers in peer-reviewed journals and more than 120 papers in conference proceedings.

Keynote Speaker

Title of Talk: Revolutionizing Computing and Sensing through III–V Integrated Photonics

Prof. Hamed Dalir

Associate Professor

Electrical and Computer Engineering

University of Florida, USA



Dr. Hamed Dalir is an Associate Professor of Electrical and Computer Engineering at the University of Florida, where he has served as Area Chair for Electronics since 2025. He has been recognized in the Stanford–Elsevier Top 2% Scientists Ranking (2024 Edition, Top 0.3% in Optics) for his contributions to photonic computing, semiconductor lasers, AI hardware, and integrated sensing systems. Dr. Dalir received his Ph.D. from the Institute of Science Tokyo and continued his research as a postdoctoral scholar at UC Berkeley. Over the years, he has published more than 300 peer-reviewed articles and filed over 20 patents, some of which have been transferred to companies including Fuji Xerox and Broadcom. His research has been supported by agencies and industry partners such as TSMC, DOE, DARPA, AFWERX, AFOSR, ARO, ONR, and NASA, including a dedicated wafer-scale fabrication run from TSMC. He is a SPIE Senior Member, has served on several SPIE program committees, chair, and was honored as a SPIE Community Champion (2020). He is also grateful to have received recognitions such as the Best Project Collaboration Award from TSMC (2025), the ECE Faculty of the Year (Student Choice, 2024–25), ECE Teaching Award (2024–2025) the Rising Star in Photonics by the American Chemical Society (2025), and the IAAM Scientist Medal and Fellowship (2024), among others.

Keynote Speaker

Title of Talk : Silicon Photonics Inspired Guided Wave THz Photonic Switches and filters

Abstract:

Next generation communication and computing system in classical as well as quantum domain will require photonic devices, particularly switches that are fast, energy-efficient, ultra-compact and reconfigurable. One of the ways to overcome many existing problems in Si-based photonic devices is to hybridize the Si platform with nonvolatile phase change materials like $\text{Ge}_2\text{Sb}_2\text{Te}_5$ (GST) offering crucial properties such as high optical contrast, high scalability, and compatibility with the CMOS technology. The mentioned research area has been explored extensively by us in the recent past. Inspired by our own work as above and silicon nanophotonics in general, we have investigated and achieved success in proving the concepts and demonstration of great potential and performance of photonic switches and filters on SOI waveguides in THz spectral regime. Same will be presented in detail in this conference.

Prof. Rajesh Kumar

Physics Department

Indian Institute of Technology Roorkee, India

Email: rajesh.kumar@ph.iitr.ac.in



Professor Rajesh Kumar received M.Sc.(Physics) and M.Tech.(Optoelectronics and Optical Communication) from IIT Delhi. He obtained PhD in Photonics Engineering from Ghent University-IMEC (Belgium). After completing Ph.D. degree, he worked at Optoelectronics Research Center, University of Southampton (U.K.), and University of Colorado, Boulder (USA). In 2015, he joined IIT Roorkee where he is currently an Associate Professor. Professor Kumar's research interest is focused around CMOS compatible silicon photonic devices. He has authored /co-authored more than 90 peer-reviewed papers in prestigious journals (including in Nature and Nature Photonics) and conference proceedings; and has delivered several expert talks in national and international forums. He has held editorial and expert positions in journals and professional bodies. He has been continuously and actively involved in different national and international research projects including BRICS STI Framework and National Quantum Mission. Professor Kumar is a senior member of OPTICA, IEEE and Life-fellow of Optical Society of India.

Keynote Speaker

Title of Talk: Title: Brillouin Scattering and its Applications to Microwave Photonics

Abstract:

Brillouin scattering is one of the strongest optical nonlinearities that provide wavelength transparent operation with reconfigurable bandwidth. Over the last decade, it has been harnessed in fiber and microresonator platforms for a number of applications in fundamental and applied physics that range from ultra-narrow linewidth Brillouin lasers, Brillouin gyroscopes, microwave photonic filters and instantaneous frequency measurement, Kerr and soliton combs, and slow- and fast-light to name a few. This talk will present a brief overview of stimulated Brillouin scattering and its applications to microwave photonics.

Prof. Ravi Pant

Associate Professor

Indian Institute of Science Education and Research
IISER-TVM, Kerala, India



Ravi Pant received his PhD from the College of Optical Sciences, University of Arizona, Tucson, USA in 2009. From 2008 to 2010, he was a Postdoctoral Fellow at the Centre for Ultrahighbandwidth Devices for Optical Systems (CUDOS), School of Physics, University of Sydney, Australia, working in the area of soliton self-frequency shift. From 2010 to 2013, he was an Australian Research Council (ARC) Postdoctoral Fellow at the University of Sydney, where he led the first demonstration of On-chip stimulated Brillouin scattering.

He is currently an Associate Professor at the Indian Institute of Science Education and Research IISER-TVM, Kerala, India. His main research interests include Brillouin scattering based microwave photonics, fiber and microresonator Brillouin lasers, frequency combs, slow- and fast-light, and other nonlinear optical phenomena in microresonators. He has published more than 100 journal and conference papers in prestigious journals such as Optica, Communications Physics, Physical Review Research, Advances in Optics and Photonics, Journal of Lightwave Technology, and Optics Letters to name a few. He has been a reviewer for prestigious journals such as Nature Communications, Optica, Optics Letters, Journal of Lightwave Technology, Nature Photonics, Light Science and Applications, and APL Photonics.

Tutorial Speaker

Title of Talk: AI and Machine Learning for Quantum Communications

Prof. Vimal Bhatia

Professor

Department of Electrical Engineering

IIT Indore, India



Vimal Bhatia (SM'12, FIETE, FOSI) is currently working as a Professor (HAG) with the Indian Institute of Technology (IIT) Indore, India, and is an adjunct faculty at IIT Delhi and IIIT Delhi, India. He received Ph.D. degree from Institute for Digital Communications with The University of Edinburgh, Edinburgh, U.K., in 2005. During Ph.D. he also received the IEE fellowship for collaborative research at the Department of Systems and Computer Engineering, Carleton University, Canada, and is Young Faculty Research Fellow from MeitY, Govt of India. He is also a recipient of Prof. S. N. Mitra Memorial Award (2024), Prof. SVC Aiya Memorial Award (2019), National Slovak Fellowship, and European Mobility Scheme for Senior Researcher at Czech Republic. He has worked with various IT companies for over 11 years both in India and the UK. He is a PI/co-PI/coordinator for external projects with funding of over USD 25 million from MeitY, DST, UKIERI, MoE, AKA, IUSSTF and KPMG. He has more than 450 peer reviewed publications, and has filed 16 patents (with 11 granted). He has supervised 26 awarded PhD thesis, and 2 PhD thesis submitted. His research interests are in the broader areas of communications, non-Gaussian non-parametric signal processing, machine/deep learning with applications to communications and photonics. He is a reviewer for IEEE, Elsevier, Wiley, Springer, and IET. He is currently Senior Member of IEEE, Fellow IETE and certified SCRUM Master. He was also the General Co-Chair for IEEE ANTS 2018, and General Vice-Chair for IEEE ANTS 2017. He has delivered many talks, tutorials and conducted faculty development programs for the World Bank's NPIU TEQIP-III and invited talk at WWRF46-Paris. He is currently Associate Editor for IETE Technical Review, Frontiers in Communications and Networks, Frontiers in Signal Processing, IEEE Transactions on Green Communications and Networking, and IEEE Wireless Communications Letters. He is current member Steering Committee for IEEE ANTS. He has been mentioned amongst the World's Top 2% Scientists by the Stanford University in 2021, 2022 and 2023.

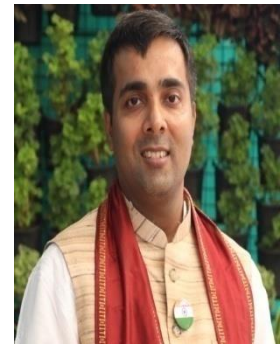
Tutorial Speaker

Title of Talk: Advanced Memory for Image Processing and Logic Operation

Abstract: Artificial Intelligence (AI)/ Machine Learning (ML) algorithms are being widely used currently for various applications that include self-driving cars, virtual assistants on smartphones, image processing algorithms, homeland security, and human speech processing, etc. Most of these algorithms involve updating parameters/weights in the model continuously during the training process. Currently, these algorithms are being run on giant, power-hungry computational hubs, which follow traditional von Neumann architecture, causing substantial loss in energy and time during training process due to von Neumann bottleneck. The most viable solution is the low-power memristor or memcapacitor, which alleviates the challenges of von Neumann bottleneck and scaling by plugging into processing-in-memory (PIM). Here, we present the realization of memory devices and crossbar to implement image processing and logic operations via implementing PIM.

Prof. Shaibal Mukherjee

Professor
Department of Electrical Engineering
IIT Indore, India



Shaibal Mukherjee completed his PhD in Electrical and Computer Engineering, University of Oklahoma, USA in 2009 followed by his postdoctoral research work in the Center of Quantum Devices, Electrical Engineering and Computer Science, Northwestern University, USA. In September 2010, he joined IIT Indore and currently is a Professor in the Department of Electrical Engineering at IIT Indore. The Hybrid Nanodevice Research Group (HNRG) led by Shaibal at IIT Indore explores new physics of micro- and nano-structured materials, and to apply this knowledge in realizing advanced tools and devices for chemical, biological, optical, electronic and energy applications. He has published 145+ research articles in peer-reviewed journals, 110+ international conference proceedings, 11 book/book chapters and 16 patents (Granted: 14 and Filed/Published: 2). He is the recipient of various prestigious awards such as “**2025 Friedrich Wilhelm Bessel Research Award by Alexander von Humboldt Foundation**”, “**2024 Microelectronic Engineering Journal Middle Career Investigator Award and Lectureship**”, “**2024 TIH-IoT CHANAKYA Faculty Fellowship, IIT Bombay**”, “**2023 Japan Society for the Promotion of Science (JSPS) Invitational Fellowship Award**”, “**2021 JSPS Invitational Fellowship Award**”, “**2020 DUO-India Professor Fellowship Award**”, “**2019 DAAD Fellowship Award**”, “**2018 Materials Research Society of India (MRSI) Medal**”, “**2016 Young Faculty Research Fellowship (YFRF) under Visvesvaraya PhD Scheme for Electronics and IT**”. He is an Associate Editor for IEEE Sensors Journal, a senior member of IEEE, a regular member of Optical Society of America and Life Fellow of MRSI and Optical Society of India. He is a fellow of IoP, JSPS, Humboldt Foundation, RSC and IET. He is the founding Chair of IEEE Madhya Pradesh (MP) Section Electron Devices Society (EDS) chapter. He is also the Director, Co-Founder and Mentor of QuanTechL2M Innovations Pvt. Ltd.

Tutorial Speaker

Title of Talk: Semiconductor Optoelectronic Devices for Optical Communication and Interconnects

Abstract

Silicon-based nano-photonic devices for broadband optical communication, computing and information storage are presented which include a silicon nanophotonic resistive switch is proposed with an on-off extinction ratio of over 20dB. The interaction of plasmons and electromagnetic wave at nanoscale leads to large control over the optical signal via electrical control. An optical modulator based on hybrid silicon is realized with Si-ITO heterojunction enabling intensity modulation with an extinction ratio over 20 dB via electrical tuning of optical absorption. The device is promising as a silicon photonic platform not only for optical modulation but also in other applications such as electrically tunable photonic devices, adjustable dispersion compensators and in optical delay lines for optical communication and optical interconnects.

Prof. Mukesh Kumar

Professor
Department of Electrical Engineering
IIT Indore, India



Dr. Mukesh Kumar is currently a Professor in the Department of Electrical Engineering at Indian Institute of Technology (IIT) Indore. He received his Master's of Technology (M.Tech) from Indian Institute of Technology (IIT) Kharagpur, India in 2004 and PhD in Electronics in 2009 from Tokyo Institute of Technology, Japan. He had been in University of California Berkeley, USA as an Exchange Researcher. He was a JSPS Postdoctoral Research Fellow in Tokyo Institute of Technology, Japan. His research interests include Integrated Optoelectronics, Silicon Photonics, Nanophotonics, Semiconductor Optoelectronics and Nanofabrication Technology. He has executed number of sponsored research projects funded by the Government of India and currently working on several research projects including one under National Quantum Mission. He has published over hundred research articles in journals and conferences of international repute and has published five patents. He is also leading the photonics outreach program of IIT Indore to reach out to higher schools and smaller colleges for spreading the know-how of Photonics and Semiconductor Technology. He has also served as the Founding Head of Centre for Advanced Electronics at IIT Indore. He is also serving as the Associate Editor of IEEE Photonics Journal. He is the recipient of Scientific High-level Visiting Fellowship 2023 from French Institute. He is a Fellow of Japan Society for Promotion of Science (JSPS), a senior member of IEEE, a senior member of Optical Society of America, Optica and Life Fellow of Optical Society of India. He is an Adjunct Professor at Purdue University, USA.

Invited Speaker

Title of Talk: Photonic Spin Hall Effect for Advancing Sensing Applications

Abstract:

The talk provides an in-depth exploration of the photonic spin-Hall effect (PSHE) in light, discussing its origins and real-life implications. It covers various phenomena, including the spin-orbital interaction in light and optical vortex, as well as spin-dependent effects in paraxial fields. The manipulation of light shapes through spin control using plasmonic structured interfaces is also highlighted, along with the establishment of a robust spin-directional coupling via evanescent near fields. To improve the PSHE based sensing, plasmonic and two-dimensional (2D) materials are also being explored for possible uses.

Prof. Yogendra Kumar Prajapati

Professor

Motilal Nehru National Institute of Technology Allahabad
Prayagraj, Uttar Pradesh, India.



Dr. Yogendra Kumar Prajapati is currently a professor at the Motilal Nehru National Institute of Technology Allahabad in Prayagraj, Uttar Pradesh, India. Dr. Prajapati has made significant contributions to both experimental and theoretical research in the fields of photonic devices and optical communication. Dr. Prajapati has supervised 14 Ph.D. theses and 32 M.Tech theses and has published 180 research papers in the Science Citation Index (SCI). He is a senior member of the IEEE and Optica, as well as a member of the SPIE. Additionally, he serves as an Associate Editor for the IEEE Sensors Journal and IEEE Access. Dr. Prajapati has received several accolades, including the Sir Visvesvaraya Young Faculty Research Fellowship Award in 2016 from the Ministry of Electronics and Information Technology in New Delhi and the Young Scientist Award from DST, SERB in 2014.

Invited Speaker

Title of Talk: Next Generation Semiconductor Devices: Nanostructured Solar Cells

Abstract of the Talk :

InP and GaAs-based nanostructures such as nanowires, nanocones, and nanopylramids are considered as potential contenders for futuristic optoelectronic applications including solar cells and photodetectors. Both GaAs and InP exhibit superior optical and electronic properties such as high absorption coefficients, ideal direct bandgap, high electron mobility and capability to form heterojunctions, which make them suitable for the intended applications. This talk will provide deep insights into the optical and electrical modelling and optimization of III-V nanostructure based solar cells using ANSYS FDTD and Charge Solver Modules. The comparative analysis of the optoelectronic properties of different nanostructures can provide valuable information regarding their photovoltaic performance.

Dr. Dip Prakash Samajdar

Assistant Professor
Department of Electronics and Communication Engineering
Indian Institute of Information Technology,
Design and Manufacturing Technology (IIITDM)
Jabalpur, India



Dr. Dip Prakash Samajdar is an Assistant Professor in the Department of Electronics and Communication Engineering at PDPM Indian Institute of Information Technology, Design and Manufacturing Technology (IIITDM) Jabalpur, India since 2017. He received his Ph. D Degree on Experimental and Theoretical Investigation of III-V-Bismide Semiconductors in 2016 from University of Calcutta after the completion of his B.Sc (Physics), B. Tech (RadioPhysics and Electronics) and M. Tech (RadioPhysics and Electronics) Degrees from the same University in 2007, 2010 and 2012 respectively. Till date, he has authored more than 195 research articles in peer-reviewed journals and conference proceedings. His research interest includes III-V semiconductor nanostructures, Nanostructured Solar Cells, Novel Electronic Devices and Perovskite Solar Cells. He is a Senior Member of IEEE, a fellow of IETE, and Life Member of OSI and MRSI. He is also the Associate Dean of Research, Sponsored Projects and Consultancy at PDPM IIITDM Jabalpur.

Invited Speaker

Title of Talk: Advances in Silicon Photonic Integrated Circuits: A Leap Towards Photonic Chips for Data Centre and Accelerated Computing

Abstract: Photonic Integrated Circuits (PICs) are revolutionizing the field of optical communication, data centres and high-speed computing through the compact, energy-efficient, and high-speed on-chip optical processing systems that overcomes the limitations of conventional electronic technologies. While data centers and high-speed computing infrastructures face exponential growth in data traffic and energy demand, PICs offer a scalable solution through WDM, coherent optical interconnects, and optical switching at terabit-per-second rates. The realization of on-chip MUX/DeMUX, optical transceivers will pave the way silicon photonic technologies in this domain.

In this work, we present various design and fabrication aspects of PICs fabricated on the Silicon-On-Insulator (SOI) platform. This work reports on the design and fabrication of PICs for Multi-channel multiplexing and de-multiplexing operations on SOI platforms. The design process consisted of a systematic optimization of integrated photonic components such as vertical grating couplers, tapered waveguides, and MRRs, among others. These key components were optimized with the use of FDTD simulations in order to enhance the overall device performance. Strong resonances are obtained in the transmission spectra of the MRRs after their radius and coupling gap were optimized; these guarantee minimum crosstalk and signal integrity across channels.

Dr. Vinod Parmar

Scientist

Optics and Photonics Instrumentation (OPI),
CSIR-Central Scientific Instruments Organisation
(CSIR-CSIO), Chandigarh, India



Dr. Vinod Parmar has received his doctorate (Ph.D.) from Indian Institute of Technology Delhi (IIT Delhi) in the field of laser-material interaction process. He carried out his doctoral research work at IIT Delhi and Purdue University (USA). He is currently working as a Scientist in the division of Optics and Photonics Instrumentation (OPI), CSIR-Central Scientific Instruments Organisation (CSIR-CSIO), Chandigarh. His current research interests include, Silicon Photonics, Surface enhanced Raman spectroscopy (SERS), Photonic Integrated Circuits, and laser-material interactions.

During his academic journey, he received research excellence travel award (RETA) by IIT Delhi. He has also been awarded with internationally reputed fellowships including Fulbright–Nehru Doctoral Research Fellowship to pursue research at Purdue University (USA). For the postdoctoral research, he was awarded with the prestigious Marie Curie Fellowship to pursue research at EPFL, Switzerland. In addition to several publications in refereed journals and various national and international conferences, Dr. Parmar has obtained three (03) patents and these technologies has been transferred to the industry. *His main expertise is on Micro and Nano-fabrication using e-beam lithography technique, ultrafast laser-based texturing and surface modification, Laser lithography, dry and wet-etching processes.* Now a days, he is working on photonic integrated circuits, On-chip devices, photonic sensors, and silicon photonics-based logic gates and devices at CSIR-CSIO Chandigarh.

Invited Speaker

Tentative title : Advances in Hybrid Plasmonic Sensing and Its Applications

Abstract:

In the current technological era, sensing technology has become crucial for real-time assessment, surveillance, and data collection in healthcare, environmental monitoring, industrial automation, structural health diagnostics, and biomedical engineering. Photonics and Plasmonics utilize light for immediate and precise detection, advancing in response to the demands for accuracy, speed, and miniaturization in sensing systems. Usually, the photonic sensors utilize light-matter interactions to facilitate rapid passive measurements, with a powerful capability to detect subtle biological or environmental variations. Moreover, the Plasmonic sensing devices confine the EM waves to subwavelength scales for the nanoscale detection of chemical, biological, and physical elements. Hence, the photonics and plasmonics make lab-on-chip applications better by rendering them swifter, more sensitive, and easier to use. These sensors are increasingly employed for real-time biosensing, medical diagnostics, and environmental analysis for rapidly and precisely detecting diseases, biomolecules, and pollutants. The hybrid Plasmonic structures (HPWs) that combine the good properties of the plasmonic modes and the dielectric waveguides, is essentially a key progress for various research domains, related to biosensing, etc.

Dr. Rakesh Ranjan

Associate Professor

Department of Electronics and Communication Engineering
National Institute of Technology Patna, Bihar, India



Dr. Rakesh Ranjan (Member, IEEE) is a proficient researcher and educator in the domain of Electronics and Communication Engineering. He obtained his M.Tech. and Ph.D. degrees from the Indian School of Mines, Dhanbad (now the Indian Institute of Technology (ISM) Dhanbad), in 2008 and 2015, respectively. He currently serves as an Associate Professor in the Department of Electronics and Communication Engineering at the National Institute of Technology Patna (NIT Patna), Bihar, India. Dr. Ranjan has shown a significant academic presence through research published in numerous reputed international journals/conferences, and patent. His research is focused on optical fiber technology and communication, silicon photonics, hybrid plasmonic devices, optical wireless communication, vehicular technology, and IoT applications. In addition to his academic achievements, Dr. Ranjan engaged in significant academic and service responsibilities, assuming on various roles at both the institute and departmental levels at NIT Patna. He serves as a reviewer for several prestigious international journals and conferences. Dr. Ranjan's journey from his doctoral work and ongoing research/academic contributions demonstrates his devotion to teaching and innovation. His affiliation with the IEEE further reflects his global engineering community involvement and career progress.

Invited Speaker

Title of Talk: 2D-powered Silicon Photonics: A New Era of Light-Based Computing

Abstract:

Silicon photonics has revolutionized the way light is manipulated on a chip, offering high speed data processing and seamless integration with existing CMOS technology. However, the lack of strong electro-optic effects and the need for active tuning materials limit its potential for truly reconfigurable or energy-efficient photonic systems. In recent years, the integration of two-dimensional (2D) materials has opened exciting new possibilities. These atomically thin materials—such as graphene, transition metal dichalcogenides (TMDs), and emerging ferroelectric layers exhibit exceptional optical, electronic, and nonlinear properties that can be precisely engineered at the nanoscale. When combined with silicon or silicon-nitride photonic platforms, they enable enhanced light-matter interaction, low-loss modulation, and even non-volatile optical memory effects. This talk will discuss recent progress in hybrid 2D silicon photonic technologies, highlighting how this synergy is paving the way for next-generation optical communication, computing, and neuromorphic systems driven by light.

Dr. Lalit Singh

Postdoctoral Researcher

Nanyang Technological University (NTU)

Singapore



Dr. Lalit Singh is a distinguished researcher in the field of electrical engineering, specializing in integrated silicon photonics. Currently, Dr. Singh is working as a Postdoctoral Researcher at Nanyang Technological University (NTU), Singapore, and as a visiting scientist at A*Star Singapore. He received his Ph.D. from the Indian Institute of Technology (IIT) Indore. He has published more than 35 research articles in reputed journals and international conference proceedings.

His recent work focuses on the heterogeneous integration of 2D and other advanced materials with silicon nitride photonics to realize non-volatile and energy-efficient photonic computing devices. His broader research interests include optoelectronic and nanophotonic devices based on silicon hybrid materials, ferroelectric heterostructures, transition metal oxides (TMOs), and 2D materials, with applications in optical modulation, detection, and neuromorphic computation.

Invited Speaker

Title of Talk: Heterogenous Silicon Photonics (SiPh) for Next Generation Optical Communication

Abstract

The exponential growth of global data traffic demands photonic interconnects that combine high bandwidth, low power consumption, and dense integration. Silicon photonics offers a mature CMOS-compatible platform for large-scale optical communication systems; however, the limited electro-optic response and lack of efficient light sources in silicon restrict its full potential. Heterogeneous silicon photonics, enabled through the integration of novel materials such as III–V semiconductors, lithium niobate, 2D materials, and transparent conducting oxides (TCOs), provides a promising route to overcome these limitations. In particular, TCOs like indium tin oxide (ITO) and aluminum-doped zinc oxide (AZO), operating in their epsilon-near-zero (ENZ) regime, exhibit strong index tunability and enhanced light–matter interaction, allowing for ultrafast, compact, and energy-efficient modulators and switches. This work reviews recent advances in heterogeneous integration strategies, device architectures, and performance optimization leveraging ENZ materials within the silicon photonics platform. Such hybrid systems are expected to play a pivotal role in realizing next-generation optical communication technologies with terabit-per-second data rates and sub-femtojoule-per-bit energy efficiency.

Dr. Swati Rajput

Assistant Professor

Department of Electronics Engineering

Indian Institute of Technology Dhanbad, India



Dr. Swati Rajput is currently working as an Assistant Professor in the Department of Electronics Engineering at the Indian Institute of Technology (Indian School of Mines) Dhanbad since September 2024. Prior to this, she served as a DST Inspire Faculty in the Department of Electrical Engineering at IIT Jodhpur from May 2023 to September 2024. She received her Ph.D. in Electrical Engineering from the IIT Indore in December 2021. She holds an M.Tech in Optoelectronics from S.G.S.I.T.S. Indore and a B.Tech in Electronics and Telecommunication from B.I.T. Durg, India.

After her doctoral studies, she worked as a Postdoctoral Fellow in the Department of Electrical and Computer Engineering at the University of Toronto, Canada, from 2022 to May 2023. During her postdoctoral tenure, she also conducted research at the Quantum Nanofabrication Centre, University of Waterloo, Canada. Her research interests include Optical Communication, Silicon Photonics, and Semiconductor Optoelectronics.

Invited Speaker

Title of Talk: Theory of Merging the Graphene Plasmons to the Cavity Resonance

Abstract :

Theory of Merging the Graphene Plasmons to the Cavity Resonance” to obtain the tunable hybrid resonator which can help in developing the tunable THz functional elements. The concept of merging the graphene plasmon resonance to cavity resonance allows to confine the heavy electric field in the graphene element hybridized to the metallic or dielectric cavity that can help in controlling the resonance of metallic or dielectric cavity through external electrostatic field.

Dr. Gaurav Varshney

Assistant Professor
ECE Department
NIT Patna, India



Gaurav Varshney finished M. Tech at NSUT-East Campus Delhi, India in 2014 with the specialization in RF and Microwave Engineering and PhD at National Institute of Technology Delhi, India in 2018. Currently, he is serving ECE Department National Institute of Technology Patna, Bihar, India as Assistant Professor since Jan-2020.

He worked on the dielectric resonator antennas, MIMO antennas, and the antenna containing the metallic and graphene radiators for microwave, THz and optical domains. He has attained the specialization in design and implementation of functional elements for the different frequency systems and applications. He has published more than hundred articles in the different peer-reviewed journals of high impact. The diversity of this publications with the limited number of co-authors or as a sole author shows his efforts in the domain of Electromagnetics.

He has been a researcher in the domain of THz electronics which brought him to the level of global leaders in this domain. He had worked on Metamaterials and provided multiple innovations in the relevant domains. He is working on the THz functional elements for around last 10 years and provided the multiple concepts in design and development of THz antennas, filters and sensors. His founding concept of Tunable Terahertz Dielectric Resonator Antennas is being followed by the renowned researchers around the globe. Moreover, he has proposed multiple concepts in the area of designing the absorption-based sensors, specially, the concept of Metal-free absorbers using Graphite has become vital area of research in the current time for developing the ultrathin metal-free packing thin films for THz electronics in electromagnetic interference shielding.

Invited Speaker

Title of the Talk: Intelligent Fiber-Based Plasmonic Biosensor for Disease Detection

Abstract :

The title of the talk illustrates about an intelligent fiber-based plasmonic biosensor designed for highly sensitive and selective disease detection. By integrating surface plasmon resonance (SPR) with optical fiber technology, the sensor enables real-time monitoring of biomolecular interactions in a compact and flexible platform. The inclusion of machine learning algorithms enhances detection accuracy and facilitates rapid data analysis for clinical interpretation. The optimized plasmonic configuration ensures improved sensitivity, stability, and reproducibility. The talk will cover the potential of intelligent fiber-plasmonic systems as a next-generation diagnostic tool, offering a promising pathway toward non-invasive, point-of care biomedical sensing and precision healthcare applications.

Dr. Sarika Pal

Assistant Professor
Department of Electronics Engineering
NIT, Uttarakhand, Srinagar Pauri Garhwal, India



Sarika Pal is presently working as Assistant Professor in the Department of Electronics Engineering at National Institute of Technology, Uttarakhand, Srinagar Pauri Garhwal. Dr. Sarika has made a significant contribution in research areas of Plasmonic sensors. She has been awarded one R& D projects amounting of 25 Lakh under Core Research Grant sponsored by SERB, New Delhi. She has published 50 SCI/Scopus indexed research papers in different journals of IEEE Transactions, IEEE sensor journal, Elsevier, IOP, and Springer publications. She has published one patent. Dr. Sarika has supervised 04 PhDs and 03 research scholars are currently pursuing their research under her supervision. Her research interests include optical communication, design and development of Plasmonic sensor.

Invited Speaker

Title of Talk: Integrated Photonics: A Unified Platform for Computing, Sensing, and High-Speed Interconnects

Abstract of my talk

Integrated photonics has emerged as a transformative platform that enables the miniaturization and on-chip integration of key components for optical computing, biochemical sensing, and high-speed data communication. By leveraging CMOS-compatible materials and advanced nanophotonic architectures, it allows scalable, energy-efficient, and multifunctional device integration. Recent progress in silicon-based and hybrid photonic technologies such as wide-FSR optical filters, high-speed modulators, 2D material-assisted plasmonic sensors, and hardware-efficient optical neural networks demonstrates remarkable potential for both computing and sensing applications.

This talk will highlight the design and optimization of photonic structures for high-performance signal modulation, optical filtering, and label-free biochemical detection. It will also discuss the development of multi-operand optical neurons and photonic crystal platforms that advance optical information processing and hardware-efficient computing. Collectively, these innovations position integrated photonics as a foundational technology for next-generation intelligent, connected, and miniaturized systems.

Dr. Sourabh Jain

Assistant Professor

Department of Electronics and Communication Engineering
Indian Institute of Information Technology, Bhopal, India



Dr. Sourabh Jain is an Assistant Professor in the Department of Electronics and Communication Engineering at the Indian Institute of Information Technology, Bhopal. He earned his M.Tech. in Nanotechnology from NIT Bhopal, followed by a Ph.D. in Integrated Photonics from IIT Indore, and completed his postdoctoral research at The University of Texas at Austin, USA. His research focuses on silicon photonics, nanophotonic device engineering, and optical computing and biosensing. Dr. Jain has published over 40 research papers in leading international journals and conferences and contributed to patents in the field of photonic device design. He is a member of IEEE, Optica and SPIE and has delivered invited talks at prominent events including CLEO and SPIE Photonics West.

Invited Speaker

Title of Talk: A Gateway to Synthesis of All-Optical Devices with Tailored Functionalities

Abstract

I will present my recent proposal, which states that judicious combinations of all-optical devices can yield an all-optical device with tailored functionalities. The underlying concept draws inspiration from Fourier series—where complex waveforms are synthesized through the superposition of simpler components.

Analogously, there exist infinitely many distinct ways to combine identical or diverse all-optical devices, each with varying parameters. These combinations can produce an infinite spectrum of devices with unique input-output (I/O) characteristics. This opens a promising pathway for the systematic synthesis of all-optical devices engineered for specific functionalities.

To support this proposition, I will showcase both series and parallel configurations of nonlinear Mach-Zehnder interferometers (NMZIs), demonstrating their ability to realize:

1. An ideal optical switch with step-like I/O behaviour
2. An optical isolator
3. An optical pulse generator
4. An optical power filter
5. An optical limiter

Importantly, the scope of this proposal extends beyond NMZIs. Other optical components—and even heterogeneous combinations thereof—can be orchestrated to construct all-optical devices exhibiting desired I/O characteristics.

Prof. Sarang Medhekar

Professor and Head of the Department

Physics at the Central University of Jharkhand (CUJ), India



Prof. Sarang Medhekar serves as Professor and Head of the Department of Physics at the Central University of Jharkhand (CUJ). A distinguished academic and researcher, he has successfully led multiple government-funded projects and authored over 65 publications in reputed international journals. He is also the inventor of five patents. Currently, Prof. Medhekar is the Principal Investigator (PI) for two major initiatives: (i) **InSWIM (Space Weather Impact Monitoring)** – a collaborative project with the Space Physics Laboratory, Vikram Sarabhai Space Centre, ISRO and (ii) **DST-FIST Grant Project** – aimed at strengthening advanced research infrastructure in the department. His research interests include photonic devices, all-optical switching, photonic computing, photonic crystals, and spatial soliton propagation.

Invited Speaker

Title of Talk: Engineered Nanophotonic Devices for Future Photonic Integration

Abstract:

Integrated photonics offers a promising solution to data-driven world, with applications spanning modulation, detection, and switching. Optical switches play a pivotal role in photonic circuits; however, their miniaturization is fundamentally hindered by diffraction limits. To overcome these limitations, the rapidly growing field of nanophotonics specially plasmonics which focuses on design of subwavelength devices that circumvent diffraction barriers. Moreover, optical resistive switches exhibit design similarities with plasmonic waveguides. Leveraging light benefits, these switches offer significant advantages in terms of bandwidth, speed, and tunability. Notably engineering in device design can lead to enhanced switching characteristics. These enhanced characteristics position resistive switches as promising candidates for future applications in high-density photonic integration and neuromorphic computing.

Dr. Rahul Dev Mishra
Assistant Professor
Department of electronics and communication
IIIT Surat, India



Dr. Rahul Dev Mishra has completed M. Tech with Gold medal from Madhav Institute of Technology and Science Gwalior. He has completed his PhD from Department of Electrical Engineering, IIT Indore in 2024. He has worked as a Junior research fellow, Senior research fellow and also as Translation Research Fellow. He has been awarded with best paper award Oral and poster. He has been also awarded with graduate student scholarship by IEEE photonics society in 2024. He has been visiting researcher to Politecnico di Bari Italy. He is the member of IEEE and OPTICA since January 2020. He is the life member of Indian Society of Technical Education (ISTE) since 2019. Dr. Rahul Dev Mishra is currently working as Assistant Professor at Department of electronics and communication in IIIT Surat. His research area are Integrated nanophotonics, optoelectronics and resistive switches.

Invited Speaker

Title of the Talk: CAVITY SOLITONS: FROM MEMORY TO METROLOGY

Abstract:

Optical solitons are localized light pulses or beams that maintain or periodically restore their shape and size during propagation. Among the large varieties of optical solitons, cavity solitons, a distinct form of spatial dissipative solitons that arise in wide-area nonlinear microcavities, have emerged as a promising candidate for the “future bits” of optical information. In this talk, I will present our theoretical investigations on controlling the apparently random dynamics of cavity solitons for the development of advanced optical technologies, including scanning devices, optical memory, all-optical frequency combs, and medical imaging systems. The discussion will also highlight the key challenges for generations and control the cavity solitons and the key factors hindering the realization of these cavity-soliton based technologies for practical applications.

Prof. Soumendu Jana

Professor
Physics and Materials Science
TIET, Patiala, India



Dr. Soumendu Jana is a Professor of Physics and Materials Science at Thapar Institute of Engineering and Technology, Patiala. He earned his Ph.D. in Nonlinear Optics from BIT Mesra in 2008 and has over 23 years of experience in teaching and research. His work focuses on nonlinear dynamics, photonics, and nonlinear optics. Recipient of the BOYSCAST and Visvesvaraya Young Faculty Fellowships, Dr. Jana has published over ninety journal and conference papers and led several R&D projects funded by national agencies. He is an active reviewer for nearly thirty international journals and fellowship-funding agencies, a frequent speaker at scientific forums worldwide, a resource person of several Faculty Development Programmes including ATAL FDPs, **UGC-Human Resource Development Centre, Pondicherry University, IIT Guwahati, PEC-Chandigarh etc.** Beyond his academic pursuits, he is deeply committed to promote higher education in science, particularly in north-west India.

Invited Speaker

Title of the Talk: Photoconductive terahertz emitters

Abstract:

Photoconductive (PC) terahertz (THz) sources are widely used in THz spectroscopy, imaging, and ultrafast photonics. However, their performance is often limited by low THz output power. In this work, we discuss the key challenges, such as bias field breakdown, pump power saturation, and material constraints, faced by PC THz sources, and approaches to overcome them. High-bias field operation of GaAs-based emitters is enabled by suppressing unnecessary currents through carbon ion irradiation and bias quenching techniques. High pump energy/power operation is realized using large-area emitter designs with interdigitated electrodes, supporting μJ – mJ excitation levels. With these strategies, THz fields exceeding 230 kV/cm are achieved, and nonlinear THz effects are demonstrated using GaAs PC sources.

Dr. Abhishek Singh

Assistant Professor
Centre for Advanced Electronics
IIT Indore, India



Dr. Abhishek Singh is a Ramanujan Fellow at the Centre for Advanced Electronics, IIT Indore, India and Founder& CEO of THz-Innovations Pvt. Ltd., a startup company developing semiconductor-based terahertz (THz) devices and high-speed optoelectronics. He earned his Ph.D. in Physics from TIFR Mumbai, India and completed a prestigious Helmholtz Postdoctoral Fellowship at HZDR Dresden, Germany. He has authored 20+ peer-reviewed publications, holds patents in THz device technology, and has been honoured with awards including the Helmholtz Postdoc Fellowship and the URSI Young Scientist Award.

Programmable Optical Networks with Intelligent SDN Switching

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2. Optoelectronic Nanodevice Research Laboratory, Indian Institute of Technology (IIT) Indore, M.P., India, 453552

3. Department of Computer Science and Engineering, NIT Arunachal Pradesh, Jote-791113, India

Abstract: A SDN-controlled optical switching, presenting architectures, technologies, and applications is proposed. An AI-driven SDN-optical framework with hybrid switches, achieving lower latency and power use, while outlining future directions in QoT-aware control, orchestration, telemetry, and quantum-ready networking is presented in the paper. This paper surveys SDN-controlled optical switching, proposing an AI-driven framework with hybrid MZI-MEMS switches. Simulations show up to 28.9% latency reduction and 32.4% power savings compared to conventional setups, while outlining future directions in QoT-aware control, orchestration, telemetry, and quantum-ready networking.

Brief Discussion: An intelligent SDN-controlled optical switching framework that integrates AI-assisted path computation, in-band telemetry, and hybrid optical switch fabrics (MZI + MEMS) [1] is proposed. The framework supports dynamic bandwidth allocation, traffic-class-based slicing, and energy-aware reconfiguration, addressing the limitations of static provisioning and centralized control saturation. Through comparative evaluation and simulation-based analysis, the proposed design achieves significant improvements in end-to-end latency and power consumption compared to traditional electrical or hybrid SDN architectures [2] as shown in Fig. 1A and 1B. In addition, we identified and classified major research challenges such as wavelength continuity, multi-domain orchestration, and optical telemetry. The convergence of Software-Defined Networking (SDN) with programmable optical switching technologies represents a critical advancement toward building scalable, flexible, and energy-efficient next-generation networks.

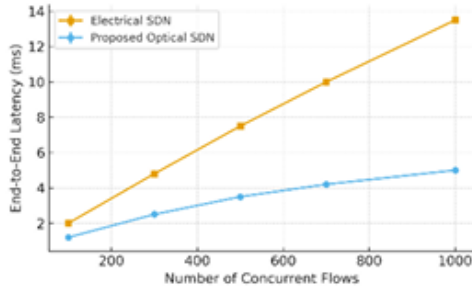


Figure 1A

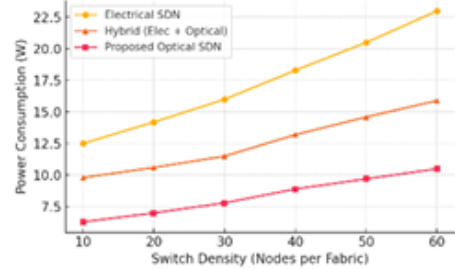


Figure 1B

Fig. 1A illustrates the scalability of the proposed solution, projecting latency trends up to 1000 concurrent flows. Traditional SDN systems experience exponential latency growth beyond 500 flows, while our framework shows a much slower increase due to AI-based adaptive path optimization. Fig. 1B highlights that optical switching, when managed efficiently through SDN, results in a 31.5% reduction in overall power consumption compared to purely electrical designs.

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Label Free detection of Chikungunya Virus using Silicon Photonic dumbbell shaped micro-ring resonator

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Abstract: An innovative design of dumbbell shaped micro-ring resonator (MRR) is devised on silicon-on-insulator (SOI) platform to detect the chikungunya virus. The maximum quality factor of 498.35, sensitivity of 521nm/RIU, free spectral range of 16.44nm and shift in resonant wavelength for healthy and infected conditions are observed in the proposed on-chip device.

Keywords: Silicon photonics, Lab-On-Chip, Dumbell shaped micro-ring resonator, Chikungunya virus, Label free biosensor.

Introduction: Chikungunya fever caused by chikungunya virus (CHIKV), poses global health burden due to 35 million infections annually, high morbidity, and absence of specific antiviral therapy. This arboviral infection is characterized by acute fever, severe polyarthralgia and prolonged joint pain which highlight its clinical severity[1]. Early and accurate detection of CHIKV is important for effective patient management and outbreak control. Hence, the development of silicon photonic lab-on-chip biosensor based on evanescent field optical sensing for CHIKV detection is crucial for the holistic improvement in healthcare diagnostics.

Design and Simulation of Photonic Integrated Circuit : A dumbbell shaped micro-ring resonator (MRR) [2] is constructed using Lumerical MODE on silicon-on- insulator (SOI) platform consisting 0.18 μm thick silicon (Si) device layer and 2 μm thick buried oxide layer (SiO₂). The radius of MRR is 5.6 μm with a coupling length 4 μm and a width of 0.4 μm for MRR and bus waveguide. A broadband light source (1500-1600 nm) is injected through the input port of the bus waveguide. The transmission spectrum was detected at drop port via frequency domain monitor to observe resonant wavelength shifts corresponding to the varying refractive indices (RI) of blood components under healthy and chikungunya virus infected conditions [3].

Results and Discussion: In this study, a dumbbell shaped MRR-based biosensor is employed for detection of chikungunya virus. The proposed sensor exhibits a shift in resonant wavelength with varying RI of platelets and RBCs under healthy condition compared with the infected condition. A maximum Q-factor of 498.35 for resonant wavelength of 1546.49 corresponding to the RI 1.38, a sensitivity of 521nm/RIU and a high FSR of 16.44nm. It can offer a rapid response times to function as a lab-on-chip label free biosensor for point-of-care diagnostic devices.

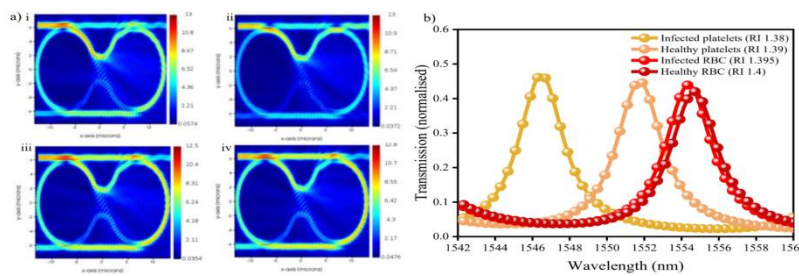


Fig. 1 a) electric field profile of dumbbell shaped MRR for: i) infected platelets, ii) healthy platelets, iii) infected RBC and iv) healthy RBC, **b)** Transmission spectrum at the drop port of dumbbell shaped MRR-based biosensor for detection of various blood components under chikungunya virus infected and healthy conditions.

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Optical Diode Characteristics Based on Nonlinear Properties of Long Period Fiber Grating

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Jawaharlal Institute of Technology, Borawan, Khargone (M.P.), India – 451228

Abstract: Present study deals with analytical study of the bi-stable switching characteristics of nonlinear long period fiber grating. The nonlinear coupled-mode equations were solved analytically to obtain the intensity dependent expression of grating transitivity. The results show that long period fiber grating exhibits N-type switching properties that can be used for all optical computing applications. Finally, the concept for designing the optical tunnel diode is described on the basis of the characteristics of N-type switching which are the prominent applications for optical storage devices.

Analytical Model: This section provides the mathematical model to investigate how the spectral property of long period grating modifies with intensity of the incident beam. To study the bi-stable switching properties the nonlinear coupled mode equation is solved analytically, the expression for the transitivity (T_{nlpfg}) of the LPFG is obtained as

$$T_{nlpfg} = |\tau_{nlpfg}|^2 = 1 - \frac{4\Gamma \sin^2(3q_n L/4)}{(1 + \Gamma)^2}.$$

Results & Discussions: Nonlinear LPFG based N-type optical switching phenomena has been studied using the parameters of chalcogenide glass LPFG having core index $n_{core} = 2.450$, cladding index $n_{clad} = 2.442$, resonance wavelength $\lambda_R = 1550$ nm, nonlinear Kerr coefficient $n_2 = 2.7 \times 10^{-13}$ cm²/W, grating index $n_g = 10 \times 10^{-4}$ and grating length $L = 1$ cm corresponds to the grating strength $\kappa L = 20.358$. All the incident wavelengths considered here are slightly greater than to the resonance wavelength of the long period fiber grating ($\lambda > \lambda_R$).

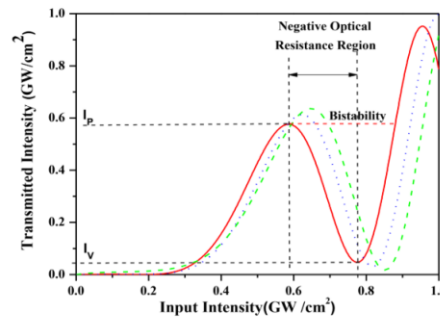


Fig.1: Curve plotted for three various incident wavelengths at 1550.05 nm (red solid curve), 1550.1 nm (blue dotted curve) and 1550.15 nm (green dashed curve)

The curves in Figure 1 of the nonlinear LPFG are similar to the V–I curves of a tunnel diode. In the figure 1, peak and valley of transmitted intensity can be calculated by I_p and I_v , respectively. Also the negative optical resistance region has been clearly visible in the figure 1 calculated from peak to valley input intensities. The results indicate that an appropriate selection of wavelength of input light and physical parameters of LPFG can change the peak and valley threshold intensity of bistability. Such findings can also be useful to design optical tunnel diode. Also the N-type optical switching is also very useful in optical computing applications like switching the optical signal, amplification of signal and most useful acts as logic memory optical storage devices.

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Fabrication and Characterization of Mach-Zehnder Interferometer on single Chip

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Integrated optical devices such as optical coherence tomography on a chip finds huge demand various frontincluding point of contact devices for biomedical applications. We fabricated a basic unit of Mach-ZehnderInterferometer (MZI) on a single chip which is said to be heart of such devices. We also simulated and characterized the fabricated device for low frequency operations

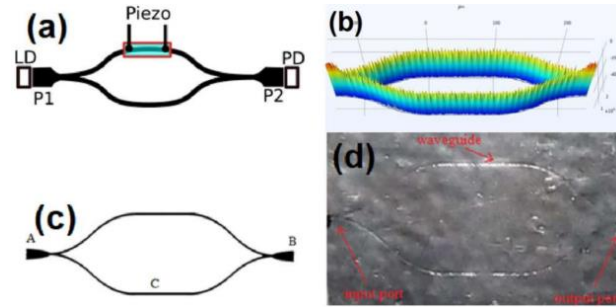


Figure - 1: Mach-Zehnder Interferometer (a) basic design considered for simulation and fabrication; (b) simulation results (c) positive mask used for UV photolithography and (d) fabricated PMMA waveguide showing MZI. In Fig (a) LD – Laser diode, PD – Photo diode, P1 and P2 – input and output ports. Piezo – Piezo oscillator connected to variable frequency function generator and in Fig (c) A and B are tappers and C is the waveguide.

Device is fabricated by using photolithography process. We adopted the standard RCA-I and RCA-II process for cleaning the substrate and deposit the thin layer of PMMA by using spin coating unit. After spin coat Applying photomask of MZI and expose under UV light. All technical details of photolithography process will discuss in full length paper.

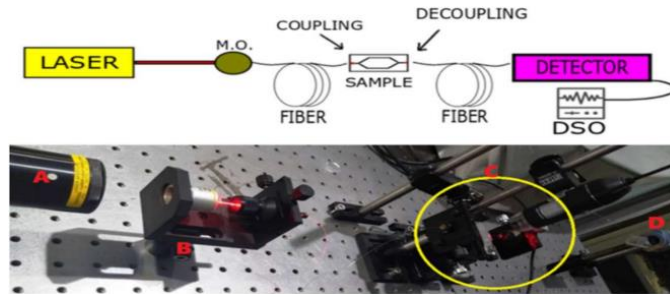


Figure – 2: Schematic (top) and lab picture (bottom) of characterization setup

Figure 2 shows characterization setup of MZI. Output results of characterization will show in full length paper. We have fabricated integrated optical MZI of dimensions having footprint of less than 1sq.cm. The device could be able to modulate and guide waves. A response time of about 1ms is observed.

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Exploring Supercontinuum Generation Dynamics in Highly Nonlinear Photonic Crystal Fibers

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²Department of Physics, SLAS, Mody University of Science and Technology, Lakshmangarh, Rajasthan, India

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Abstract

This study investigates supercontinuum generation in highly nonlinear photonic crystal fibers under both normal and anomalous dispersion regimes. Using numerical simulations based on the finite-difference time-domain method and the nonlinear Schrödinger equation, we analyse the propagation of femtosecond pulses at telecommunication wavelengths. The designed fiber exhibits high nonlinearity and tailored dispersion, enabling efficient supercontinuum generation at low input power levels. In the normal dispersion regime, the supercontinuum spectrum is broad and coherent, primarily driven by self-phase modulation and four-wave mixing. In contrast, the anomalous dispersion regime results in even broader spectral expansion dominated by soliton fission and Raman-induced frequency shifts. A comparative analysis of different pulse durations reveals that shorter pulses produce superior spectral broadening and coherence. These findings highlight the potential of photonic crystal fibers as compact and efficient broadband light sources for applications in telecommunications, imaging, and sensing.

Keywords

Photonic crystal fiber; Supercontinuum generation; Nonlinear optics; Dispersion engineering; Lead silicate glass; Ultrafast pulse propagation.

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Highly Sensitive TiO₂-Au and Si₃N₄-Au Coated PCF-SPR Biosensor

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¹Department of Physics, DAV University Jalandhar- 144012, India

²Department of Physics, SLAS, Mody University of Science and Technology, Lakshmangarh, Rajasthan, India

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Abstract

This work proposes a novel photonic crystal fibre (PCF) based surface plasmon resonance (SPR) sensor for detecting different analyte, with its characteristics numerically analysed. To enhance sensitivity and resolution, the three plasmonic material gold (Au), silver (Ag) and copper (Cu) are employed. To improve the stability of the evanescent field, titanium oxide (TiO₂) and silicon nitride (Si₃N₄) are independently introduced as an adhesive layer for the plasmonic material. A comprehensive sensitivity analysis is performed to examine the effects of confinement loss, resonance depth and sensitivity. The sensor design and performance are investigated using finite element method (FEM), focusing on the influence of structural parameters such as pitch distance, air hole diameter, the thickness of plasmonic and analyte layers, and geometrical arrangements of air holes. The proposed sensor demonstrates potential for a wide range of applications, such as real-time remote sensing, power, medical science, environment monitoring and other engineering fields.

Keywords: Photonic crystal fiber; surface plasmon resonance; wavelength sensitivity; amplitude sensitivity.

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Generating High-Energy pulses in Gratings Free Chirped Pulse Amplification System at 2.86 μm

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High-energy ultrashort pulses especially in the mid infrared regime are indispensable for many applications. Over several methods of pulse generation, chirped pulse amplification (CPA) remains a powerful approach due to its stability to stretch, amplify and recompress the weaker pulse into high power ultrashort laser pulse. Since the traditional CPA system which is having some disadvantages such as misalignments due to it is fully rely on bulk optics components, we adopt the all-fiber CPA. In this work, we numerically investigate an all-fiber CPA system operating at 2.86 μm , fully based on ZBLAN fluoride fibers (ZrF₄-BaF₂-LaF₃-AlF₃-NaF). The proposed set up consists of normal dispersion fiber stretcher, Er³⁺ -doped gain fiber amplifier and tapered photonic crystal fiber compressor with tailored dispersion for self-similar compression. The system is modelled using generalized nonlinear Schrödinger equation (GNLSE) as follows,

$$\frac{\partial U}{\partial z} = \frac{g(z)}{2} U - \left[\sum_{n \geq 2} \frac{i^{n+1}}{n!} \beta_n(z) \frac{\partial^n U}{\partial t^n} \right] + i\gamma(z)(\omega_0) \times \left[1 + \frac{i}{\omega_0} \frac{\partial}{\partial t} \right] \left[U \int_{-\infty}^{\infty} R(t) |U(z, t - t_0)|^2 dt \right] \quad (1)$$

Where U is the electric field amplitude of the given input hyperbolic secant pulse at 2860 nm. β_n is the dispersion parameter and γ is the nonlinear coefficient. $g(= g_0 (1 + \int |U|^2 / dt Es))$ is the gain coefficient where g_0 is the small signal gain coefficient and Es is the saturation energy for a doped fiber. For Pulse compression, analytical solution of self-similar evolution is obtained under special fiber design condition as below,

$$U(z, t) = \left[\frac{P_0}{1 - \xi D(z)} \right]^{1/2} \text{sech} \left[\frac{t - t_0}{T_0 (1 - \xi D(z))} \right] \times \exp \left[\frac{i \xi (t - t_0)^2}{[1 - \xi D(z)]} \right] \exp \left[\frac{G(z)}{2} \right] \quad (2)$$

Where t_0 is the initial position of the input pulse peak power in the time domain, $T_0(1 - \xi D(z))$ is the similariton width and ξ is the chirp parameter. T_0 and P_0 are the initial pulse width and peak power.

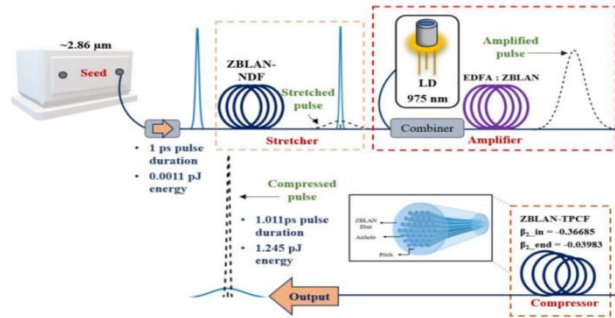


Fig. 1 Schematic of proposed CPA system. NDF: ZBLAN – normal dispersion ZBLAN fiber, EDFA: ZBLAN – erbium doped ZBLAN amplifier, and LD - laser diode.

Numerical outcomes of the proposed CPA shows that 0.0011 pJ energy of a 1 ps pulse with 1mW power is amplified to 1.245 pJ with a duration of 1.0111 ps, achieving a peak power of 1086 mW which is almost 1000 times greater than the input pulse. So, it is concluded that ZBLAN based all fiber CPA system shows a compact and durable approach of to generate high energy ultrashort laser pulses in the mid-IR, with its ability to generate pedestal free compressed pulse it holds strong potential for high-field ultrafast optics.

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Experimental Analysis on Beam Interference and Signal Degradation in NLOS Full-Duplex UOWC Links

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This work experimentally demonstrates a non-line-of-sight (NLOS) FPGA-based full-duplex underwater optical wireless communication (UOWC) system, which showcases the impact of interference of two light beams, with hybrid power states (one varying and the other at fixed power). In such systems, the quality of communication is often degraded due to scattering, back-reflection, and self-interference in multi-path optical beam propagation. It has been well discussed for light-of-sight (LOS) UOWC configurations [1-2]. The experimental setup shown in Fig. 1(a) comprises two transmitters (TX1 & TX2), both emitting 445 nm non-return-to-zero on-off keying (NRZ-OOK) modulated wavelengths at an adjustable power (30-90 mW) at a speed of 100 Kbps. Two corresponding receivers (RX1 & RX2), comprising Si-based pin Photodetector (PD), transimpedance amplifier (TIA), and voltage amplifier (VA), are aligned in an NLOS configuration utilizing a diffuse reflector (DR). These are employed to mimic realistic underwater scenarios, unlike LOS systems, where direct propagation dominates. Beam1 and Beam2, shown in Fig. 1(a), are reflected through a DR submerged underwater at a 45° angle from TX1 and TX2. The system employs Basys-3 FPGA boards on both ends to stream 8-bit modulated data. The study records RX1 responses for TX1 fixed at 30 mW while TX2 varies in power with 30mW, 60mW, and 90mW.

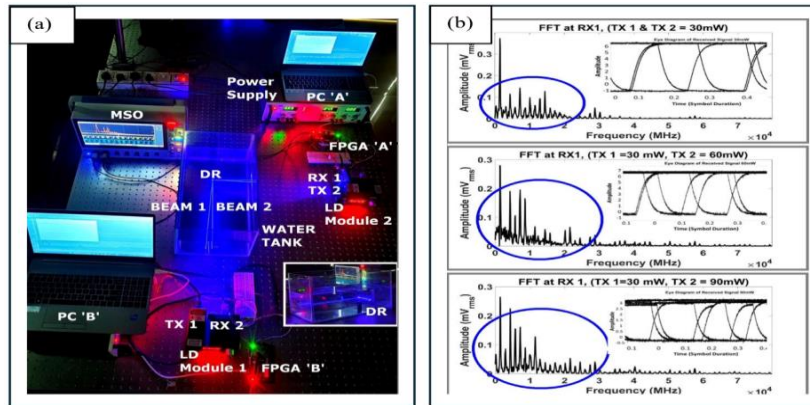


Fig. 1 (a) NLOS full-duplex UOWC Experimental setup (left side); (b) Time domain (eye diagram) & frequency domain (FFT) responses of signal received at RX1 (right side)

The eye diagram indicates signal noise, where a wider vertical eye opening reflects lower noise. In Fig. 1(b), at 30 mW, RX1 shows a wide eye opening, confirming minimal noise in the signal, and the frequency plots show fewer harmonics at the PD. At higher powers (60 mW and 90 mW), the eye diagram is distorted with reduced eye opening. At 90 mW, jitter appears, and added peaks in the frequency plots indicate induced noise as side lobes, further degrading signal quality. It is observed that beam interference is strongly power-dependent, with higher optical powers causing greater degradation of received signal quality. In conclusion, though the experimental validation emphasizes that NLOS full-duplex UOWC offers practical feasibility for underwater links, system performance is still highly sensitive to interference. However, using various optical filter strategies, it is possible to overcome the spreading of the reflected light in NLOS configuration, which will reduce the localized scattering, limit the beam overlap, and suppress interference.

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Analyzing High-Efficiency Hybrid Silicon-HfO₂-ITO based Electro-Optic Modulator

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High-speed, compact, and efficient electro-optic modulators (EOMs) are fundamental components for next-generation optical interconnects and communication systems. While silicon photonics offers a mature platform, the inherently weak plasma dispersion effect in silicon often leads to larger device footprints or higher power consumption. This work presents a comprehensive design and simulation of a high-performance ring resonator EOM that incorporates an Indium Tin Oxide (ITO) and Hafnium Dioxide (HfO₂) stack on a silicon waveguide. The introduction of ITO, a transparent conducting oxide, near its epsilon-near-zero (ENZ) region allows for a significant change in its refractive index with an applied voltage. The ultrathin HfO₂ layer acts as a gate dielectric, enabling the formation of a strong carrier accumulation layer at the Si/HfO₂ interface, thereby enhancing the modulation efficiency.

The device was analyzed using a Lumerical multi-physics workflow, using FDTD, CHARGE, MODE, and INTERCONNECT solvers. For benchmarking, a standard all-silicon EOM was simulated, yielding a high Quality(Q) factor of 18,922 and an extinction ratio (ER) of 15.5 dB.

Our proposed hybrid Si-HfO₂-ITO structure was optimized with a 6000 nm radius ring and 15 nm thick ITO and HfO₂ layers. This design achieves an outstanding modulation efficiency of 1.13 nm V⁻¹. While this enhanced efficiency results in a lower Q-factor of approximately 391 and higher propagation loss compared to the silicon device, it maintains a strong ER of 10.52 dB.

In conclusion, the simulation confirms that leveraging ITO's strong electro-optic response in a hybrid Si-HfO₂-ITO platform yields a remarkable improvement in tuning efficiency, making it a promising candidate for compact, low-voltage optical modulators.

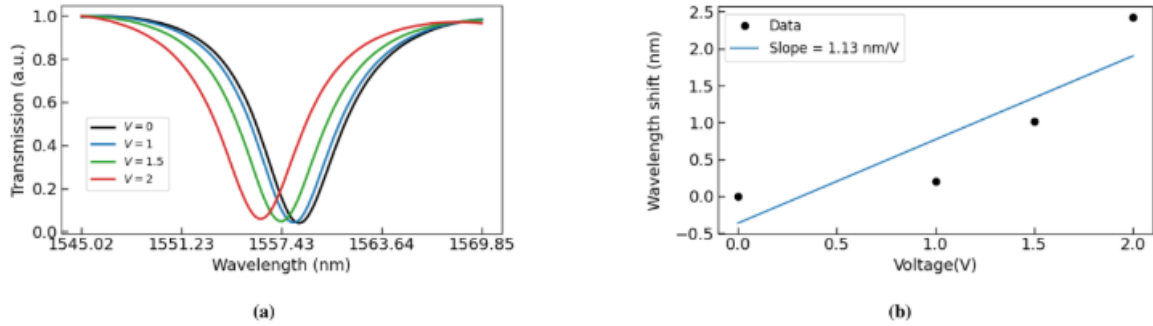


Fig. 1.: (a) Simulated transmission spectra of the hybrid EOM for various applied voltages (b) and the corresponding resonant wavelength shift as a function of applied voltage.

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Optical Thermometry Study of Rare-Earth Doped SrMoO₄

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Abstract: Phosphors were synthesized via the urea-assisted auto-combustion method and were subjected to structural and optical studies. The tetragonal crystal structure is being validated by X-ray diffractometer. Absorption spectra lie near the UV region as shown by the UV-Vis-NIR analysis. The FTIR analysis confirms O-Mo-O bending and Mo-O stretching. The PL, PLE, and TDPL spectra were recorded for all the prepared phosphors with 296 nm excitation. Dy³⁺/Er³⁺ co-doped SrMoO₄ phosphor is a promising candidate for tunable light sources as it changes emission with temperature and excitation wavelengths, and optical thermometry applications because with temperature it changes its intensity for fixed emission.

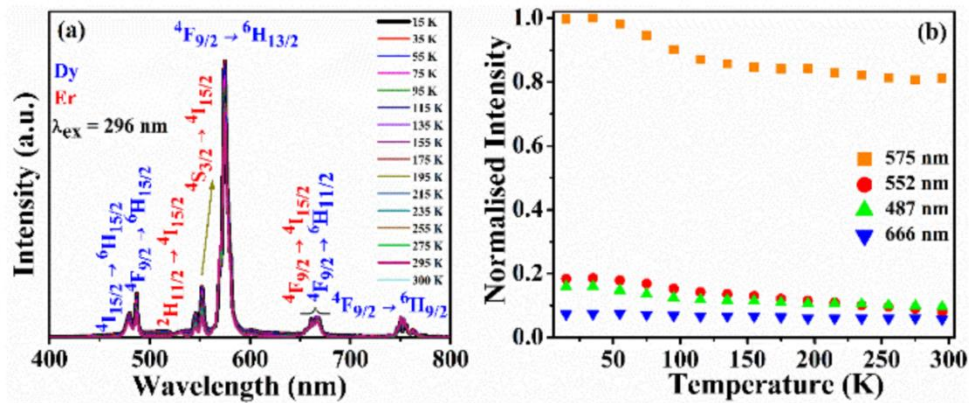


Figure 1 (a) TDPL emission spectra of D4E3 phosphor, (b) Normalised intensity plot of TDPL spectra.

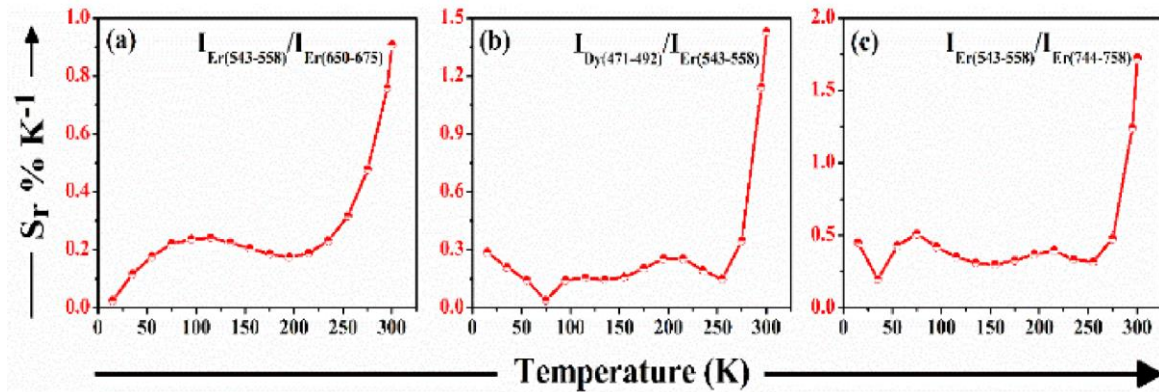


Figure 2 SR values for non-thermally coupled levels of (a) Er(543-558)/Er(650-675), (b) Dy(471-492)/Er(543-558), and, (c) Er(543-558)/Er(744-758).

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Compact and Highly Directional Silicon Photonic Antenna

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A compact surface grating antenna has been designed on a 300-nm silicon-on-insulator (SOI) platform. The proposed structure used as the radiating elements in optical phased array. The directionality of 94 % at 1550 nm and the compact footprint $6.78 \mu\text{m} \times 3 \mu\text{m}$ using Particle Swarm Optimization is obtained.

Photonic antennas are the surface grating couplers used to couple light between optical fibres, integrated photonic circuits, or free-space communication [1]. Conventional silicon-on-insulator (SOI) platforms with a 220-nm silicon thickness, grating couplers are often designed with length exceeding $10 \mu\text{m}$ to ensure efficient coupling between optical fiber and integrated optical waveguides. These are effective for applications such as fiber-to-chip interfaces, where the emitted light must closely match the mode profile of the optical fiber. However, for high-density applications such as optical phased arrays (OPAs) smaller antenna elements are required. One effective way to improve coupling efficiency with compact footprint is to utilize SOI waveguides with increased thickness. In the proposed work, a silicon grating antenna based on a 300-nm-thick silicon core and a buried oxide (BOX) layer of $1 \mu\text{m}$ on a SOI platform is designed. The proposed work utilizes L-shaped geometry and Subwavelength Grating (SWG) to achieve compact size, and high directionality for efficient off-chip light emission. SWG is used for antenna apodization and to reduce back reflections by implementing anti-reflection nanostructures between the periodic L-shaped segments and increasing the minimum feature size [2,3]. To further improve the directionality, bottom reflectors are used, which are made of Silicon instead of metal reflectors [4]. The parameters are optimized using Particle Swarm Optimization (PSO) and Finite-Difference Time-Domain (FDTD) simulations. The antenna has a compact footprint of $6.78 \mu\text{m} \times 3 \mu\text{m}$ and achieves a diffraction efficiency of 0.83, a directionality of 94 %.

Fig.1(a) shows the 3-dimensional structure of the proposed waveguide grating antenna which consist of tapered waveguide and is used to feed the antenna segments. It also shows the two-section apodized and periodic section along with the SWG structure. Fig.1(b) shows the transmission of tapered waveguide from the input waveguide. The P_{tapered} is fed to the antenna segments where P_{up} , P_{down} , P_{ref} , and P_{forward} are the power radiated upwards, downwards, reflected and the remaining stray power in the forward direction, respectively, of the grating antenna. Fig.1(c) shows the far-field radiation intensity of the proposed antenna.

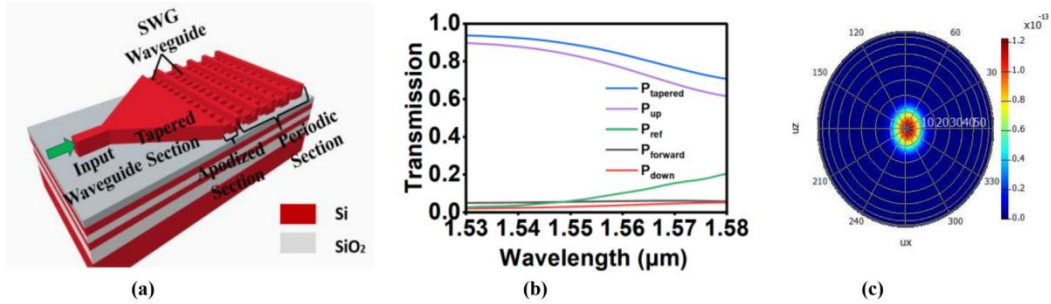


Fig. 1 Proposed Waveguide Grating Antenna (a) 3-Dimensional Structure (b) Transmission versus wavelength where P_{tapered} is the input power to the antenna, P_{up} , P_{down} , P_{ref} , and P_{forward} are the power radiated upwards, downwards, reflected, and forward from the grating antenna. (c) Far field Radiation Intensity at 1550 nm.

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Efficiency Improvement of Silicon Solar Cells with Embedded Cross Shaped Nanostructures

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Abstract: A cross-shaped Ti nano-rod enhanced silicon solar cell with SiO₂/Si₃N₄ coating achieves 85% visible and 94% near-IR absorption, delivering 60.32 mA/cm² current via optimized FDTD design for next-gen high efficiency photovoltaic.

Keywords: Solar cell; cross-shaped Nano-rods; Surface Plasmon; Absorption;

Introduction: Improving the efficiency of thin-film silicon solar cells is a key challenge in advancing next generation photovoltaic technologies[1]. Due to their reduced thickness, these cells often suffer from limited light absorption, particularly in the longer wavelength regions of the solar spectrum[2,3]. To address this limitation, plasmonic nanostructures have emerged as a powerful solution. By incorporating metallic nanoparticles in the silicon layer, localized surface plasmon resonances (LSPR) can be excited, enhancing light scattering and trapping within the active region[4,5]. This not only boosts absorption but also increases photocurrent generation. In this work, we explore a plasmonic-enhanced thin-film silicon solar cell design that integrates optimized metal cross-shaped nano-rod and anti-reflection coatings, aiming for significant improvements in light harvesting and overall device efficiency.

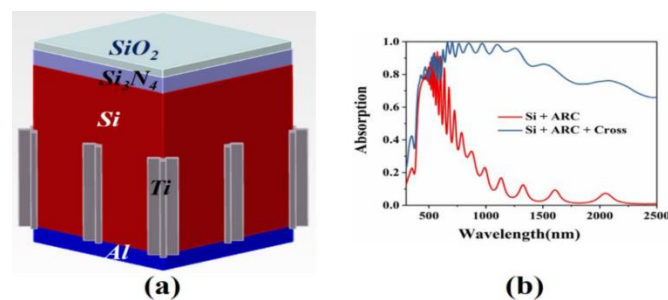


Fig.1. (a) proposed solar cell structure, (b) Absorption vs. wavelength graph for the cross-shaped embedded rod with anti- reflection coating (ARC)

Results: Figure 1(b) clearly highlights the exceptional optical performance of the proposed structure, demonstrating a remarkably high average absorption of 85% in the visible spectrum (400–700 nm), where solar irradiance is most intense. Furthermore, the design maintains superior absorption efficiency in the near-infrared region (700–1800 nm), achieving an impressive 94% average absorption. This broad-spectrum enhancement underscores the effectiveness of the plasmonic and anti-reflective features integrated into the device architecture.

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Analysis of Smooth Curve Tapered Optical fiber Surface Plasmon Resonance sensor

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The theoretical model of tapered surface plasmon resonance is analysed and compared for smooth curve sine, raised sine, gaussian and Tanh profile. By using the ray model approach propagation constant of light in tapered optical fiber and surface plasmon wave is calculated at different taper ratio for each tapered profile. To find out sensitivity of tapered fiber, the change in resonance wavelength is obtained as the small change in refractive index. The considered smooth curve tapered profiles is shown in Fig.1. A step index plastic clad silica fiber of core radius 300 μm , numerical aperture 0.22 is used with different profile of tapered sensing region having 1cm length. The taper region of the fiber is coated with gold metal. The resonance condition of light and surface plasmon wave is given by this equation

$$\frac{2\pi}{\lambda} \sqrt{\epsilon_f} \sin\theta = \frac{2\pi}{\lambda} \sqrt{\frac{\epsilon_m + \epsilon_s}{\epsilon_m \epsilon_s}} \quad (1)$$

where ϵ_f , ϵ_s , and ϵ_m are the dielectric constant of tapered fiber core, sensing region and metal layer respectively and λ is the wavelength of the light. If the angle is defined with respect to the normal of the core cladding interface, then incident angle θ is converted into transformed angle $\phi(z)$ in tapered region which is given by this equation

$$\phi(z) = \cos^{-1} \left[\frac{r_i \cos \theta}{r(z)} \right] - \tan^{-1} \left[\frac{r_i - r_0}{L} \right] \quad (2)$$

where r_i and r_0 is radius at input and output end of the tapered fiber and $r(z)$ are the radius at z distance in the taper region of length L . If the taper radius $r(z)$ is smooth curve of sine, raised sine, gaussian and Tanh type than the plasmonic condition is varies. In Fig.2 the plasmonic resonance condition is shown for sine curve tapered optical fiber. The sensing media refractive index of different analytes varies therefore, the plasmonic condition is also varies. In the present work, due the change in this plasmonic condition we calculate the sensitivity of the tapered optical fiber having different smooth sine, raised sine, gaussian and Tanh curves. The sensitivity has been also calculated and compared for the different taper ratio 1.00, 1.25, 1.5, 1.25 and 3.0. It is found that these tapered curves of the optical fiber enhance the sensitivity of the surface plasmon resonance sensor.

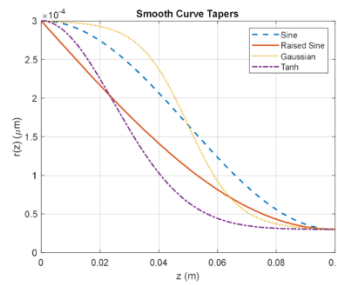


Fig. 1 Different smooth curve taper Profile

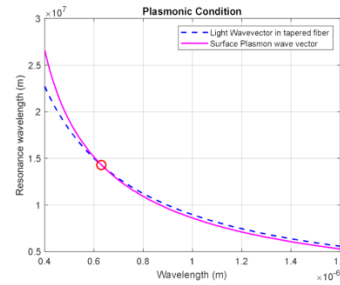


Fig. 2 Propagation constant of tapered fiber and Surface plasmon Wave

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Analysis of Pulsed Laser Deposited Crystalline Ge₂Sb₂Te₅ Thin Films on Silicon Nitride and Silicon Dioxide

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Introduction: Owing to their unique high contrast electrical and optical properties, phase change materials have found widespread applications in integrated circuits technology be it electronics or photonics [1,2]. The non-volatile nature of PCMs like Ge₂Sb₂Te₅ (GST-225) due to its stable reversibility in phases and a high refractive index contrast between its crystalline and amorphous phases makes it suitable for active switching in photonic integrated devices [3]. Pulsed laser deposition (PLD) technique is known to be advantageous when thin films of ternary (or higher order) materials are to be deposited since, under optimal conditions, it enables precise stoichiometric transfer creating films with the same composition as the target material [4]. The objective of this work is to analyse the structural and optical properties of GST-225 thin films deposited on substrates like silicon nitride and silicon dioxide using PLD.

Experimental analysis and results: The crystalline GST-225 (c-GST) thin films were deposited on silicon nitride (SiN) on silicon and silicon dioxide (SiO₂) on silicon substrates at room temperature. The thickness of SiN and SiO₂ is 200nm and 300nm, respectively. A third harmonic Nd:YAG laser operating at 355nm wavelength was used to ablate the crystalline-GST target. The energy per pulse being set to 80mJ with a repetition rate of 10Hz and 6000 shots, a c-GST thin film of 160nm and 135nm were deposited on SiN and SiO₂ respectively. The percentage elemental composition (Ge, Sb, Te) of the as-deposited films was determined using EDS analysis of FESEM to be (24.61%, 23.31%, 52.08%) and (20.84%, 28.70%, 50.46%) respectively for the SiN and SiO₂ substrates. The structural analysis of the thin films was done using XRD. Both deposited thin films exhibit crystalline FCC structure as opposed to the HCP phase of the c-GST target. The corresponding XRD spectra for the deposited films are shown in Fig. 1(a) and 1(b). The average crystallite size was determined using the Scherrer's semi-empirical equation as $D = K\lambda/\beta \cos\theta$, where D, K, λ , β and θ are the average crystallite size, shape factor, X-ray wavelength used for characterisation, full width half maxima of the diffraction peak and diffraction angle respectively. The determined D was for film deposited in SiN is 18.48nm while that on SiO₂ is 21.09nm. The percentage of crystallinity is also analysed to be as 68.6% for film on SiN and 71.7% for the film on SiO₂.

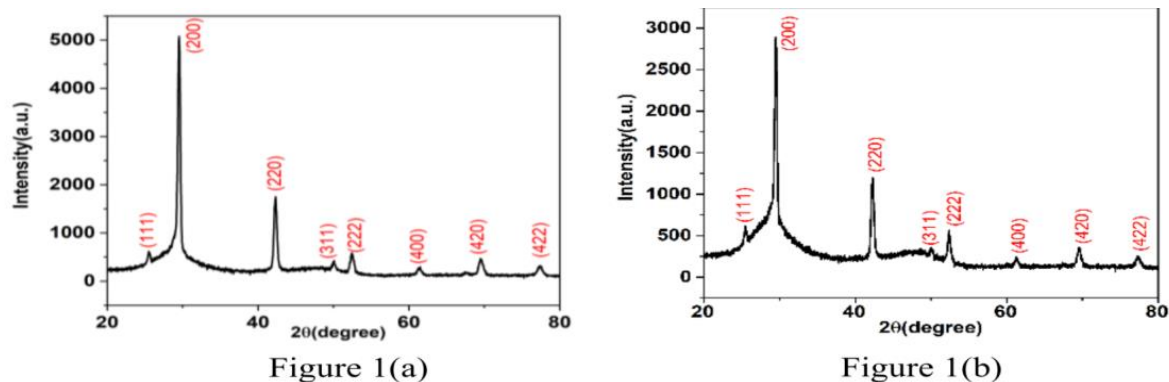


Fig. 1 The XRD spectra of c-GST as-deposited thin films on (a) Silicon Nitride and (b) Silicon dioxide

Thus, it can be seen from the structural analysis that the phase of the deposited c-GST films changes from hcp phase of target to fcc in both the cases. The elemental composition is slightly deviated in both cases but closely resembles the material composition of GST-225.

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Performance Analysis of Defective Plasmonic Sensors through Data-Driven Machine Learning Approach

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Abstract: Plasmonic waveguide has emerged as a promising candidate for realizing compact and highly efficient photonic devices. The Metal-Insulator-Metal (MIM) waveguide possess a unique feature of confining light far beyond the diffraction limit and hence localizing the light in sub-wavelength regime. In this work, a plasmonic MIM waveguide structure coupled to periodic stub resonator is investigated for tunable band stop characteristics. The stop band region can be tuned by controlling the geometrical parameters of the stub resonators. The impact of deliberately introducing structural defect is analyzed by breaking the transitional symmetry of resonator and therefore, exciting a localized defect mode within the specified stop- band. This defect mode is sensitive to changes in the surrounding condition and measured in terms of sensitivity to detect red shift in resonance condition for per unit change in Refractive Index Unit (RIU).

Furthermore, the behavior of the defect mode is modeled using Machine learning (ML) techniques. This approach enables rapid evaluation of the defect mode characteristics without requiring repeated full-wave simulations, significantly accelerating the design process. Additionally, the model is optimized for improved performance, providing insights into how the defect mode shifts in response to changes in the geometrical parameters. Such predictive modeling is particularly valuable for developing plasmonic sensors with high tunability, and reliable performance.

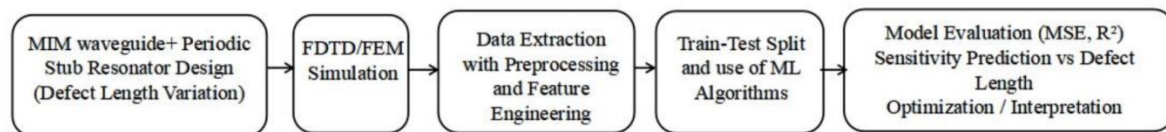


Fig. : Proposed Work-flow

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Tunable Magneto-Optical Properties in One Dimensional Magneto Photonic Crystal of Lithium and Nickel Ferrites

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Magneto-photonic crystals (MPhCs) have attracted significant attention due to their tunable magneto-optical properties and advanced control over polarization and transmission properties. In this work, we present a theoretical study of a one-dimensional MPhC composed of alternating layers of Lithium Ferrite (LiFe-TT73) and Nickel Ferrite (NiFe-TT2). The transmittance, reflectance, and Faraday rotation (FR) angle are calculated using the 4×4 transfer matrix method. Light propagation is modelled in the longitudinal magnetization configuration, incorporating gyro tropic permeability and frequency-dependent material parameters. The study demonstrates a strong dependence of FR angle, transmittance, and reflectance on the number of periods, filling factor, and external magnetic field. The frequency dependent spectra is obtained for right hand circular polarisation as well as for left hand circular polarisation which reveals polarisation dependent band gaps and resonance features. This tunability of magneto-optical properties opens a pathway toward the design of smart devices and the potential application of MPhCs in integrated photonic components such as optical isolators, modulators, nonreciprocal devices, filters, and magnetic field sensors.

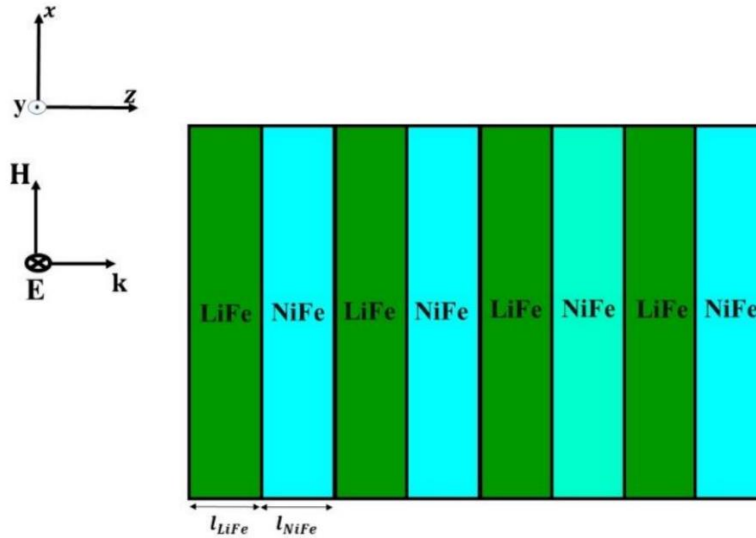


Fig. 1 Schematic representation of the MPC structure consisting of two ferrite materials.

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A Broadband and Thermally Robust Metamaterial Absorber for Solar Energy Harvesting

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Abstract : We propose a thermally robust, polarization-insensitive metamaterial absorber achieving 96.87% absorption across 200–2500 nm, with high angular stability and a short-circuit current density of 37.569 mA/cm², optimized for efficient solar thermal and photovoltaic energy harvesting applications.

Keywords: Metamaterial Absorber; Solar Energy Harvesting; Photovoltaics; Titanium Nitride;

Introduction: This work demonstrates a thermally stable, polarization-insensitive metamaterial absorber that achieves near-unity absorption across the entire solar spectrum (200–2500 nm), addressing spectral mismatch and radiative losses for enhanced solar energy harvesting efficiency. The structure comprises a hollow square Titanium Nitride (TiN) resonator, a Silicon Nitride (Si₃N₄) dielectric spacer, and a Tungsten (W) ground plane. This design facilitates strong light matter interaction through localized surface plasmon resonances and multiple interference effects, achieving an average absorption of 96.87%. Numerical simulation is done using COMSOL Multiphysics. TiN is used since it is a refractory material shows plasmonic resonance from vis-IR region. Si₃N₄ acts as a dielectric spacer and has high intrinsic absorption]. W acts as a back reflector. The thickness of W is taken much greater than skin depth to ensure zero transmission. TiN and W both are thermally and mechanically robust. Together, TiN-Si₃N₄-W stack helps in impedance matching with air, reducing reflection and increasing average absorption. With compact unit cell dimensions of 450nm × 450nm × 560nm, the absorber is well-suited for integration into thin-film and miniaturized photovoltaic systems.

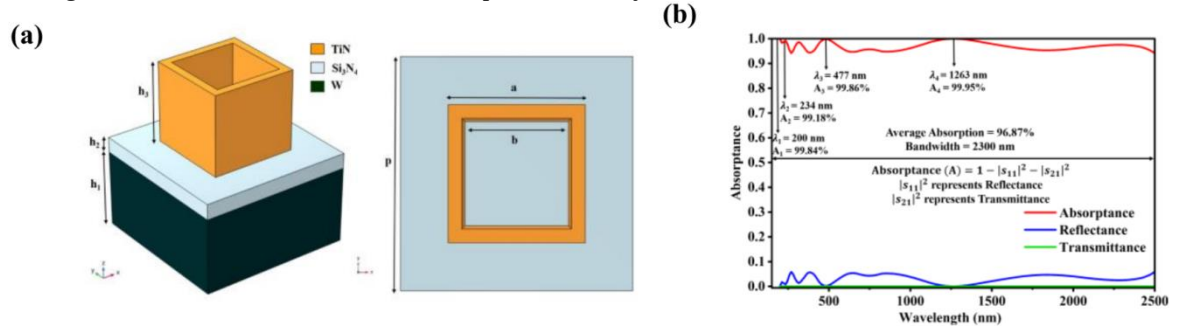


Fig. 1. Schematic diagram of the MPA, (a) Perspective view, and Top view, (b) Absorption spectra of the proposed structure.

Result: The TiN–Si₃N₄–W solar absorber achieves high absorption (96.87%) and Jsc (37.569 mA/cm²) across the full solar spectrum, while using simple, cost-effective, and durable materials. Its design overcomes complexity and scalability issues, making it a strong candidate for practical photovoltaic and solar thermal applications. This work offers a promising pathway toward efficient and robust solar energy harvesting technologies.

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Adaptive Resource Allocation and Hybrid Topology Interconnection-Based Reliable Optical Access Network

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Abstract—Currently, almost every aspect of life is connected to the internet, making technology essential for both daily activities and business operations. The proposed hybrid topology, combining ring and star interconnections, employs adaptive resource allocation in the distribution network to minimize power requirements during periods of low traffic. In the feeder network, a dual-link approach using Free Space Optics (FSO) and Single Mode Fiber (SMF) is implemented to support data transmission up to 5 km. The FSO link performs efficiently under normal weather conditions, while the SMF link ensures reliable performance during adverse weather, particularly rainfall, when attenuation is significant, and higher transmitter power is needed. The proposed architecture achieves a Q-factor in the range of 6–8 and a Bit Error Rate (BER) between 10^{-9} and 10^{-12} , making it highly suitable for smart city infrastructure and large-scale IoT applications. Furthermore, by integrating a hybrid SMF/FSO feeder link, the architecture enables high data rate transmission over extended distances, even across challenging terrains or obstructed paths.

In this paper, an adaptive resource allocation-based hybrid topology interconnection with fault tolerance in all segments of optical access networks is presented as a reliable solution delivering wavelength as traffic offered by end users. Additionally, the proposed architecture has the potential to reduce service interruptions, minimize system downtime, and lower energy consumption through its hybrid topology interconnection. Overall, this architecture demonstrates strong potential for supporting IoT applications, smart cities, and other future high-bandwidth services. The proposed architecture is easily scalable as the user base or bandwidth requirements grow, lowering the initial OPEX. Transmitting at lower data rates wherever possible can help to reduce energy usage because high data rate transfers often demand more power.

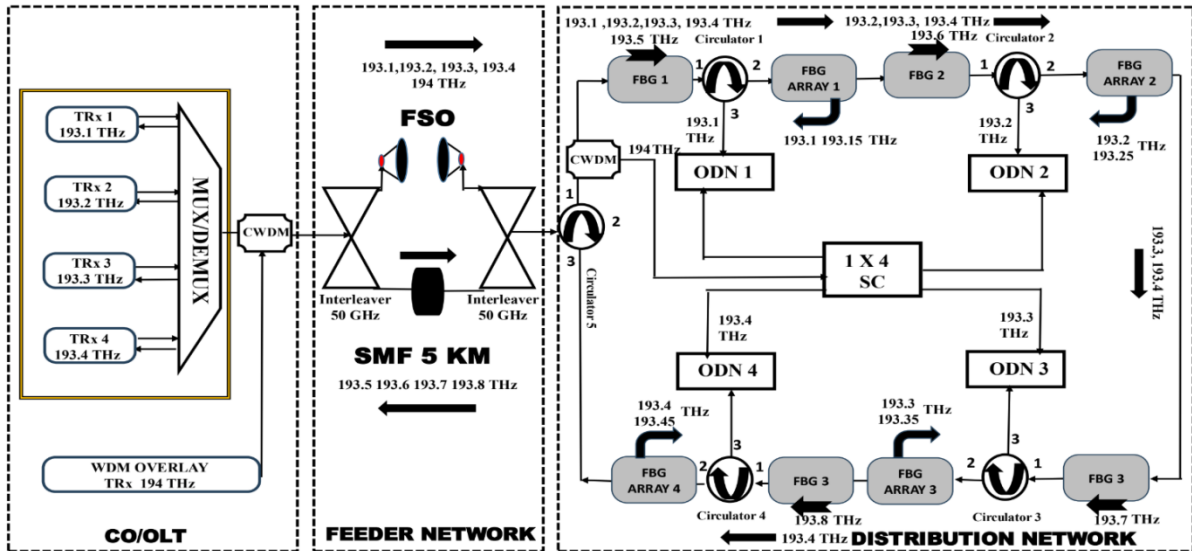


Fig. 1 Proposed adaptive resource allocation-based hybrid topology interconnection architecture.

Biosensing of Endogenous Fluorophores in Blood Plasma through Resonance Energy Transfer by g-C₃N₄ QDs and its Aid in Discriminating Liver Diseases

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Abstract:

Hepatocellular carcinoma (HCC) and liver cirrhosis are progressive liver disorders for which early diagnosis is still a challenge. Discrimination and quantification of fluorophores in the blood plasma with the native fluorescence is difficult. Hence with the aid of nano biosensors the native fluorescence of these fluorophores can be discriminated with better quantification. Graphitic carbon nitride (g-C₃N₄), possess a 2D graphene-like sheet structure and has attracted tremendous attention owing to its optical properties, its facile processing, stable fluorescence, biocompatibility and low toxicity. g-C₃N₄ QDs have demonstrated to enhance these properties with non-zero band gap, tunable fluorescence properties, high quantum yield, exceptional dispersibility in various media and good biocompatibility making them highly useful for the application in the optical sensors. Although plasmonic quantum dots are widely used in the biosensing, g-C₃N₄ QDs offer distinct advantages in the enhancing of the fluorescence emission signals of the endogenous fluorophores present in the blood plasma. In this study, we explore the integration of g-C₃N₄ QDs with blood plasma samples to enhance the emission intensity of key endogenous fluorophores, particularly flavin adenine dinucleotide (FAD). Since the emission and excitation spectra of the both the g-C₃N₄ QDs and FAD endogenous fluorophores in the blood plasma were found to be in the same region, this facilitated energy transfer between the g-C₃N₄ QDs and the fluorophores in the plasma thus enhancing the fluorescence emission signals. This enhancement allows for better discrimination of the healthy plasma samples from that of the diseased (cirrhotic and HCC) samples leading to accurate diagnosis of the diseased conditions. Discriminant and statistical analyses were performed to evaluate the discrimination between g-C₃N₄ QDs and the plasma fluorophores. The limit of detection (LOD) was determined to be 1.7 μ L, demonstrating the high sensitivity allowing for early detection of the liver diseases. This approach provides a promising pathway for the development of non-invasive, fluorescence-based diagnostics for liver diseases such as cirrhosis and HCC. This has been further integrated to enable point of care discrimination using microfluidic detection.

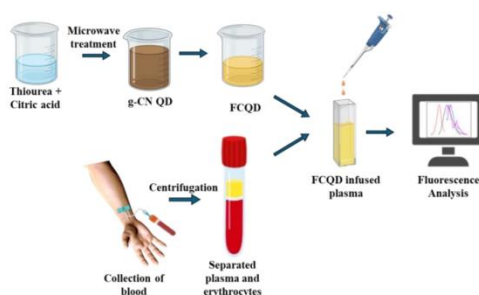


Fig. 1 Schematic representation of the Fluorescence Resonance Sensing from human blood plasma using g-CN QD.

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Hybrid D-Shaped Surface Plasmon Resonance Sensor for Enhanced Refractive Index Detection Using ANN Modeling

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Machine learning (ML) has emerged as a pivotal tool in advancing sensing technologies across diverse fields such as biosensing, agriculture, and industrial automation. The proposed study utilizes numerical simulation techniques of a D-shaped optic fiber surface plasmon resonance (SPR)-based refractive index sensor featuring silver (Ag), gold (Au), and antimonene coatings with grating structures. Using a finite element method (FEM) based platform, the study optimizes material combinations and coating thicknesses to achieve superior sensor performance. The key parameters, including grating period, width, number of gratings, corrugation depth, and coating thickness, were analyzed to evaluate their influence on sensor sensitivity [1, 2]. Among the examined configurations—Au/antimonene [3], Ag/antimonene, and hybrid Ag/Au/antimonene—the hybrid multilayer structure (Ag 30 nm / Au 20 nm / 6 antimonene layers of 0.5nm thickness each layer) exhibited the highest wavelength sensitivity of 15,000 nm/RIU and a maximum resolution of 6.66×10^{-6} RIU over the refractive index range of 1.38–1.42 depicted in Fig. 1. The enhanced performance is attributed to stronger Plasmon coupling and improved field confinement in the hybrid configuration.

An artificial neural network (ANN) model was further implemented with different activation functions (ReLU, Sigmoid, and Tanh) and epochs (50, 100, 150) to predict confinement loss. The ReLU activation function demonstrated the best regression performance, achieving an (R^2) of 0.9628 and an MSE of 9.956 at 100 epochs depicted in Fig.2, outperforming Sigmoid and Tanh. by 24.59% and 13.07%, respectively. The results indicate significantly enhanced sensitivity compared to a conventional D-shaped Ag–Au–antimonene coated fiber SPR sensor, highlighting its potential for future chemical, biochemical, and environmental sensing applications requiring high precision.

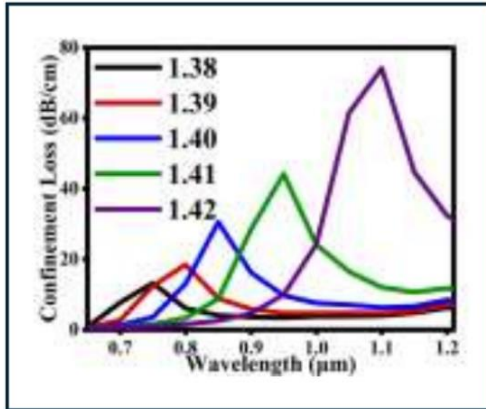


Fig.1: Confinement Loss spectrum variation with wavelength for analyte ranging from 1.38- 1.42 at $Au_t=10$ nm, $Ag_t=40$ nm, and Antimonene of 6 layer.

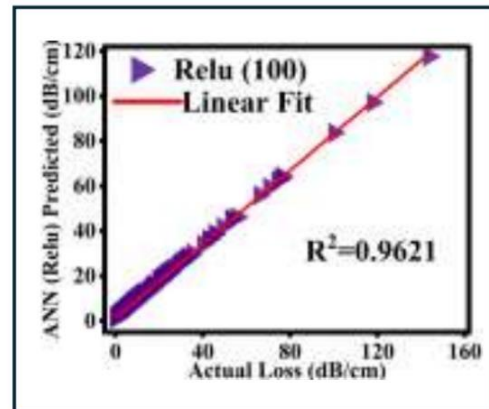


Fig.2: Simulated actual values are plotted on the x-axis, predictions from the ReLU-based ANN on the y-axis, and they are compared against the theoretical linear $y=x$.

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Assessing Thermal Effects and Performance of Optical Interconnects vs. Copper and CNT Interconnects in Deep-Submicron Technologies

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Objective: A Continuous CMOS scaling has driven electrical interconnects to their thermal and delay limits. This work performs a temperature-aware comparison of optical interconnects (OIs) with copper (Cu) and single wall carbon-nanotube bundle (SWCNT-B) interconnects at 22 nm and 14 nm nodes.

Methodology: A novel Active Voltage Current Feedback Regulated-Gain Cascode (AVCF-RGC) transimpedance amplifier (TIA) as shown in Figure 1(a), is integrated into the OI receiver for thermal-aware modeling. The de- sign, implemented in 22 nm and 14 nm CMOS, is simulated using Tanner EDA, considering temperature dependent carrier mobility, parasitic capacitance, and photodiode parameters from 200–500 K. The laser power follows:

$$P_{laser}(T) = \eta_s(T)[I_{bias} - I_{th}(T)]h\nu, \quad (1)$$

where $\eta_s(T) = \eta_s(T_0)e^{-\gamma(T-T_0)}$ and $I_{th}(T) = I_{th}(T_0) + \frac{dI_{th}}{dT}(T - T_0)$. The receiver gain varies as:

$$Z_{TIA}(T) \propto g_{mp}(T)[1 + g_{mq}R_{oq}]R_{op}(T). \quad (2)$$

Novelty: While optical and electrical interconnects are well explored, thermal-aware modeling and comparative analysis across emerging nanoscale nodes remains limited. This work introduces a unified temperature dependent framework for OIs incorporating:

- Thermal modeling of OI components with a compact AVCF-RGC TIA receiver offering low input impedance and wide bandwidth.
- Comparative analysis of delay, power, and power–delay product (PDP) of OI, Cu, and SWCNT-B on rough SiC substrates via SPICE simulations at 22 nm and 14 nm nodes.

Key Results: The proposed OI with AVCF-RGC TIA demonstrates ultra-low input impedance and wide bandwidth, maintaining stable operation across 200–500 K. Compared with Cu and SWCNT-B links, it achieves >90% delay improvement as shown in Figure 1(b), and > 80% power reduction as shown in Figure 1(c) at 200 500 K, validating its superior thermal resilience and energy efficiency for next-generation photonic VLSI systems.

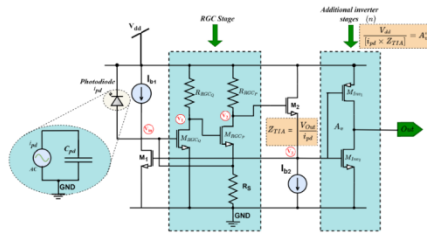


Figure 1(a)

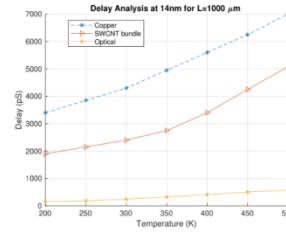


Figure 1(b)

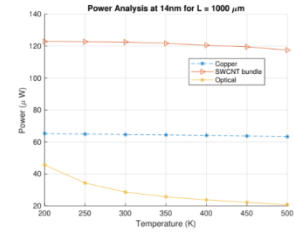


Figure 1(c)

Fig. 1: (a) Proposed AVCF–RGC TIA receiver integrated in optical link. (b) Delay–temperature comparison for OI, Cu, and SWCNT–B interconnects. (c) Power–temperature comparison.

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Theoretical investigation of Cos Gaussian beams in a defect superlattice in presence of both the linear and quadratic electro optic effects

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This paper deals with the theoretical investigation of spatial evolution and interactions of Cos Gaussian (CG) beams in presence of a defect superlattice in a photorefractive (PR) crystal with both the linear and the quadratic electro optic coefficients. The Helmholtz equation in the paraxial approximation is used to set up the dynamical evolution of beam in such photorefractive crystals with a defect superlattice. For a defect superlattice, three different conditions are studied – positive defect, negative defect, and no defect. Diffraction effects due to the inherit lattice parameters can be observed. [1]

The study is conducted by varying the value of the control parameter in CG beam. The control parameter controls the formation of the side lobes of the beam. The electric field is also varied which also gives rise to linear and quadratic nonlinearity, which scales proportionately. At lower values of electric field, there is limited non-linear response, but as the electric field increases the non-linear response increases which leads to self-trapping effect. At certain electric fields the self-trapping effect can be seen clearly with soliton formation.

Interactions of two Cos Gaussian beams are also studied. Interesting interaction effects can be observed when the control parameter is set to a non-unitary value. Along with the interactions, interplay effects when a hypothetical non-linear crystal is also studied. For a hypothetical crystal the linear and quadratic non-linear effect values are manually tuned, which give rise to very unconventional results. [2]

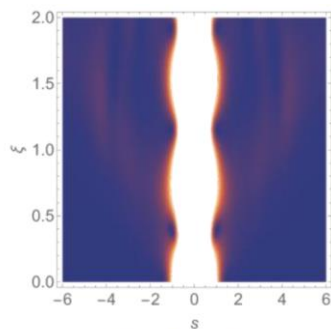


Fig. 1: $b=1$

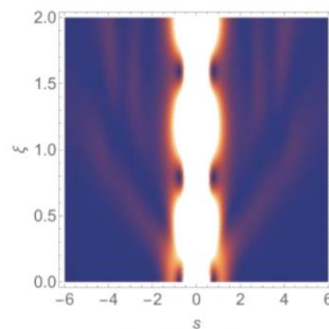


Fig. 2: $b=2$

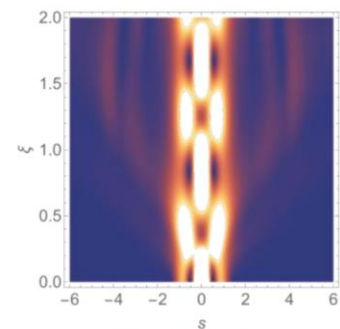


Fig. 3: $b=3$

In Figure 1-3, the electric field is set to $E = 1 \times 10^5 \text{ V m}^{-1}$, while the CG control parameter is set varied. At $b=3$, an interesting pattern of self-trapping and to-and-fro energy transfer in the main and the side lobes.

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Hybrid Plasmonic nanohole SERS substrate with gold nanoparticles for enhanced detection of milk adulterants

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Abstract: The study reports the design investigations of a hybrid SERS substrate comprising AuNPs-decorated on silicon nanoholes for enhanced detection of milk adulterants (thiram and dicyandiamide). The enhancement factor (EF) of 2.6×10^5 in single unit cell, and in an array of 6×6 unit cells, the EF is 1.12×10^7 along XZ plane and 2.92×10^5 along XY plane is obtained.

Keywords: Surface-Enhanced Raman Spectroscopy (SERS), Gold nanoparticles (AuNPs), plasmonics.

I. Introduction

SERS is widely implemented in a variety of areas, including biosensing, glucose and food sensing. In one such application, gaining popularity in food safety due to its ability to detect particular chemicals, metal ions, and pathogens quickly and accurately [1]. The SERS enhancement factor is directly proportional to the fourth power of the local electric field (equation 1), where E_{loc} and E_0 represent the local electric fields in the presence and absence of the nanoparticles [2].

$$G = \frac{|E_{loc}(\omega_R)|^4}{|E_0(\omega_0)|^4}$$

II. Design of a Hybrid Plasmonic System

The innovative design of hybrid SERS substrate is simulated via Ansys Lumerical FDTD for field enhancement visualization. The silicon substrate consists of nanoholes with diameter and depth of 20 nm respectively and gold nanoparticles with 20 nm diameter positioned over the silicon nanoholes. The simulation was carried out for a single unit cell and also for the array of 6×6 unit cells.

III Results and Discussion

The enhancement factor in single unit cell of hybrid SERS substrate was observed to be 2.6×10^5 . In array structure, an enhancement of 1.12×10^7 and 2.92×10^5 was found along XZ and XY plane respectively, which indicates strong field amplification. The enhancement occurs at the interface between the nanoparticle and the nanohole, offers ultra-sensitive molecule identification.

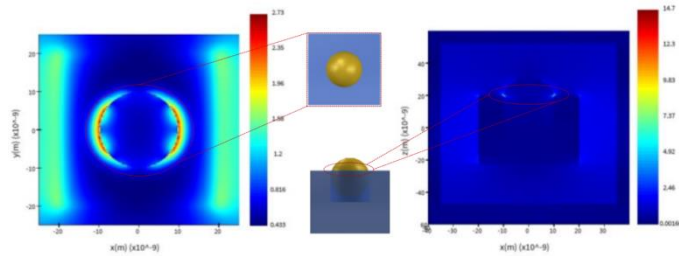


Figure 1. The electric field distribution along X-Y plane (EXY), and X-Z plane (EXZ) in a hybrid system containing single gold nanoparticles over a nanohole on a silicon layer.

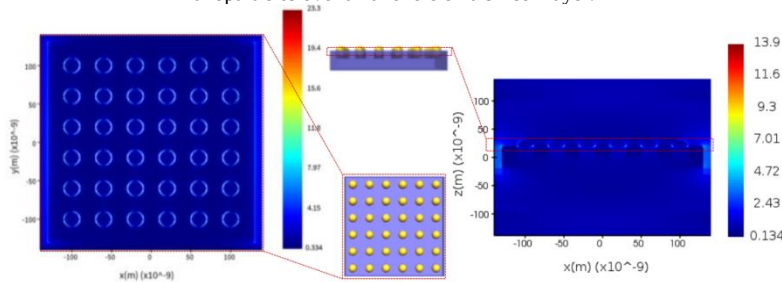


Figure 2. The electric field distribution along XY plane (EXY), and X-Z plane (EXZ) in a hybrid system containing gold nanoparticles over nanoholes (an array of 6×6 unit cells).

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Design and Simulation of Slot-Based Microring Resonator for Biosensing Application

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ABSTRACT:

Photonic ring resonators have proved a key way to chip-scale integrated systems and high-sensitivity sensing, with compact footprints, high quality factors, and compatibility with CMOS. In this paper, a slot-based micro ring resonator is designed and simulated to detect biomarkers with high sensitivity. The silicon-on-insulator(SOI) platform with an optimized slot width provides a higher optical confinement and light-analyte interaction, a high Q-factor, and better stability of the resonances. The design parameters that affect sensitivity, such as the waveguide geometry, coupling conditions, and the selection of resonance wavelength, are analysed. The proposed design of the ring resonator has better performance over other micro rings, thus can be used in real-time biosensing in medical diagnostics.

I. INTRODUCTION:

Photonic ring resonators exploit the resonant enhancement of circulating optical fields to provide effective filtering, modulation, and sensing in a small footprint [1]. Silicon photonics has grown quickly because there is a need for scalable and low-cost optical systems. Photonic ring resonators are now a flexible platform that can be used for many applications, such as signal processing, telecommunications, biochemical sensing, and environmental sensing.

II. DESIGN AND PROPOSED RESULT:

The proposed slot-based microring resonator is created on a silicon-on-insulator (SOI) using COMSOL Multiphysics.

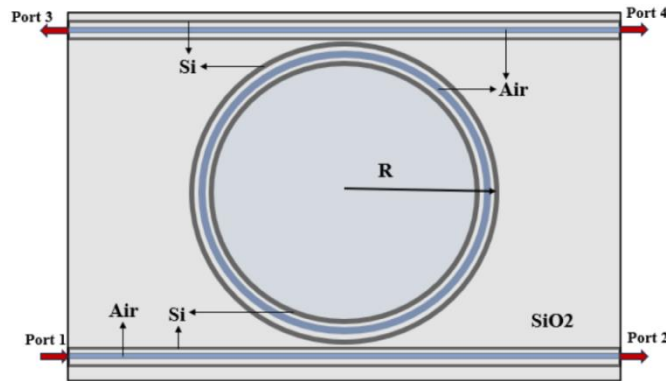


Fig.1 Design Structure of Slot-based Microring Resonator

A slot waveguide [2], along with the ring, is added to improve the confinement of light and the interaction between light and the analyte. The proposed slotted microring resonator (SMRR) will exhibit strong resonance behaviour and a high Q-factor of more than 80 and a sensitivity of about 400-1000 nm/RIU.

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Highly Sensitive D-Shaped PCF-Based SPR Biosensor in Near Infrared Range

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In this study, a photonic crystal fibre (PCF)-based surface plasmon resonance sensor (SPR) is designed and analysed numerically by using the finite element method (FEM). This sensor constitutes a D-shaped PCF deposited with a layer of Indium Tin Oxide (ITO) and Titanium Dioxide (TiO₂). Here, ITO is used as a plasmonic material, while TiO₂ serves as a mid-index adhesive layer that amplifies the SPR effect. To obtain the best sensor performance, the ITO and TiO₂ thicknesses are optimised at 55 nm and 40 nm, respectively. The air holes are arranged in a hexagonal pattern with the pitch value of 2.2 μm . The maximum confinement loss and amplitude sensitivity of the sensor reaches up to 29.27 RIU⁻¹ and 907.17 dB/cm, respectively. Similarly, the minimum FWHM value achieved for the proposed structure is 14.5 nm, which illustrates the better response of the sensor. The suggested sensor is suitable to detect biomolecules in the near-infrared regime.

This study presents a state-of-the-art PCF-SPR sensor designed to efficiently identify biomolecules in liquids with refractive indices between 1.30 and 1.35 in the NIR regime. We conducted a numerical study to design and evaluate a D-shaped PCF-based SPR sensor, incorporating layers of ITO and TiO₂. This work was carried out using FEM-based COMSOL Multiphysics software. We determine that the loss curve and significant shift in resonance wavelength when the RI of the sensing medium changes after adsorption of biomolecules. According to the simulation result, the peak amplitude sensitivity reaches 29.27 RIU⁻¹ with a maximum loss of 907.17 dB/cm. The FWHM of 14.5 nm is achieved. Moreover, the sensitivity can be further enhanced by changing performance parameters like the PCF geometric shape and the thickness of the ITO layer.

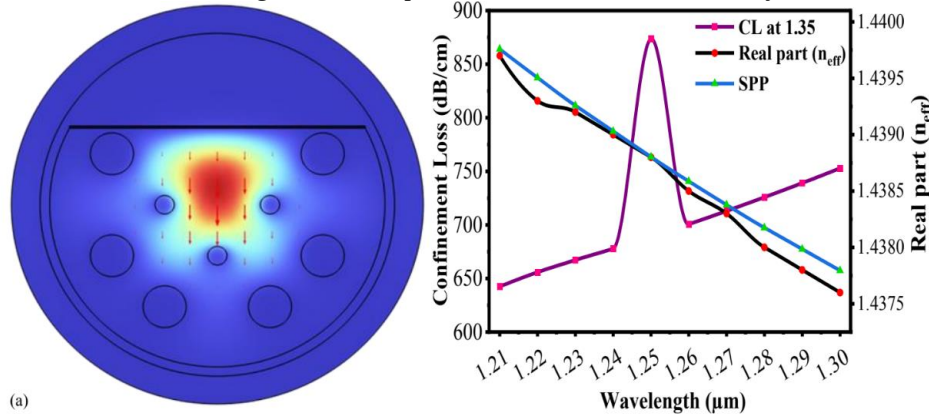


Fig. 1 (a) Core mode view and (b) Loss spectrum and dispersion relationship

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Low Phase Noise X-band Signal Generation using Dual-Loop Optoelectronic Oscillator

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Next-generation radar systems are increasingly adopting photonic architectures to overcome limitations of conventional electronics. Recently, an X-band photonic radar system has demonstrated remarkable performance during field trails, where ultralow phase noise sources are critical for enhanced object detection sensitivity and accuracy [1]. Optoelectronic oscillators (OEOs) are emerging as promising sources for generating stable, low-noise microwave wave signal. However, traditional single-loop OEOs (SL-OEOs) face an inherent trade-off between phase noise and spectral purity [2]. Increasing the cavity length to minimize phase noise inversely reduces the free spectral range (FSR) leading to increased side mode oscillations which are difficult to filter out thus affecting the spectral purity. Dual-loop OEOs (DL-OEO) address these limitations through the incorporation of a secondary feedback loop, extending the effective optical path length and enabling Vernier based single-mode selection [3]. This configuration yields improved phase noise and enhanced side-mode suppression ratio (SMSR).

This work investigates the performance characteristics of DL-OEOs for low phase noise X-band (9.52GHz) signal generation, presenting a direct comparison to SL-OEO counterparts. We analyze the sensitivity of signal quality to factors such as fiber lengths, Mach-Zehnder Modulator (MZM) bias point, loop gain, and phase matching. The experimental setup, illustrated in Fig. 1(a), employs a continuous-wave (CW) laser operating at 1550nm, modulating it with a LiNbO₃-based MZM. The modulated optical signal is then split via a 50:50 optical coupler into two paths, each incorporating a distinct length of single-mode fiber. The first path comprises a 50 km fiber, followed by an Erbium-doped fiber amplifier (EDFA) and variable optical attenuator (OA). The second path consists of a 500m fiber and again a variable OA. Both optical paths are converted into electrical signals via high-bandwidth InGaAs-based photodetectors (10GHz). These signals are then combined using a Wilkinson-type 2-way power divider. A 9.52GHz RF bandpass filter with a 14MHz bandwidth selects the desired fundamental frequency, and the filtered signal is fed back to the MZM's RF input, completing the feedback loop. A tunable RF phase shifter is incorporated to precisely manage phase matching within the loops. When one of the feedback paths is disconnected, the setup operates effectively as a SL-OEO, allowing for direct comparison.

Fig. 1(b) shows the generated stable single mode X-band signal at 9.52GHz using DL-OEO experimental setup. We observed that stable, low-phase-noise operation in the DL-OEO configuration is critically dependent on the precise biasing of the MZM at the quadrature bias point and the fulfilment of phase matching conditions which is integer multiples of 2π , confirming the Vernier effect. Precise adjustment of the optical attenuators in Barkhausen criterion.

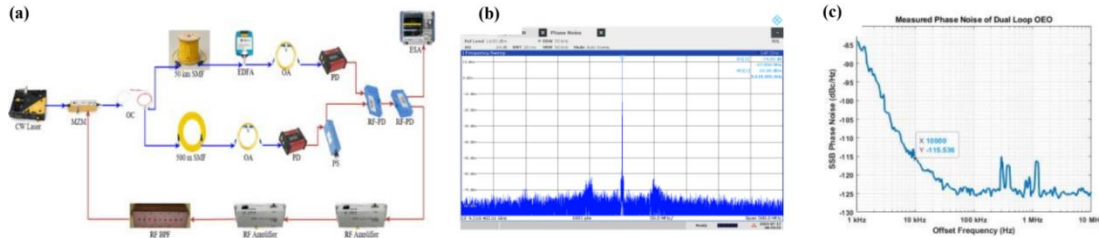


Fig. 1 (a) Experimental setup of the proposed DL-OEO (b) RF spectrum and (c) phase noise of the X-band signal generated. The phase noise performance of the generated X-band signal by DL-OEO is shown in Fig. 1(c) and its performance comparison with SL-OEO counterpart is tabulated in Table I. These results validate that the DL-OEO architecture effectively addresses the performance limitations of traditional SL-OEOs.

TABLE I. PERFORMANCE COMPARISON OF OEO ARCHITECTURES

Sl.No.	OEO Architecture	Phase Noise at 100kHz offset	SMSR
1.	SL-OEO 500m	-97dBc/Hz	75dB
2.	SL-OEO 50km	-115dBc/Hz	30dB
3.	DL-OEO 500m/50km	-115dBc/Hz	75dB

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Investigation of Optoelectronic and Photovoltaic Properties of Cs₂AgSbCl₆ Lead-free Double Perovskite Using DFT and SCAPS-1D Simulation

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Double perovskite (DP) is a promising option for renewable energy harvesting to address the global energy shortages [1]. Recently, the lead replacement with homovalent elements (Sn, Ge) and heterovalent elements (Ag⁺, Sb³⁺, In³⁺, and Bi³⁺), with general formula of DP's A₂BB'X₆, where B denotes trivalent cations and B' represent monovalent cations, respectively, has been studied [2, 3]. Lead-free double perovskite solar cells (PSCs) are currently of interest to researchers studying photovoltaic (PV) properties. The outstanding structural, optoelectronic, and photovoltaic properties of DP Cs₂AgSbCl₆ are investigated in this work. We found that the indirect bandgap (E_g) of DP Cs₂AgSbCl₆ is 2.49 eV using the PBE-GGA_TB-mBJ approximation, which is very similar to the experimental bandgap of 2.54 eV [4]. Its strong absorption coefficient values in the visible and ultraviolet spectrums demonstrate that Cs₂AgSbCl₆ DP is a suitable choice for solar cell (SC) applications due to its optoelectronic characteristics. Our study explores the effects of hole transport layer (HTL) and electron transport layer (ETL) on the performance of these SCs employing DP as the absorber. In this study, SCAPS-1D has been used to model the typical n-i-p planner heterojunction topology. In depth research and discussion are conducted on the impacts of different factors, including PVSK thickness (t), defect density (N_t), recombination R(x), and generation rates G(x). It is determined that the optimized device outputs are improved PCE of 15.66 %, FF of 78.20 %, Voc of 1.33 V, and J_{sc} of 15.00 mA/cm². Furthermore, the potential of Cs₂AgSbCl₆ DP as a usable material for non-lead-based PSCs is assessed by analyzing the J-V (current-voltage) and QE (quantum efficiency) characteristics of the ETL and HTL. According to these simulation results, one of the best methods for fabricating the PSC structure under practical circumstances is to use them to fabricate stable and effective Pb-free DP.

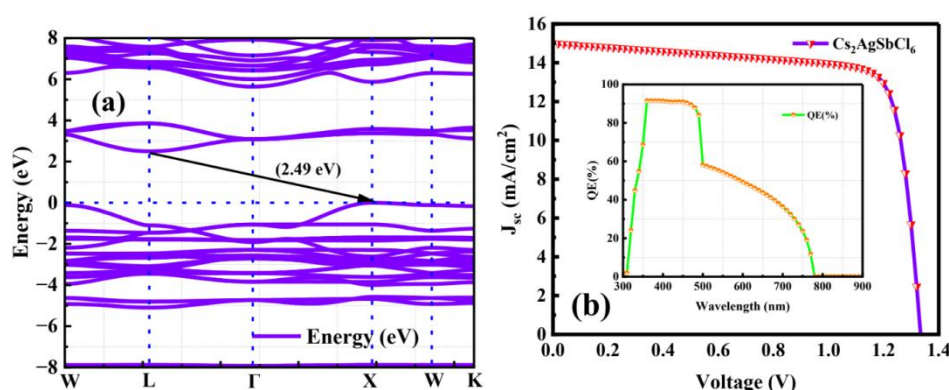


Fig. 1 (a) The calculated band structure of Cs₂AgSbCl₆ double perovskite and (b) J-V curve for the studied structure of DP Cs₂AgSbCl₆ and QE curve shown in the inset.

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Impact of external perturbation to Brillouin lasing in microresonator

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ABSTRACT

High-Q microresonators enable strong optical nonlinearities, including Kerr and Brillouin effects, even at low pump powers. However, light absorption induces thermo-optic and thermo-elastic shifts that dynamically modify the cavity resonance, often leading to optical bistability and instability [1]. In Brillouin lasers, where optical and acoustic modes are coupled, such thermal feedback can significantly influence the pump–Stokes detuning and thus the system's stability [2,3]. Here, we experimentally analyze how pump-power variations and associated thermal nonlinearities affect the steady-state operation of a Brillouin laser in a microresonator.

Here, we investigate the impact of pump laser power on the stability of the Brillouin Stokes power. Figure 1(a) shows the concept of our study, where initially (see Fig. 1(a)(A)) the pump laser and Brillouin Stokes are blue–red detuned, respectively, from their resonances. The pump laser power is then reduced (Figs. 1(a) (B)–(D)) and the Stokes power is recorded (see blue plot Fig. 1(c)). As seen from the blue plot in Fig. 1(c), the Stokes power remains stable as the pump power is further reduced except few kinks, which occur when we scan the system to characterize the tuning of resonances shown in Fig. 1(b), which shows the stability of the system against a reduction in launched pump power. These results demonstrate that the blue–red detuned intracavity-pumping configuration remains robust against moderate pump-power fluctuations, with instability emerging only beyond a threshold reduction.

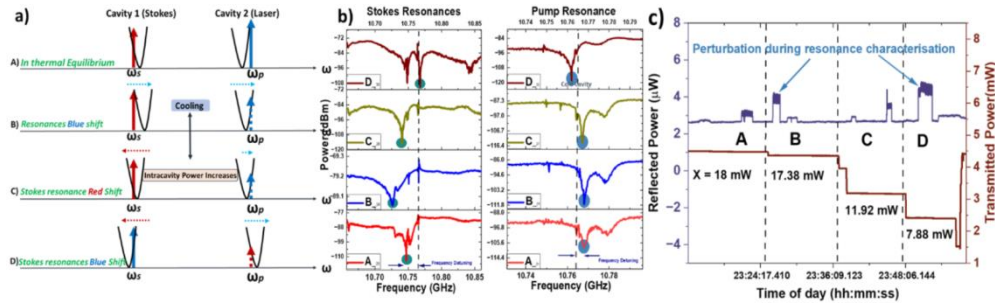


Figure 1(a) Conceptual sequence of pump-power tuning. (A) Initial condition: pump (blue) is blue-detuned and Brillouin Stokes (red) is red detuned relative to their respective resonances. (B) A small reduction in launched pump power cools the cavity, producing a blue shift of the pump resonance. (C) If the pump resonance moves closer to the fixed pump wavelength, pump detuning decreases, and intra-cavity pump power can increase, causing local heating and a red shift of the Stokes resonance. (D) Further reduction of the launched pump power eventually drives the system out of the stable operating point. (b) Measured resonance traces while changing pump power (points A–D correspond to the states in panel a). (c) Measured Stokes (blue) and pump (red) power versus time, showing overall stability of Stokes power with small kinks that coincide with the resonance scanning events in (b).

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Structural, Electronic, Thermoelectric and Optical properties of inorganic Cesium Copper Halide Perovskite Cs₃Cu₂I₅ for optoelectronics applications: A DFT Study

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Recently all inorganic copper halides perovskites gained attention for their excellent photoluminescence properties, environmental stability and defect tolerance nature, making them promising candidates for light emitting and scintillation devices [1]. In this study, the structural, electronic, thermoelectric and optical properties of all inorganic copper halide perovskite Cs₃Cu₂I₅ have been computed using FPLAW method implemented in WIEN2k via Density Functional Theory (DFT) [2]. The crystal structure has been optimized using Generalized Gradient Approximation (GGA-PBE) potential giving the bandgap of 2.18 eV and further band structure refinements have been carried out using MBJ potential giving the bandgap of 3.85 eV which is matched with the previous reported experimental studies. The volume optimization results exhibit lattice parameters of $a = 10.69 \text{ \AA}$, $b = 12.22 \text{ \AA}$, $c = 14.97 \text{ \AA}$ with minimum energy (E_0) = -498212.513 Ry at volume (V_0) = 12203.05 a.u.³ in the orthorhombic Pnma (62) space group. The computed crystal structure and corresponding band structure are shown in Fig. 1(a) and Fig. 1(b) respectively. The computed absorption coefficient exhibits the highest peak in the range of 4 eV – 13 eV which lies in the range of deep UV region of electromagnetic spectrum and the computed reflectivity spectra shows a pronounced rise in the UV region (4 – 10 eV), first peaked at 4.44 eV and second peaked at 8.5 eV. By compiling these results, it can be concluded that Cs₃Cu₂I₅ shows best suitability for UV detections. In recent future, Cs₃Cu₂I₅ can be a suitable choice to replace lead halide perovskite for the deep UV photodetectors and other optoelectronics devices.

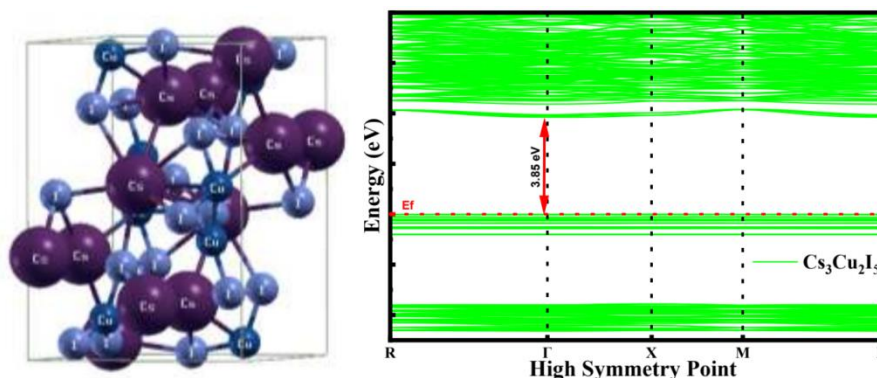


Fig.1. (a) Crystal Structure of Cs₃Cu₂I₅ (b) The calculated Band structure of Cs₃Cu₂I₅

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Comprehensive Analysis of Structural and Optoelectronic properties of Lead-Free CsSnI2Br using DFT via Wien-2K Tool

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Over the past few years, the transition towards eco-friendly alternatives of lead (Pb) perovskites has been accelerated due to the toxicity of Pb-based counterparts and their detrimental effects on the human health and environment. Hence tin (Sn) based perovskites got immense attention as competitive candidates for eco-friendly perovskite solar cells (PSC) [1]. The mixed-halide composition helps in achieving band gap tuning and enhancing optoelectronic properties such that these materials can be utilised for the harvesting of solar energy [2]. This study focuses on the study of the structural and optoelectronic properties of inorganic tin based mixed halide perovskite CsSnI2Br computed by using WIEN2K software which incorporates density functional theory (DFT) principles. The cubic crystal structure is optimised and Generalized Gradient Approximation (GGA-PBE) and TB-mBJ approximations are utilised to calculate band structure. The direct bandgap (E_g) of 1.41 eV is obtained for CsSnI2Br from DFT study which is approximate to the experimentally reported E_g value of 1.42 eV [3]. The obtained band- structure is represented in Fig.1(a). The computed absorption spectra shown in Fig.1(b) represents that peak values of absorption coefficient in the visible region are $51.79 \times 10^4 \text{ cm}^{-1}$ and $48.95 \times 10^4 \text{ cm}^{-1}$ for xx and zz components respectively. The visible spectrum region corresponds to photon energies roughly between 1.8 eV and 3.1 eV and obtained peak is also in this range. The reflectivity represents information about the reflection of incident light from material surface. At energy limit zero reflectivity obtained are of low values such as 0.15 along component xx and 0.11 along component zz. The perovskite material may be beneficial for photovoltaic applications. Thus, this study reveals that CsSnI2Br can be a potential material for being used as an absorber layer in Pb-free PSCs and other optoelectronic devices.

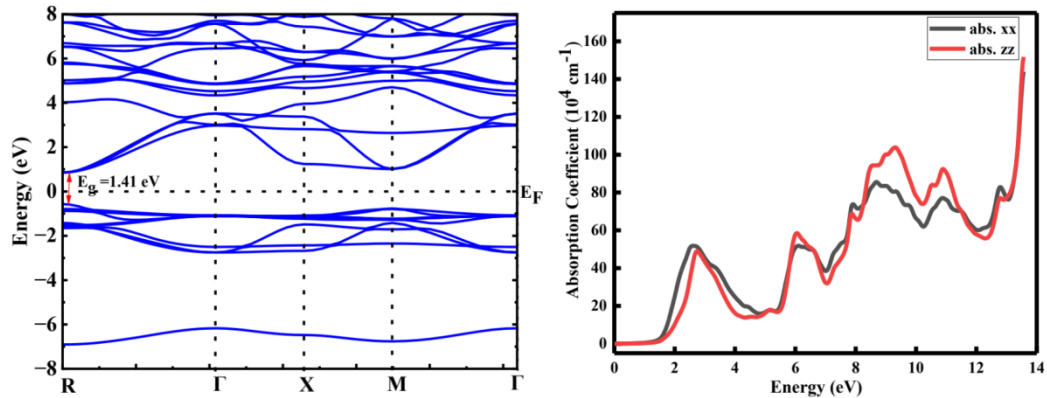


Fig. 1 (a) The calculated band structure of CsSnI2Br perovskite and (b) the absorption coefficient $\alpha(\omega)$ of CsSnI2Br as a function of photon energies

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Non-Gaussian Quantum Optical Approach for True Random Number Generation Using Cubic-Phase Nonlinearity

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Abstract

Quantum true random number generators (QTRNG) exploit the inherent unpredictability of quantum optical processes to produce true random sequences beyond the limitations of classical algorithms. This proposed work based on non-Gaussian cubic phase operations designed to enhance quantum fluctuations and entropy in photon-number measurements. The proposed circuit implemented in Strawberry Fields using a two-mode optical circuit initialized with a single-photon Fock state $|1,0\rangle$. The evolution of the optical state is described by

$$|\psi_{out}\rangle = \hat{B}\left(\frac{\pi}{4}\right)\hat{S}_1(r)\hat{V}_0(\gamma)\hat{R}_0(\theta)|1,0\rangle$$

This configuration provides a discrete quantum resource facilitating non-classical correlations when combined with non-Gaussian operations. In fig1. first operation creates superposition state with a phase rotation $\hat{R}_0(\theta) = e^{i\theta\hat{n}}$ with $\theta = \pi/4$ rotates the quantum state in phase space [1] prepares it for subsequent interactions without altering photon-number statistics. To enhance non-classicality, a cubic phase gate $\hat{V}_0(\gamma) = e^{i\gamma\hat{x}^3}$ is applied to mode zero. This gate modifies higher-order moments of the position quadrature, $\hat{x} = (\hat{a} + \hat{a}^\dagger)/\sqrt{2}$ introduces strong non-Gaussianity for quantum randomness. The strength parameter $\gamma_{cubic} = 0.35$ is tunable allowing control over the degree of nonlinearity in the quantum state. The first mode undergoes a squeezing operation $\hat{S}_1(r) = \exp[r(2\hat{a}^2 + \hat{a}^{\dagger 2})]$ with a small squeezing factor $r = 0.3$. Squeezing narrows the uncertainty in one quadrature increases the conjugate quadrature broadening the photon-number distribution [2]. This operation enriches the statistics of the mode and enables entanglement with mode zero when mixed through the subsequent beam splitter. A balanced beamsplitter $\hat{B}(\pi/4) = \exp[\pi/4(\hat{a}_0\hat{a}_1^\dagger - \hat{a}_1^\dagger\hat{a}_0)]$ mixes the two modes creates quantum interference and redistributing correlations between the modes. This operation is essential for generating complex photon-number statistics and when measured produces high-quality randomness. When measuring both modes in the fock basis using MeasurementFock() produces discrete photon-number outcomes n_0 and n_1 . Bits are extracted from the parity of mode one photons mapping ensures each measurement [3, 4] generates a statistically unbiased binary outcome. The fock_backend of Strawberry Fields is employed to accurately simulate non-Gaussian operations and photon-number QTRNG, measurements (Fig 1). A cut-off dimension of 8 truncates the Hilbert space and preserves sufficient nonlinearity enables the simulation of higher-order effects without excessive computational cost. The simulation was performed for 2,00,000 single-shot measurements with each simulation progress reported every 20,000 shots. The circuit was repeatedly run and collection of generated sequence was subjected to check the preliminary restart experiment, autocorrelation, Dieharder, ENT, NIST SP800-22 and SP800-90B Statistical test suite. The sequences passed all the test and achieved an average p-value of 0.45 above the 0.01 threshold indicates robust statistical randomness. This proposed work establishes a scalable and reliable approach for true random number generation in quantum communication, photonic computing, and secure information-processing applications. By tuning parameters such as the cubic-phase strength and squeezing factor, the system allows flexible control over randomness quality for future quantum technologies.

Keywords: QTRNG, ENT, NIST, Cubic phase strength, squeezing factor

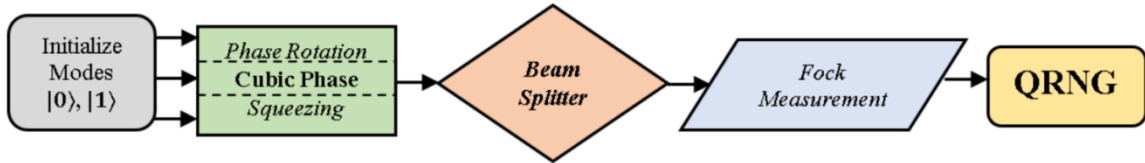


Fig1. Proposed Flow of QRNG Generation using Cubic phase nonlinearity

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Error-Mitigation-Enhanced Hybrid Quantum–Classical Neural Architectures for NISQ Systems

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Abstract

Quantum circuits implemented on Noisy Intermediate-Scale Quantum (NISQ) devices are highly affected by gate errors and decoherence. The proposed paper focuses on identifying an efficient QEM (Quantum Error Mitigation) technique suitable for real-world deployment. After optimizing the quantum circuit to reduce gate count, the model was tested under noisy simulations using default mixed. Various QEM techniques such as ZNE (Zero Noise Extrapolation), PEC (Probabilistic Error Cancellation), and VD (Virtual Distillation) were compared in terms of accuracy and robustness under noise.

Additionally, a hybrid optimization framework is proposed, combining QNGD (Quantum Natural Gradient Descent) for the quantum parameters and ADAM for classical layers, applied within a Hybrid Quantum-Classical Neural Network (HQNN) (Fig 1), resulting in greater stability. Among the QEM methods, PEC performed better, significantly restoring accuracy even in noisy scenarios. The model tested using samples from the IEEE-CIS Fraud Detection dataset, real-world dataset to identify fraudulent online transactions. The noise-optimized circuits achieve up to 96% training accuracy and 95.9% validation accuracy, highlighting the feasibility of QEM for real-world applications on NISQ devices[1, 2].

Keywords: NISQ, QEM, VD, ZNE, HQNN

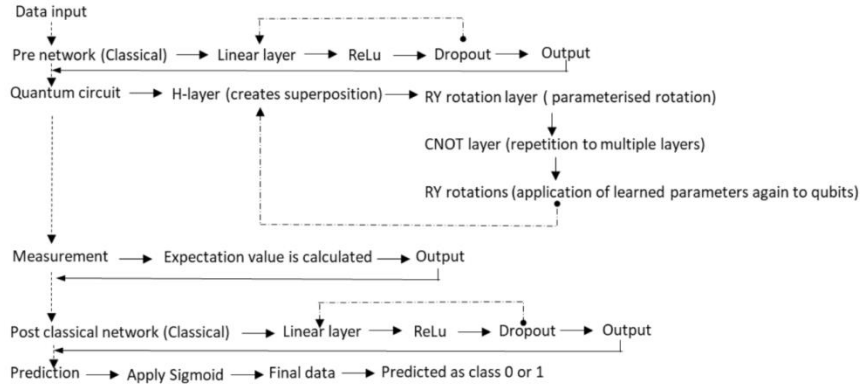


Figure 1. Hybrid QNN generalized methodology

ADAM finds the best parameter to minimize the model's error. It uses average of both the gradients (first moment) and the squared gradients (second moment). By keeping track of these ADAM can adjust the step size (learning rate) for each parameter individually, which helps the model converge fast.

$$m_t = \beta_1 m_{t-1} + (1 - \beta_1) \nabla \mathcal{L}(\theta_t) \quad v_t = \beta_2 v_{t-1} + (1 - \beta_2) (\nabla \mathcal{L}(\theta_t))^2$$

$$\hat{m}_t = \frac{m_t}{1 - \beta_1^t} \quad \hat{v}_t = \frac{v_t}{1 - \beta_2^t} \quad \theta_{t+1} = \theta_t - \eta \frac{\hat{m}_t}{\sqrt{\hat{v}_t + \epsilon}}$$

The moving average of the gradients is m_t . The moving average of the square of the gradients is v_t . β_1 and β_2 are the decay rates. ϵ is a very small value to avoid division of zero.

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Design and Performance Analysis of Triangular-Shaped Confinement Regions in Hybrid Plasmonic Waveguides for Enhanced Biosensing

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1. Abstract

A multilayered photonic sensor with SiN, Ge, Au, and SiO₂ layers and urine cladding enhances sensitivity through evanescent field interaction. SiN guides light, Ge confines it, Au enables plasmonic coupling, and SiO₂ offers stability for biochemical and environmental sensing.

2. Introduction

Optical waveguide sensors provide high sensitivity, compactness, and cost-efficiency through guided light-matter interactions. This study presents a multilayer hybrid SiN, Ge, Au, SiO₂ waveguide with urine cladding. SiN ensures stability, Ge enables strong optical confinement, Au facilitates surface plasmon resonance, and SiO₂ offers mechanical robustness, collectively supporting advanced photonic sensing for biochemical and environmental applications.

3. Design and Result

Fig 1(a) shows the proposed SiN, Ge, Au, SiO₂ waveguide sensor with urine cladding, where the engineered multilayer structure maximizes evanescent field penetration into the analyte, enhancing light-matter interaction and overall photonic sensing efficiency.

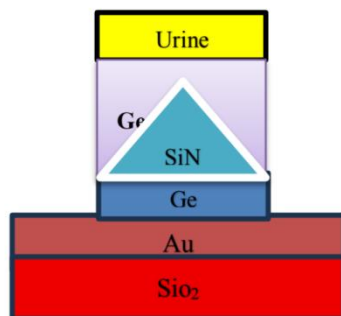


Fig 1(a) Layer Architecture of proposed hybrid Plasmonic waveguide

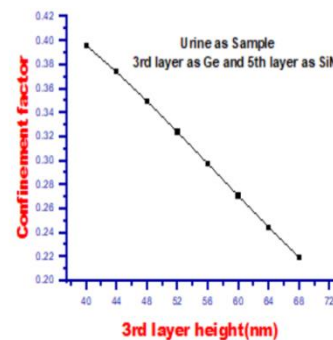


Fig 1(b) Performance of proposed waveguide for Sensing application

Fig 1(b) illustrates the influence of Ge layer height on the confinement factor. Increasing the Ge layer to 40 nm gradually adjusts the confinement factor from 0.39 to 0.21, highlighting how layer thickness can be optimized to control optical mode distribution and enhance targeted interaction with the urine-cladding analyte.

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Comparative study on cavity soliton trapping by Hermite Gaussian and Super Gaussian potentials

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Abstract: Controlling the dynamics of cavity solitons (CSs) and trapping them by appropriate potentials are of fundamental interest and significant for photonics application. Two potential profiles, namely, Hermite Gaussian (HG) and super Gaussian (SG) are used for the same and compared in view of trapping.

Introduction: CSs are unique type of optical dissipative solitons that show bistability, plasticity and exponential confinement in the transverse plane of a large-area cavity. CSs are "optical bits" in optical memory systems [1]. They have random movement in the transverse cavity plane (like a moving bright spot on a dark background). Control over the dynamics and precisely trapping the CS can open enormous opportunity for all-optical application, including quantum confinement, all-optical twistors, all-optical computing, all-optical encryption etc.

Model: We consider a microcavity comprising a vertical cavity surface emitting laser (VCSEL) with graphene saturable absorber (GSA) and frequency selective feedback (FSF). The dynamics of the intra-cavity field (E) can be described by a complex Ginzburg Landau equation (CGLE)[2,3]: $\partial E / \partial t = [-(1 - i\theta) + \mu(1 - i\alpha) + g_1|E|^2 \gamma(1 - i\beta) + sg_2|E|^2 + \alpha ns + i\Delta] E + iVE + (\sigma\lambda(\lambda_2 + \Omega_2) - i\sigma\lambda\Omega(\lambda_2 + \Omega_2))E$. Here, θ is the detuning between the feedback field and cavity field. The parameters $\mu(\gamma)$, $\alpha(\beta)$ and $g_1(g_2)$ signify the pump parameter, line width enhancement factor and saturable absorption for active (passive) medium, respectively. Saturation strength is given by s . αns is the nonsaturable absorption loss. $\Delta = \partial^2 \partial x^2 + \partial^2 \partial y^2$ is the 2D transverse Laplacian operator. The feedback field parameters σ , λ and Ω_0 represent the feedback strength, bandwidth and resonance frequency, respectively. V is the external potential. In this study we consider two different type of potentials; HG and SG. HG has bell-shaped multiple peaks and smooth decay profile, while the SG has single but flat peak and tunable decay profile; from smooth to abrupt. HG potential is given by $V_{HG}(m, n) = V_0 [H_m(xw) H_n(yw) \exp \{-12\sigma[(xw)^2 - (yw)^2]\}]/2$, where V_0 is the amplitude, H_m is Hermite polynomial of degree m , w is the width. The SG potential reads as $V_{SG} = V_0 \exp \{-(xw)^{2m} - (yw)^{2m}\}$, V_0 being it's amplitude, m is the order of potential profile and w is the width.

Result and Discussion: To generate CS and study their dynamics the CGLE is solved numerically via split step Fourier method, using some initial seed values of analytical work.

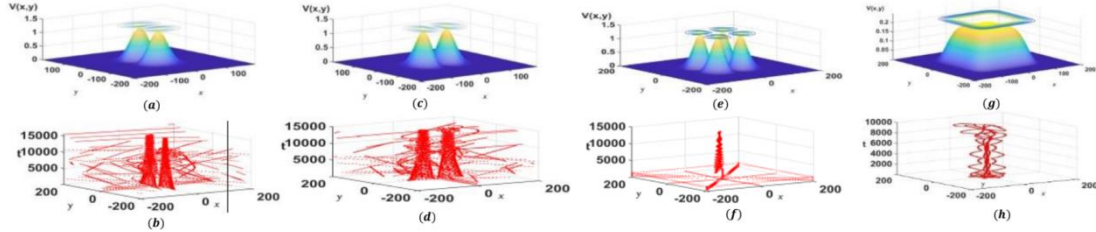


Fig. 1 Different potentials (upper panels) and corresponding trajectories of trapped CS/s (lower panels). Plots (a),(c),(e) and (g) are the potential plots of $V_{HG}(0,1)$, $V_{HG}(1,0)$, $V_{HG}(1,1)$ and V_{SG} . Plots (b),(d),(f) and (h) are the corresponding trajectories plots of CS.

Potential profile	Area under FWHM	Amplitude
V_{HG} for $m=1,0$ and $n=0,1$	4852.3	1.19 ($V_0(4\sigma^2 e^{-1})$ for $V_0 = 0.81$ and $\sigma = 1$)
V_{HG} for $m=1$ and $n=1$	6772.5	1.22 ($V_0(4\sigma^2 e^{-1})^2$ for $V_0 = 0.52$ and $\sigma = 1$)
V_{SG} for $m = 3$	34158	0.2

For simplicity, we restrict our analysis to the first-order HG potential.

Conclusion: CS prefers to stay at the maxima of potential profile. For HG profile having less area of the peak CS trapping is more precise. While the SG profile having a wide area traps CS that experiences some dynamics even being trapped. Both type of CS trapping may find appropriate applications.

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AI-Enhanced Digital Signal Processing framework using PINN and tanh for Nonlinear Compensation in Optical Fiber Communication Systems

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The Optical fibre communication (OFC) systems face significant challenges from nonlinear transmission impairments such as polarization mode dispersion, and Kerr nonlinearity. Traditional digital signal processing (DSP) techniques, achieve partial compensation but are computationally intensive and sensitive to parameter mismatches. Hybrid methods that combine physical principles and Data driven approaches using Artificial Intelligence (AI) can model complex optical channel behaviours, perform nonlinear compensation, and adapt dynamically to varying link conditions. This work proposes a DSP framework that integrates deep learning architecture such as physics-informed neural network (PINN) incorporating a nonlinear activation function tanh to approximate solutions of the Nonlinear Schrödinger Equation (NLSE) and to check its efficiency against conventional compensation algorithms. The performance has been benchmarked against traditional DSP in terms of bit error rate (BER), and computational efficiency.

Generation of optical frequency comb in a microcavity via mode locking

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The optical frequency comb (OFC) is a spectrum that consists of equally spaced lines, i.e., having equally spaced frequency components [1]. OFC gained prominence in research during the past few decades due to its numerous applications in high precision measurements, GPS, atomic clocks, high capacity optical fiber telecommunications, optical frequency metrology, spectroscopy and many more. OFC can be generated by a variety of approaches; among them probably the most popular one is by stabilizing the pulse train of mode locking laser. Also, it is the first reported method to generate OFC. The method of mode locking is used to generate the ultra-short (picosecond - femtosecond) pulses and pulse train in a cavity. A good amount of work has been done on OFC in different systems including optical fiber cavity. However, OFC generation and tuning in a microcavity via mode locking is very promising. In this paper we investigate the OFC generation by mode locking in a highly nonlinear microcavity with saturable absorber and frequency-selective feedback. The temporal evolution of the intra-cavity electric field can be modeled by the Complex Ginzburg-Landau Equation (CGLE) [2,3].

$$\frac{\partial E}{\partial t} = \left[-(1 - i\theta) + \frac{\mu(1-i\alpha)}{1+g_1|E|^2} - \frac{\gamma(1-i\beta)}{1+g_2|E|^2} + i\Delta \right] E + (a - ib)E \quad \dots \dots (1),$$

where, $a = \sigma\lambda^2\lambda_2 + \Omega_2$, $b = \sigma\lambda\Omega\lambda_2 + \Omega_2$. E is slowly varying amplitude of electric field. t is time normalized to the cavity round trip time. The first term on the right side of the eqn.(1) describes the normalized linear loss in the system. The extent of coupling of driving field to the feedback field is measured by the detuning parameter (θ). $\alpha(\beta)$ are line width parameters for active(passive) material. $\mu(\gamma)$ are the pumping parameters for active(passive) material. s is the saturation strength of nonlinearity. g_1 and g_2 are saturable absorption for active and passive medium respectively, due to graphene saturable absorber (GSA). Δ is the transverse Laplacian. σ, λ, Ω represent the strength, bandwidth and frequency of the feedback field respectively. Once there is balance between gain and loss, as well as diffraction and nonlinear effects a self-organized electric field can be formed. Inside the microcavity this leads to the formation of a set of longitudinal modes having a phase relationship. Each longitudinal mode can be represented as: $E_n(t) = A_n e^{i(\omega_n t + \phi_n)}$. A laser cavity of length L supports longitudinal modes with resonance frequencies: $\omega_n = (2\pi c/L)n$. Now, such modes with closed frequencies superpose to give rise to an ultra-short pulse. The periodic boundary condition $E(z, t) = E(z + L, t)$ leads to the formation of a pulse train, i.e., the ultra-short pulses emit in regular intervals of time. If all modes have fixed relative phases (i.e., $\phi_n = \phi_0$ for all n) then their superposition yields a periodic pulse train: $E(t) = \sum_{n=-N}^N A_n e^{i\omega_n t}$. Fourier transformation of the pulse train converts it to the frequency domain with equal spacing between two consecutive frequency lines. These evenly spaced lines are collectively known as an OFC. The microcavity can form a frequency comb with spacing: $\Delta\omega = \omega_{n+1} - \omega_n = 2\pi c/L$. We generate ultra-short pulse trains by solving the CGLE numerically via split step Fourier method (SSFM) and suitable boundary conditions. The corresponding OFC has been determined by Fourier transformation of the pulse train. A typical set of results are given in Fig.1.

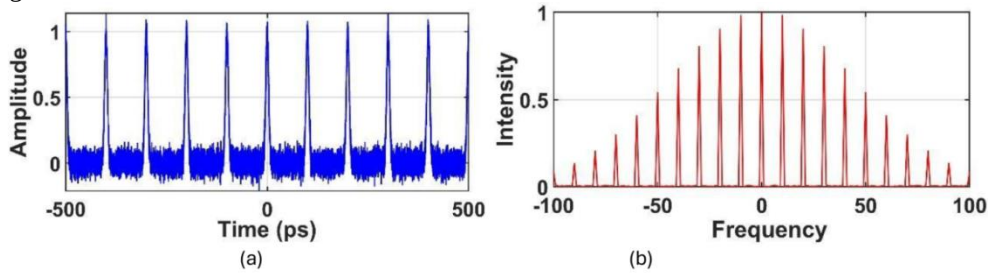


Fig. 1 (a) Time domain representation of a train of pulses. (b) OFC obtained from Fourier Transform of pulse train.

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Edge Coupler-based Photonic Integrated Circuit on SOI Platform for Demultiplexing Application

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Abstract: A four-channel demultiplexer PIC consisting of micro-ring resonators of different coupling lengths and edge couplers was designed using Ansys Lumerical MODE, achieving ~80% coupling efficiency. Demultiplexing operation was achieved in the 1500-1600nm range with an FSR of ~26nm for each channel.

Keywords: Photonic Integrated Circuit (PIC), Silicon Photonics (SiPh), Edge coupler (EC), Tapered waveguide, Micro-ring resonator (MRR)

Introduction

Silicon photonics (SiPh) has emerged as a key technology for developing compact and high-performance photonic integrated circuits (PICs), offering scalable solutions for high-speed optical communication and signal processing [1]. In this work, we propose a silicon-on-insulator (SOI) platform based four-channel wavelength demultiplexer design operating in the C-band. The design integrates edge couplers, tapered waveguides, and micro-ring resonators (MRR), which were systematically optimized using Ansys Lumerical MODE simulations to enhance coupling efficiency, transmission, and spectral selectivity.

Design and Optimization

A typical multi-tip edge coupler is used to couple light into the PIC [2]. The edge coupler design consists of 14 uniformly spaced tooth-shaped tips that maximizes mode field diameter (MFD) overlap. A 90 μ m long tapered waveguide connects the coupler teeth to a bus waveguide, ensuring smooth transmission of the coupled light mode into the PIC. Four MRRs of radius with 4.1 μ m but different coupling lengths (600nm, 670nm, 740nm and 810nm) are used to filter the input signal into four channels. The coupling lengths were optimized for different spectral selectivity and to minimize overlapping between the resonant bandwidths. The coupling gaps were optimized for sufficient distribution of the input signal over all the channels.

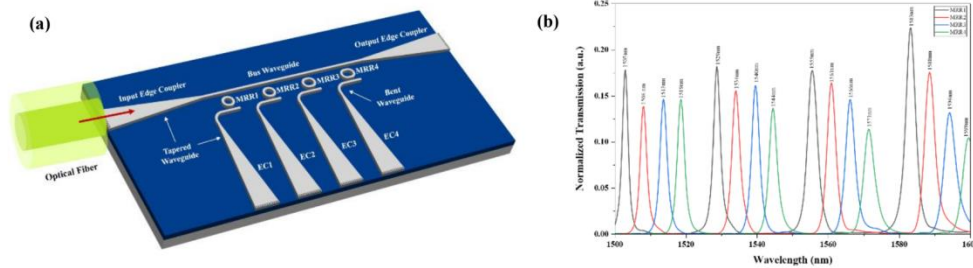


Fig. 1. (a) 3D Layout of the edge coupler based demultiplexer PIC on SOI platform (b) Transmission spectra of the MRR array showing the demultiplexing operation of the edge coupler based demultiplexer PIC.

Results and Conclusions

In this work, the demultiplexing operation of the PIC was successfully demonstrated, filtering specific wavelengths in the C-band used for optical transmission. The edge coupler-based configuration enhances the efficiency of the coupler up to ~80% in the 1500-1600nm wavelength range. The large free spectral range (FSR~27nm) prevented the spectral overlap between adjacent resonances of the same MRR, enhancing the wavelength selectivity of the demultiplexer. The smaller radii of the MRRs resulted in poor Q-factor (<1000) due to the broader resonant linewidths [3]. This was a trade-off for maximizing coupling in the MRRs and increasing the intensity at drop port. The overall design of the PIC demonstrated the potential for wavelength division demultiplexing application in SiPh-based high-speed communication and signal processing.

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Comparative Analysis of HG and LG Laser Modes for Mode Division Multiplexing Based Free Space Optical Communication Link under Fog and Atmospheric Turbulence

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In this work, a comparative analysis of Hermite-Gaussian (HG) and Laguerre-Gaussian (LG) laser modes for Mode Division Multiplexing (MDM) based Free Space Optical (FSO) communication to achieve greater data rates per transmission wavelength is presented. The performance of HG and LG laser modes over FSO transmission link under varying fog and atmospheric turbulence conditions is investigated using Optisystem simulation software. The investigation is further refined by classifying HG modes into standard (fig 1a) and elegant types, and LG modes into helical (fig 1b) and sinusoidal (fig 1c) variants, in order to evaluate the number of HG and LG modes that can be multiplexed for MDM based FSO communication system. Beam Quality factor or M2 factor is considered to evaluate the number of multiplexed modes. Q factor and Bit Error Rate (BER) are the performance parameters under consideration.

The investigation for the effect of varying fog condition on HG and LG modes is simulated by considering the Kim model for fog whereas for atmospheric turbulence Kolmogorov's model is considered. Beam quality factor or M2 factor is also evaluated for HG and LG modes to understand the number of laser modes that can be multiplexed with MDM FSO system [2]. The investigation indicates that 1D Standard HG modes represented in figure 1, with the same beam quality factor (M2 factor) exhibit similar Q-factor performance. However, one dimensional and two-dimensional HG modes with similar M2 factor values demonstrate different behaviors for FSO communication channels. Higher-order HG modes (HG(m, n) with higher n and m values) have more complex intensity patterns with more lobes and nodes resulting in greater diffraction spreading and thus reducing the propagation distance. Conversely, LG modes represented as LG_{p,l}, where p is the radial index and l is the azimuthal index suffers from weaker Q factor for higher value of azimuthal number. This work underscores the potential of mode-specific selection strategies in optimizing MDM based FSO systems for environmental conditions and future implementations of high-capacity, turbulence-resilient MDM based scheme.

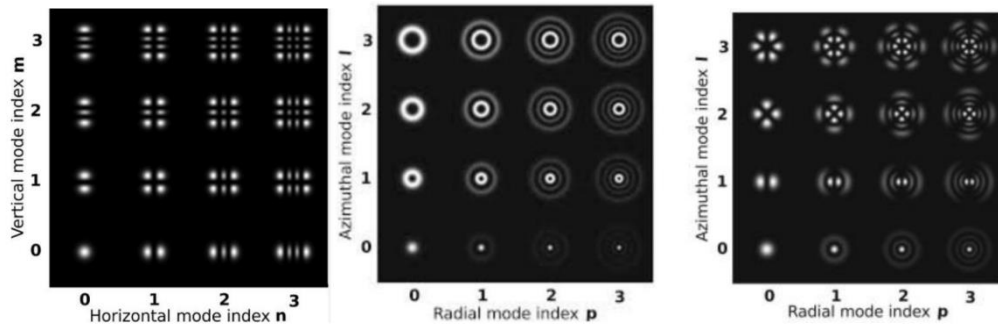


Fig. 1 Laser modes a) Standard HG Modes, b) Helical LG modes c) Sinusoidal LG Modes.

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Nonvolatile Phase Change Material Integrated Microring Resonator for THz Switching

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Silicon waveguide switches based on microring resonators (MRRs) deposited with a phase-change material (PCM) have enabled a high switching ratio due to the large contrast in the optical properties of the PCM [1]. However, the volatile nature of the PCM used increases the static power consumption of the device. In this work, we present and numerically investigate the implementation of a thermally tunable non-volatile waveguide switch for 0.5–0.52 terahertz (THz) frequencies, which has the advantage of a high switching ratio along with zero static power consumption. To maintain energy efficiency, our device consists of low-loss materials such as a high-resistivity float-zone (HRFZ) silicon waveguide and indium-tin-oxide (ITO) electrodes, as shown in Fig. 1(a). The MRR geometry is optimized for switching at the desired frequencies—specifically, the waveguide cross-section of $195\ \mu\text{m} \times 95\ \mu\text{m}$ supports single-mode switch operation and avoids multimodal dispersion [2]; the racetrack section of $5000\ \mu\text{m}$ enables improved coupling control and facilitates easier integration of the PCM and electrodes; and the curved section with a bend radius of $2000\ \mu\text{m}$ ensures the compactness of the switch.

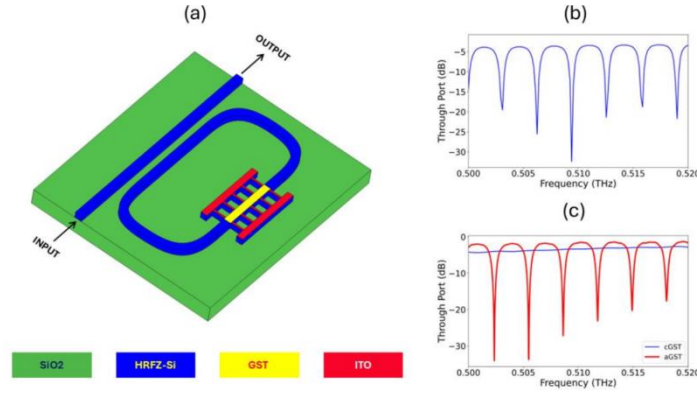


Fig.1. (a) Schematic of the proposed switch. The micro-fin ITO heater design shown is inspired by the work reported in [2]. (b) Transmission characteristics of the MRR without GST. (c) Transmission characteristics of the MRR switch for the two GST phases.

With the given MRR dimensions, the round-trip loss in the absence of GST is determined to be 20.01%, and we found that a coupling gap of $50\ \mu\text{m}$ results in a coupling coefficient of 19.16% (at 0.5094 THz), which satisfies the near-critical coupling condition and enables the MRR to operate with an extinction ratio as high as 28.97 dB at 0.5094 THz, as shown in Fig. 1(b). We found that the MRR deposited with a $2\ \mu\text{m}$ thick and $1500\ \mu\text{m}$ long crystalline GST layer exhibits approximately 48% higher round-trip losses compared to the case of amorphous GST. As a result, while the amorphous switch state (OFF state), with a coupling coefficient of 48.22% (at 0.50236 THz) continues to maintain near-critical coupling, the crystalline switch state (ON state) transitions to the undercoupled regime, as illustrated in Fig. 1(c). Owing to this contrast in optical losses between the two GST phases, the switch achieves a high switching contrast of 29.7 dB, which represents the highest value reported to date [1], mainly due to the presence of GST.

Along with achieving a high switching contrast, the proposed switch design also enables faster and more energy-efficient operation. In this work, the switching, governed by periodic crystallization and re amorphization of the GST layer, is induced using 350 V electrical pulses with durations of 26 ms and $7\ \mu\text{s}$, corresponding to energy consumptions of 138.04 mJ and 31.87 mJ, respectively.

In conclusion, this work demonstrates a compact, high-speed, and energy-efficient THz waveguide switch, thereby paving the way for the development of integrated THz communication systems.

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100G-PON over Dual Polarized 16QAM by Utilizing Heterodyne Modulated Millimeter Wave for 6G Fronthaul

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Abstract: The hasty progression in telecommunication industry in the direction of the sixth generation (6G) introduces stringent necessities for the fronthaul network under the fiber domain as well as wireless domain. To serve the ubiquitous mobility, extended reality, machine communication and holographic reality with low jitter and power proficiency during data transmission need highly efficient network as fronthaul solution which is indispensable. PON network is acknowledged as promising solution for power and cost effectiveness and enhance the sharing resources along with fiber proficiency. In this study, we present 100 Gbps based passive optical networks (100G-PON) transmission approach for 6G fronthaul that leverages millimeter wave. The progressive digital technique Dual-Polarization 16 Quadrature Amplitude Modulation (DP-16-QAM) is used to strength 6G fronthaul performance twice under dense collision whereas, heterodyne techniques is employed as based carrier generation at 180GHz for signal synthesis to enhance signal stability and diminish the phase noise [1].

The analysis of simulation model presents that convergence of DP-16-QAM with 100G-PON significantly boost the bandwidth utilization, bit rate, flexibility and availability while confirm the optical fronthaul standard ITU-T G.9804. Additionally, for the 180GHz spectrum, heterodyne simplifies the signal detection and mitigation impairment like drift and fading during communication [2]. The proposed 6G fronthaul architecture helps to acquire the 6G vision with less error vector magnitude (EVM) that ensures the channel fidelity over extended fiber.

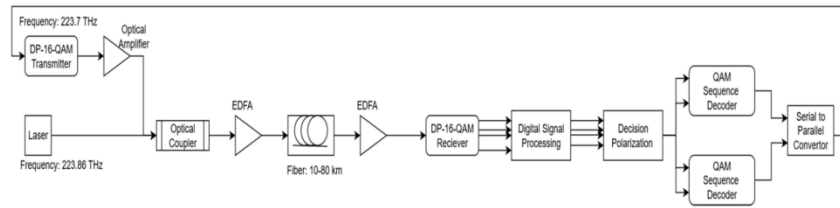


Fig. 1 100G-PON based DP-16-QAM architecture for 6G Fronthaul.

The outcomes are examined that are presenting 4% of EVM, rate of error around 10-15 and constellation figure shows spreader dots corresponding the X and Y polarizer. Overall, the proposed framework for 6G fronthaul determine the probability of conjunction of 100G-PON under optical domain and millimeter spectrum integration that offers less expensive, flexible and future proof key for next generation fronthaul telecommunication. By employing heterodyne modulation over DP-16-QAM channel, proposed architecture attains the spectral and signal efficiency, robustness for dense 6G fronthaul. The manuscript contributes to decrease the gap between wireless and optical fronthaul to sustain the 6G distribution.

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Label-Free Detection of Milk Water Adulteration Using a Long-Period Grating-Enhanced SPR Platform

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Abstract: A long-period grating-coupled SPR sensor with Au-TiO₂-analyte interfaces is proposed for detecting water adulteration in milk by monitoring the resonance dip shift corresponding to refractive index changes (1.33- 1.35). The sensor exhibits a sensitivity of 800 nm/RIU, making it highly effective for detecting milk adulteration with water.

Photonics, the science of light generation, manipulation, and detection has transformed modern sensing and communication technologies through its ability to integrate high-speed, miniaturized optical components for real-time applications [1]. Among photonic sensing techniques, Surface Plasmon Resonance (SPR) stands out for its label-free detection, real-time monitoring, and exceptional refractive index (RI) sensitivity [2]. Conventional SPR systems based on the Kretschmann prism suffer from bulkiness and angular dependence, limiting portability [3]. To overcome these challenges, long-period grating (LPG)-coupled SPR sensors enable planar, normal-incidence operation with efficient mode coupling between guided light and surface plasmon polaritons (SPPs), offering both compactness and enhanced sensitivity [2]. By integrating TiO₂ gratings on thin Au films, the sensor achieves strong field confinement and high responsiveness to RI variations. This capability is particularly vital for food quality monitoring, where subtle RI differences, such as between pure milk ($n \approx 1.35$) and water ($n \approx 1.33$) must be detected with precision [3].

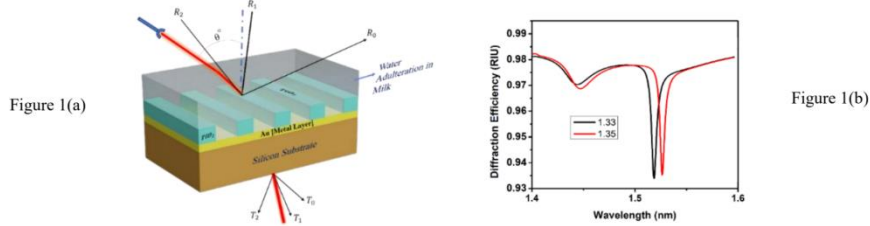


Fig. 1 (a) Cross-sectional schematic of the SPR sensor featuring a TiO₂ grating with analyte-filled spaces on an Au-coated silicon substrate, along with diffraction order mapping (R0-R2, T0-T2) under TM-polarized light for various analyte configurations. (b) Combined reflectance spectrum for RI = 1.33 (water) and RI = 1.35 (milk) showing shift from 1.517 μm to 1.520 μm .

The proposed grating-enhanced SPR sensor consists of a silicon substrate, a 107 nm Au layer, and a 692 nm TiO₂ grating with a 1500 nm period and 44.36% duty cycle. TM-polarized light is incident at 52° to excite plasmonic modes along the Au-analyte interface. As shown in Fig. 1(a), the analyte-water (RI = 1.33), milk (RI = 1.35), or their mixture-fills the TiO₂ grating grooves, forming an active sensing medium. The resonance condition for exciting surface plasmons is governed by:

$$\beta = \frac{2\pi m}{\Delta} = k_0 \sin \theta_0 \text{ or } \beta = \frac{2\pi}{\lambda} \sqrt{\frac{\epsilon_m \times \epsilon_d}{\epsilon_m + \epsilon_d}}$$

where Δ is the grating period, ϵ_m and ϵ_d are dielectric constants of metal and analyte, λ is the resonance wavelength, and $\theta_0 = 52^\circ$. Simulations reveal distinct resonance dips for different analytes. For RI = 1.33 (water), resonance occurs at $\lambda = 1.517 \mu\text{m}$, and for RI = 1.35 (milk), it shifts to $\lambda = 1.520 \mu\text{m}$ (Fig. 1(b)), indicating a measurable 11 nm shift. The sensor sensitivity $S = \Delta\lambda/\Delta n$ is 800 nm/RIU. These results confirm that the device can detect subtle RI variations relevant to milk adulteration. Strong light-analyte coupling enhances plasmonic field strength, leading to sharper resonance dips and higher selectivity.

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LSTM-Switch Model utilizing Port-wise Parametric Evaluation with Low Photonic Latency Feature for Handling Big Data

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The flow of “Big data” in extreme amounts every second has forced famous organizations like Facebook, WhatsApp, etc., to install huge data centers. The performance of these data centers [1] depends on the faster switching of data with a minimum possible error of reception. This paper is focused on minimizing the latency issues occurring in handling big data from huge data centers to solve the challenges of increasing users. We have designed a deep neural network-based 8×8 switching interconnected structure by evaluating the minimum distance between the input-output ports. The structure is trained on a fully connected Long Short-Term Memory (LSTM) feedback Deep Recurrent Neural Network (DRNN) with 12 layers to achieve maximum accuracy. Due to the training on all Input-Output (I-O) port-path combinations possible, the accuracy of predicting the minimum switching port distance is above 97%. The minimum latency of 0.32-0.4 ns has been achieved with a reception error rate of 10-18. The proposed algorithm shows a classification accuracy of 99.5% with a precision of 99.4%. The Extinction Ratio (ER) of ~20 dB, rectified latency issues, and improved accuracy rate in contrast reported techniques show the superiority of the performance of the proposed LSTM structure.

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Optimized Reversible 2:4 Decoder using Lithium Niobate MZI Based Peres and TR Gates

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Reversible computation [1] has emerged as a key paradigm for next-generation energy-efficient systems, addressing the limitations imposed by Landauer's principle [2], which links information loss to heat dissipation. The motivation for this study stems from the findings in [3], which emphasize the emerging transition toward optical transistor technologies as a cornerstone for next-generation computing systems. This work introduces an optimized reversible 2:4 decoder designed using Lithium Niobate (LN) Electro-Optic Mach-Zehnder Interferometer (EO-MZI) implementations of Peres and Thapliyal-Ranganathan (TR) gates. The goal is to achieve minimal optical cost, reduced garbage outputs, and low ancillary input requirements, making it suitable for post-CMOS, quantum, and photonic computing architectures.

The proposed design ensures one-to-one input-output mapping, eliminating information loss. By combining the compact arithmetic capabilities of the Peres gate with the control versatility of the TR gate, the architecture effectively balances logical completeness, and low hardware overhead. The decoder's block representation (Fig. 1(a)) uses Peres, TR, and Feynman gates integrated in an EO-MZI framework, ensuring fast optical switching and minimal interference.

A detailed power modeling analysis was conducted, deriving mathematical expressions for optical power at each output port. The MATLAB simulations verified the analytical model, showing precise one-hot activation of decoder outputs corresponding to each input combination, consistent with a conventional 2:4 truth table. This confirmed the logical correctness and energy-efficient operation of the reversible design.

Further validation was performed using OptiBPM simulations (Fig.2(b)), demonstrating successful optical switching and beam propagation within the MZI network for all four input cases. Each simulation scenario confirmed that only one output channel remained active for a given input pair, verifying accurate optical logic operation. The design employs 7 optical couplers to maintain a 50:50 power split ratio, with a laser wavelength of 1300 nm for stable interference and modulation control.

Compared with prior literature[4] [5], the proposed decoder achieved the lowest optical cost using only one Peres gate, one TR gate, and three Feynman gates — outperforming designs based on Toffoli, Fredkin, and SOA-MZI architectures. The results underline its potential for scalable, high-speed, and low-energy photonic logic circuits, paving the way for future quantum communication, optical memory addressing, and energy-constrained computing systems.

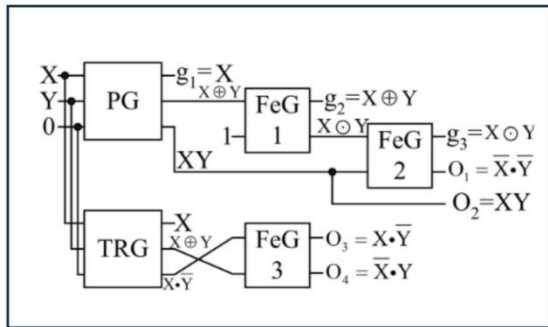


Figure 1(a)

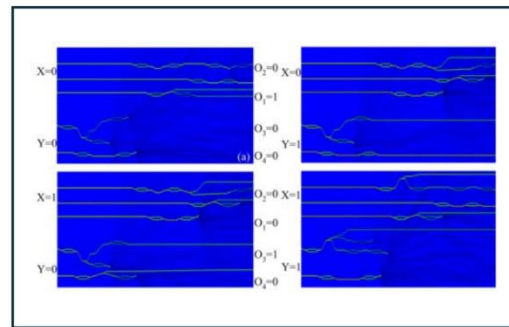


Figure 2(b)

Fig. 1(a) Block diagram from 2:4 Reversible Decoder and Fig. 1(b) BPM Simulation results for 2:4 reversible decoder using EO-MZI switch.

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Quantifying Inhomogeneous laser heating in Nano and Bulk Spinel Co₃O₄: Driven through asymmetric Raman line-shape

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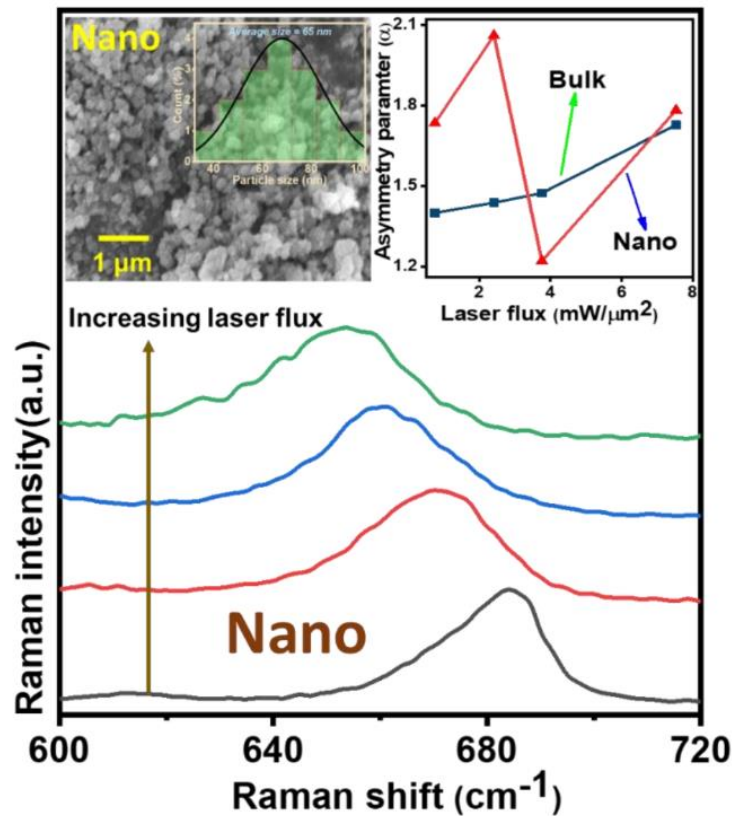
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ABSTRACT

Raman spectroscopy is a highly effective analytical technique frequently used for investigating and identifying microscopic processes in solids. With increasing laser flux, non identical asymmetric Raman line shape behaviour has been observed in Co₃O₄ nanoparticles and their bulk counterpart. This type of non monotonic asymmetric characteristics in Raman line has identified as interplay between inhomogeneous laser heating and phonon confinement in nanoparticles. As the incident laser flux increases from 0.75 mW/ μ m² to 7.53 mW/ μ m², the A_{1g} Raman mode undergoes a red shift and becomes more asymmetric. This asymmetry grows non-linearly due to the phonon confinement effect. However, in Co₃O₄ pellet (synthesized through spark plasma sintering), the asymmetry parameter exhibits a monotonic increase with rising laser flux, which further validate the role of inhomogeneous laser heating[1].



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Stoichiometrically Optimized Electrochromic Complex $[V_2O_2 + \xi(OH)_3 - \xi]$ Based Electrode: Prototype Supercapacitor with Multicolor Indicator

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The systematic structure modification of metal oxides is becoming more attractive, and effective strategies for structural tuning are highly desirable for improving their practical colour-modulating energy storage performances. Here, the ability of a stoichiometrically tuned oxide-hydroxide complex of porous vanadium oxide, namely $[V_2O_2 + \xi(OH)_3 - \xi]$ $\xi = 0.3$ for multifunctional electrochromic supercapacitor application is demonstrated. Theoretically, the pre-optimised oxide complex is synthesised using a simple wet chemical etching technique in its optimized stoichiometry $[V_2O_2 + \xi(OH)_3 - \xi]$ with $\xi = 0$, providing more electroactive surface sites. The multifunctional electrode shows a high charge storage property of 610 F g^{-1} at 1 A g^{-1} , as well as good electrochromic properties with high colour contrast of 70% and 50% at 428 and 640 nm wavelengths, faster switching, and high coloration efficiency. When assembled in a solid-state symmetric electrochromic supercapacitor device, it exhibits an ultrahigh power density of 1066 mW cm^{-2} , high energy 290 mF cm^{-2} at 0.2 mA cm^{-2} . A prepared prototype device displays red when fully charged, green when half charged, and blue when fully discharged. Clear evidence of optimising the multifunctional performance of an electrochromic supercapacitor by stoichiometric tuning is presented, along with demonstrating a device prototype of a 25 cm^2 large area device for real-life applications [1].

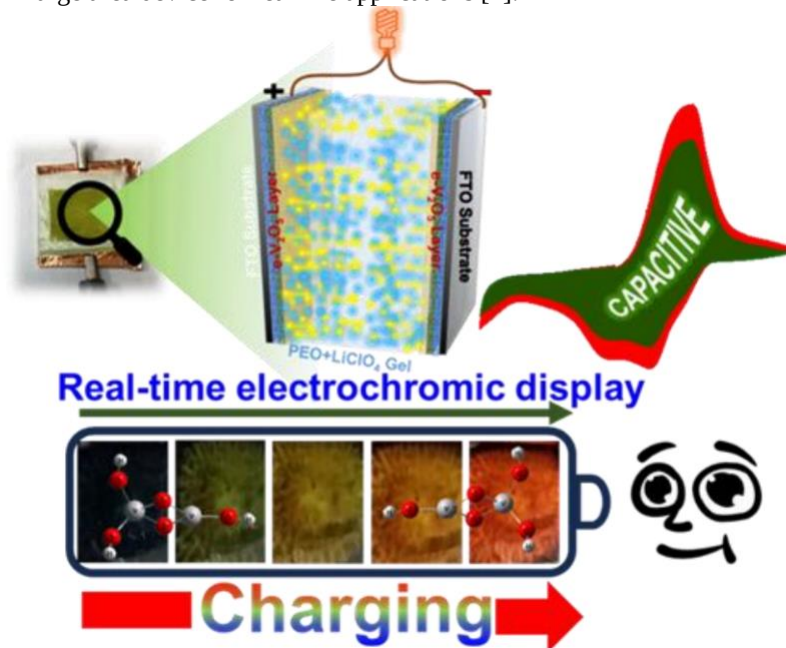


Fig. 1 Graphical representation of the abstract.

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Efficient 3.4 μm Generation via Degenerate Four-Wave Mixing in Indium Fluoride Photonic Crystal Fibers

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Mid-infrared (mid-IR, 2–20 μm) light sources are essential for spectroscopy, sensing, and materials processing due to strong molecular absorption in this region. Radiation near 3.4 μm , corresponding to the C–H stretching vibration, is particularly valuable for polymer processing, hydrocarbon detection, and non-invasive biomedical diagnostics. This work introduces a novel InF-based photonic crystal fiber (PCF) design optimized for efficient 3.4 μm generation via degenerate four-wave mixing (FWM). The originality lies in achieving near-zero dispersion at 1.622 μm within an InF-PCF geometry (pitch $\Lambda = 3.5 \mu\text{m}$, hole diameter $d = 2.5 \mu\text{m}$), enabling broadband phase matching in the mid-IR, a regime rarely realized in fluoride fibers. The integration of fully-vectorial effective-index modeling with nonlinear propagation analysis provides an accurate prediction of FWM dynamics in this wavelength region. The propagation of the optical field $U(z, t)$ is governed by the generalized nonlinear Schrödinger equation, solved numerically using the split-step Fourier method (SSFM):

$$\frac{\partial U}{\partial z} = g(z)U - \sum_{n \geq 2} \frac{i^{n+1}}{n!} \beta_n(z) \frac{\partial^n U}{\partial t^n} + i\gamma(z)\omega_0 \left(1 + \frac{i}{\omega_0} \frac{\partial}{\partial t}\right) U \int_{-\infty}^{\infty} R(t) |U(z, t - t_0)|^2 dt$$

Numerical simulations predict efficient wavelength conversion near 3.4 μm , yielding an idler gain of 18.24

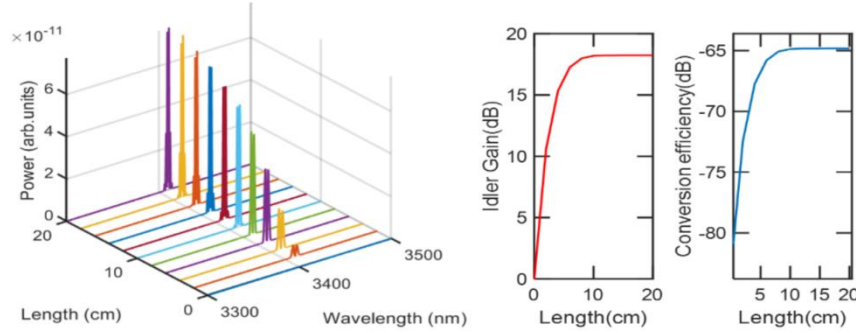


Fig.1 The output spectral profile in spatial domain of the idler generated at 3.4 μm and their gain and conversion efficiency in an InF PCF of length 0.2 m

dB, and conversion efficiency of – 64.82 dB. These results demonstrate the first optimized InF-PCF structure capable of compact, broadband 3.4 μm generation, highlighting its potential for integrated mid-IR spectroscopy and biomedical diagnostics.

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Enhancing Pockels Electro-optic Effect with Thin-Film Lithium Niobate (TFLN) in Mach-Zehnder Modulator Arrays using Single-Mode Waveguides and Optimized Electrode Gap

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Abstract

Thin-film lithium niobate (TFLN) is emerging as a breakthrough material for photonic integrated circuits due to its high electro-optic coefficient and compatibility with advanced nanofabrication. Our work proposes to design, test, and verify an EO Mach-Zehnder modulator (MZM) array, focusing on the voltage-length product ($V\pi L$)—a critical figure of merit for energy efficiency and bandwidth.

A systematic workflow is implemented virtually using the standard EO-MZM framework in Flexcompute Photonforge software, with RWG1000 single-mode waveguides and a reduced electrode gap of 2 μm . The optical simulation confirms fundamental TE mode operation; the new geometry is simulated and validated for enhanced Pockels effect overlap and strong field concentration. Device count of four ensures statistical reliability and integration density. Our workflow robustly explores physical limits, design trade-offs, and performance verification for optimized TFLN MZMs—paving the way for breakthroughs in telecom, quantum photonics, and data-centric photonic platforms.

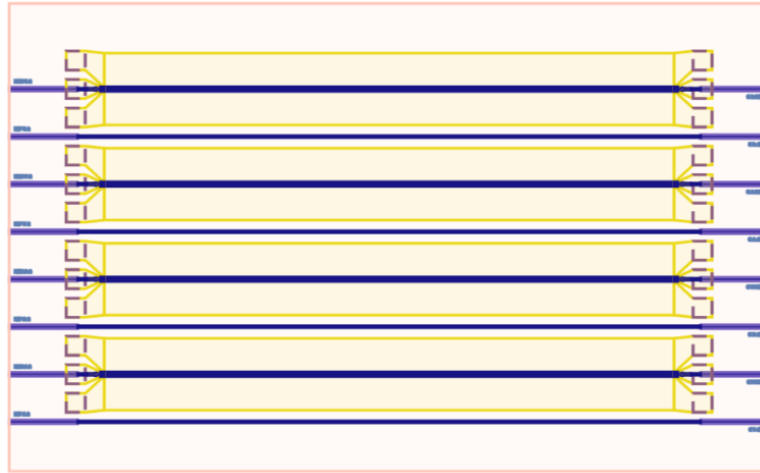


Figure 1: Schematic layout of the proposed TFLN Mach-Zehnder Modulator. Edge couplers are integrated for device testing. For reference, a straight waveguide link is included to evaluate coupling losses. GDSII layout is generated for fabrication, PHF file is used to track technology specifications, ports, models, and geometry.

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“Raman Spectroscopic Study of Hydrogen Fluoride Interaction for Optical Fiber Sensor Design”

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Abstract

The present study demonstrates the experimental development of an optical fiber sensor designed for the detection of fluoride contamination in drinking water. The sensing mechanism is based on the interaction of hydrogen fluoride (HF) with the optical fiber surface, where HF-contaminated water serves as the sensing analyte. Raman spectroscopy was employed to investigate the molecular vibrational behavior of HF, providing critical insight into the optical response and guiding the design of the fiber sensor. The observed Raman and infrared (IR) spectral variations of HF were correlated with changes in transmitted wavelength intensity, enabling precise detection of fluoride concentration levels. The fabricated sensor exhibits high sensitivity, capable of detecting fluoride concentrations as low as 100 ppb, with excellent response in the IR region. The results confirm that the developed low-cost and compact optical fiber sensor offers a reliable approach for real time monitoring of fluoride impurities in water, combining the advantages of Raman spectral analysis and fiber-optic sensing technology.

Design and Application of Optical Plasmonic Nano Antenna

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Plasmonic nano-antennas are essential components designed to efficiently link near-field signals with far-field propagating waves, overcoming the traditional diffraction limit to enable efficient subwavelength optical devices. The small size of the slot mode makes difficult to couple light to it directly from the free space or from an optical fibre. In the proposed work, an attempt has been done to design nano antenna through simulation. The excitation has been performed using a Gaussian Beam near field source. The design approach relies fundamentally on tuning geometrical parameters to control the excitation of localized surface Plasmon resonances (LSPR) and maximize local electric field enhancement. The resonant wavelength λ and antenna performance are dictated by geometric factors, including the dipole length, gap, width, and thickness. It is demonstrated that increasing the dipole length results in a strong red-shift while increasing the gap length, width, or thickness causes a blue-shift in the resonant response. A Parameter sweep on the length has been done to get best response. The most compact interface solution for plasmonic applications is the nanoantenna, which facilitates robust coupling between external light sources, such as optical fibres, and high-density components like plasmonic slot waveguides. For integrated circuits operating in the telecom range around 1.55 μm , dipole nano-antennas are typically fabricated from gold (Au) and embedded in silica. Through systematic geometry optimization, coupling efficiencies (CE) of the order of 26% can be achieved when excited by a conventional lensed optical fibre. This coupling efficiency is reported to be 185 times larger than that of the bare waveguide. Initial dimensions of the proposed dipole antenna and Gaussian feeding techniques in the structure of the nanoantenna are shown in Table 1 and Figure 1 respectively.

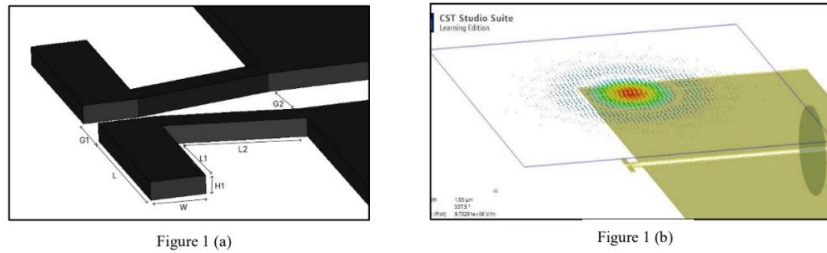


Fig. 1 (a) Dimensions of proposed nanoantenna. (b) Gaussian Excitation above proposed dipole.

Table 1 Dimensions of proposed dipole antenna.

S.No.	Parameters	Symbol	Values (nm)
1.	Gap between two sides	G_1	170
2.	Gap between waveguide wall	G_2	300
3.	Dipole length	L	485
4.	Transition distance	L_1	300
5.	Length of transition	L_2	400
6.	Height of Dipole	H_1	50 n m
7.	Width of Dipole	W	150 n m

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Polymer–MXene–Viologen-Based Suprahybrid Electrochromic Device: Flexible Smart Window with Visible and Near-Infrared Switchability

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The development of efficient, general-purpose electrochromic devices that can also serve specialized applications is essential for next-generation smart (opto)electronic technologies. In this work, we present a solid-state electrochromic device engineered through a suprahybrid strategy that integrates three distinct material families: conducting polymers, organic functional molecules, and modern 2D MXenes. Specifically, an all-organic polythiophene–viologen-based system was doped with 2D vanadium carbide (V₂C) MXene to simultaneously enhance electrochromic performance and enable novel applications. The incorporation of V₂C MXene significantly improved color contrast and switching speed, with operation demonstrated in both the visible and near-infrared regions, enabling up to 12% heat reduction. The device also exhibited high cyclic stability and remarkable coloration efficiency across two spectral ranges. To show its practicability in real life, a flexible ECD that has high flexibility was also fabricated. Leveraging its mechanical flexibility, we further fabricated a prototype smart goggle capable of selective frame-color tuning under applied bias, demonstrating potential for advanced applications such as energy-saving smart wearables and 3D vision goggles [1].

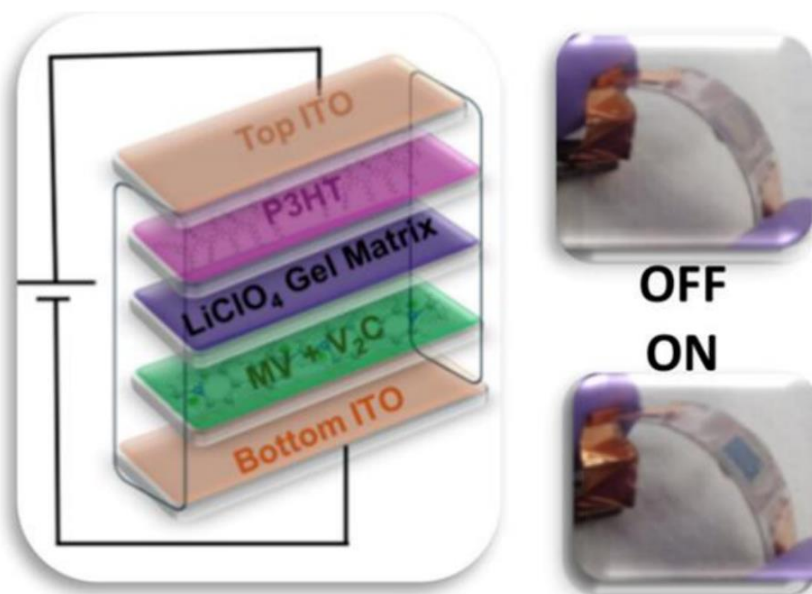


Fig. 1 Graphical representation of the abstract.

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Absorption enhancement utilizing plasmonic grating nanostructure for photodetection applications

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The infrared (IR) region is vital for high-performance thermal imaging and sensing, necessitating highly efficient light absorption[1]. This challenge is addressed using a Titanium Nitride (TiN) plasmonic grating, which functions by leveraging resonant effects within its structure to efficiently trap light and strongly confine the electric field[2], [3]. This grating design offers an effective strategy for enhancing the performance of photodetectors and sensors. Titanium nitride is a durable, CMOS-compatible, and cost-effective plasmonic material ideal for infrared photonic and optoelectronic applications[2]. In this work, one-dimensional TiN grating nanostructure is designed and simulated using rigorous coupled wave analysis (RCWA) [4] in MATLAB. The structure consists a 500 nm grating period (d), 430 nm width (w), and 200 nm height (h), deposited over a 2 nm TiN layer on Ge as shown in Fig. 1-(a).

The simulated results reveal a peak absorption of 92 % at 1310 nm for TM-polarized light as shown in Fig 1-(b), while the flat TiN layer shows less than 20 % absorption under identical conditions. This strong enhancement arises from surface plasmon resonance and coupling within the TiN grooves, which produce intense electric field confinement and efficient light trapping. For TE polarization, the absorption remains comparable to the flat TiN film, confirming the polarization-dependent plasmonic behaviour of the grating. This plasmonic resonance [5] can be verified using the equation given below.

$$\frac{2\pi}{\lambda} n_i \sin \theta + m \frac{2\pi}{d} = \pm \operatorname{Re} \left(\frac{2\pi}{\lambda} \sqrt{\frac{\epsilon_m n_i^2}{\epsilon_m + n_i^2}} \right)$$

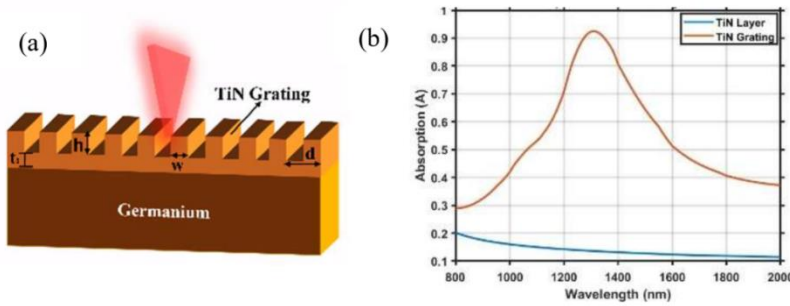


Fig. 1 (a)TiN grating structure on Germanium substrate (b) Absorption spectra of TiN grating for TM polarized normally incident light .

The proposed TiN-on-Ge design demonstrates that geometric tailoring of refractory plasmonic materials can enable highly efficient, thermally stable, and CMOS-compatible IR absorbers. Future work will extend this study toward Schottky-barrier photodetectors based on Fowler's model[6] to correlate optical absorption with photoresponse characteristics.

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Comparative Study of LVM and SSFM for Modelling Nonlocal Soliton Dynamics

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Abstract—This article presents a comparative study of the Lagrange Variational Method (LVM) and the Split Step Fourier Method (SSFM) for solving the nonlocal nonlinear Schrodinger equation, which governs the dynamics of nonlocal optical solitons. The investigation focuses on the response of solitons to input energy perturbations, considering both Gaussian and -decay type nonlocal response functions. Key aspects such as computational efficiency, accuracy, and the ability to capture nonlinear beam evolution are analyzed. The study provides insights into the advantages and limitations of the two methods, highlighting conditions under which LVM can serve as a reliable semi-analytical approach, while SSFM offers full numerical accuracy for complex nonlocal interactions.

I. INTRODUCTION

A substantial body of literature exists on nonlocal solitons—optical beams that maintain their shape over long distances while propagating through a nonlocal medium [1]– [7]. These solitons exhibit several distinctive properties not found in local nonlinear media, such as asymmetric effects of higher-order diffraction [1], low energy diffraction management [2], [3], significant phase shifts [6], and long- range soliton interactions [7]. Nonlocality can be characterized by two distinct response functions: Gaussian and exponential- decay types [5].

II. GOVERNING EQUATIONS

Nonlocal nonlinear Schrodinger equations (NNLSE) describe the propagation of optical beams in nonlocal nonlinear media [4]:

$$i \frac{\partial \psi}{\partial z} + \mu \frac{\partial^2 \psi}{\partial x^2} + \rho \psi \int_{-\infty}^{\infty} R_f(x-x') |\psi(x', z)|^2 dx' = 0, \quad (1)$$

where $R_f(x)$ is the response function defining the degree of nonlocality. We consider two typical forms: the Gaussian (GR) and exponential-decay (EDR) types, given by $R_f(x) = (1/\sqrt{\pi}\sigma) \exp(-x^2/\sigma^2)$ and $R_f(x) = (1/2\sigma) \exp(-|x|/\sigma)$, respectively, where σ characterizes the strength of nonlocality.

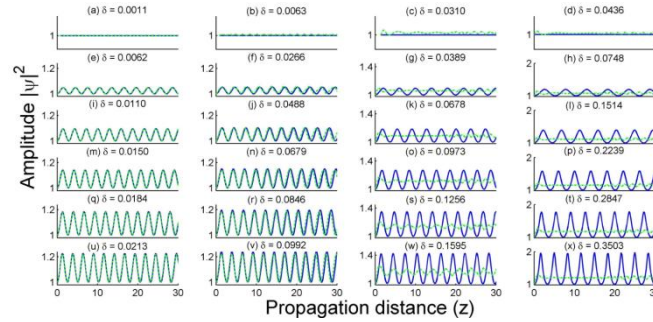


Fig. 1. Peak amplitude variation of nonlocal solitons computed via LVM and SSFM for GR.

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Raman Spectroscopy Insights into Short-Range Ordering and Abrupt Line- Shape Evolution During Laser-Induced Crystallization of Amorphous Germanium

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Amorphous solids, categorised as disordered materials, show order in very short-range and distance of this short-range is never quantified despite their importance in understanding various electronic properties. The microscopic properties of materials can be understood through Raman spectroscopy, enabling their optimization for various technological applications. Thus, a careful analysis of the Raman spectrum obtained from amorphous germanium (a-Ge) film, has been carried out to not only estimate the extent of short-range order but also to propose a method to quantify the short-range order therein. The a-Ge film was exposed to high (CW) laser power to locally crystallize and an a-Ge to nano crystalline Ge (n-Ge) transformation was evident through an abrupt Raman line shape evolution. The broad Raman spectrum centred at 269 cm⁻¹, from as-deposited a-Ge film, is replaced by an asymmetric Raman line shape centred at 298 cm⁻¹ on crystallization. The latter is red shifted and asymmetrically broadened with respect to its bulk counterpart which ascertains the presence of n-Ge. The line shape was analysed within the frame work of phonon confinement model (PCM), modified PCM and bond polarizability model (BPM) to estimate the size of nano crystallites in the laser annealed region. The integration of existing theoretical frameworks and the proposed empirical model effectively characterizes the amorphous-to-nano-crystalline phase transition in germanium thin films, enabling precise quantification of short-range order and nano-crystallite dimensions in both amorphous and nano-crystalline germanium. The laser induced crystallization has been explained using a nucleation and growth model and represented schematically.

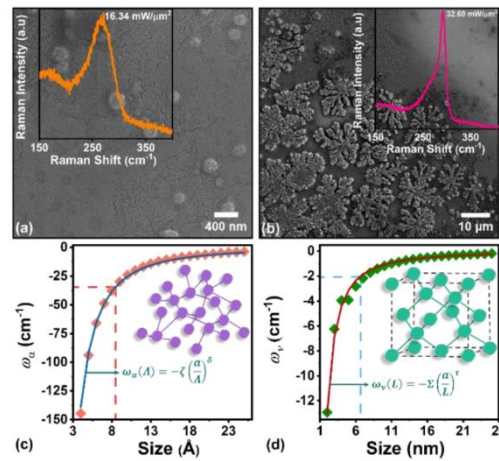


Fig. 1 (a) SEM micrograph of as-deposited Ge film along with its Raman spectra (inset), (b) SEM micrograph of the region on film from where Raman was recorded at high laser power showing a signature of laser annealing with its Raman spectra (inset), (c) Discrete data points shows variation of frequency shift obtained from theoretical Raman line shapes (using MPCM) for a-Ge with varying size parameter and the blue solid line is the fitted line using the BPM (inset shows the a-Ge structure), (d) Discrete data points shows variation of frequency shift obtained from theoretical Raman line shapes (using PCM) for n-Ge with varying crystallite size and the red solid line shows the fitted line using the BPM (inset shows the n-Ge structure)

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FLASH-SR: Fast, Low-power, All-passive, Scalable, High-speed SR Flip-Flop

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This work presents a passive interferometric SR flip-flop using directional couplers and tuned feedback to achieve bistability. Simulations demonstrate 300 Gb/s operation with a minimum switching time of 14ps and a contrast of 27.69 dB. The SOA-free design targets optical cache memory and photonic logic.

We introduced a passive interferometric SR flip-flop that achieves bistability using cascaded directional couplers, phase shifters, and tuned optical feedback, eliminating reliance on Semiconductor Optical Amplifiers (SOAs) (Fig. 1(a)) common in MZI-based [1], [5] and resonator-driven designs [2]–[4]. Independent Set (1550 nm) and Reset (1555 nm) pulses ensure spectral separation and WDM compatibility. Simulations confirm 300 Gb/s operation with a 14ps minimum switching time, 53/14 ps rise/fall times (Fig. 1(b)), and 27.69 dB contrast. Unlike SOA-dependent devices, the flip-flop relies solely on phase-controlled interference for latching. Future validation requires BPM/FDTD directional coupler analysis to validate wavelength dependence, gap tolerance, and fabrication feasibility. The proposed flip-flop finds its applications in optical cache memories (Fig. 1(c)) and PCIM (Photonic Compute in memory) operations.

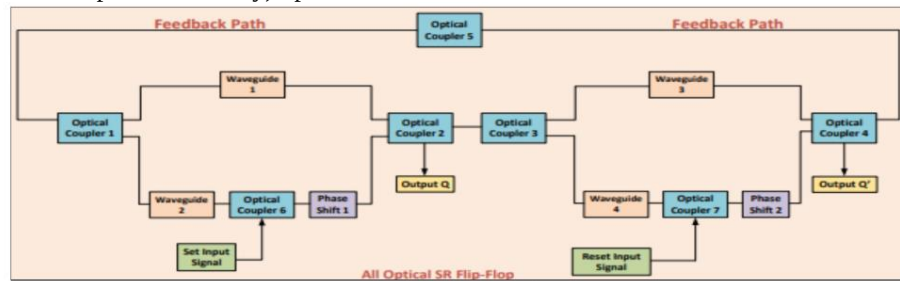


Figure 1(a)

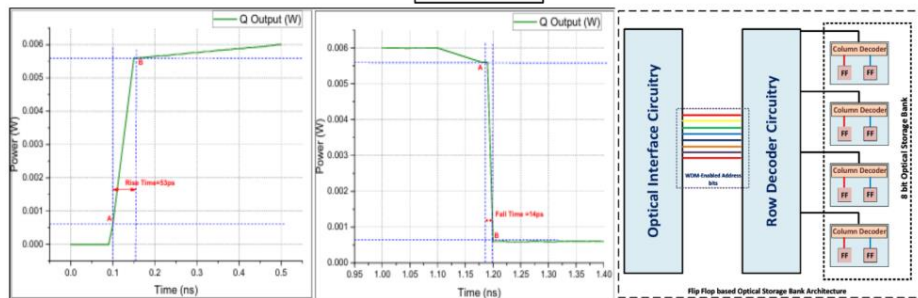


Figure 1(b)

Figure 1(c)

Fig. 1(a) Proposed SOA free Flip-Flop Architecture., **Fig. 1(b)** Rise and Fall time graphs. **Fig. 1(c)** Flip-Flop based Cache Memory Architecture.

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LightSpeedCIM: All-Passive Photonic Compute-in-Memory for Ultra-Fast AI Acceleration

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This work proposes an all-passive photonic compute-in-memory cell achieving 50 Gb/s data rate, 12 ps switching time, and bit error rate below 10^{-9} . The scalable 16Kb array supports in-memory AND logic, enabling ultrafast, low-power AI acceleration.

This work presents a fully passive photonic compute-in-memory (PCIM) cell and CIM architecture that integrates memory and logic using only optical components, eliminating the need for active elements (Fig. 1) unlike other works [1 - 4]. The memory cell achieves a 50 Gb/s data rate, a 12ps switching time, and a bit error rate of less than 10^{-9} , surpassing previous SOA-based and phase-change photonic memories in terms of speed, power, and stability. The same cell supports in-memory AND logic, enabling true CIM functionality. A scalable 16 Kb CIM array is realized, offering row-column addressability, which paves the way for ultrafast, low latency, and energy-efficient AI systems. Future work includes exploring its compatibility with photonic neural networks and integrating it with photonic accelerators [5].

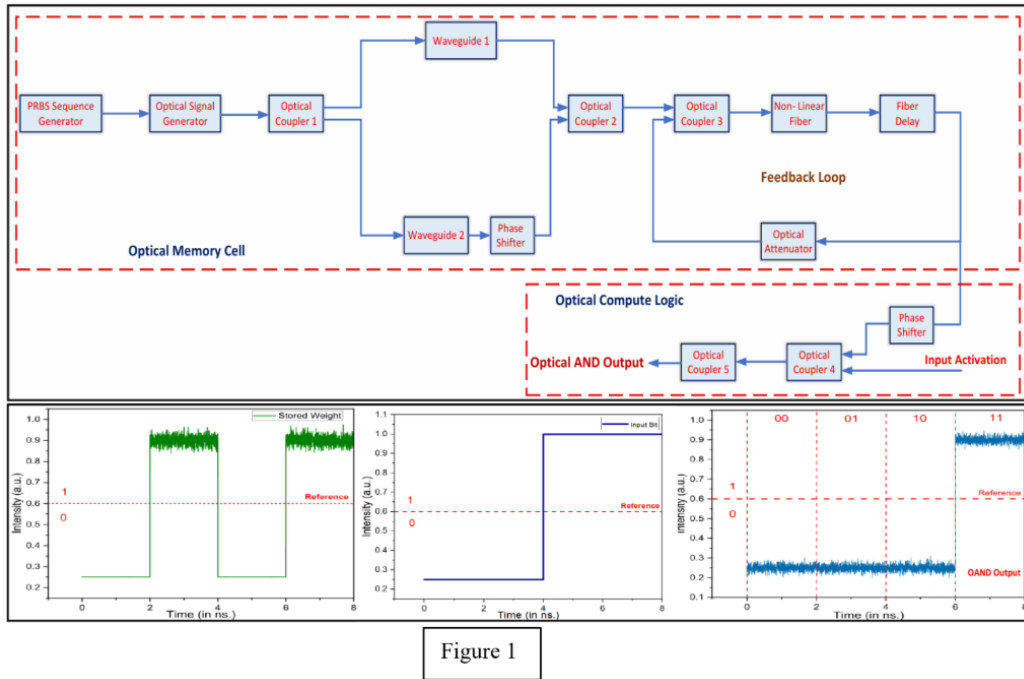


Figure 1

Fig. 1 Proposed Photonic CIM (AND) cell and its functioning results.

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A Viologen/ α -MnO₂ Inorganic/Organic Hybrid Assembly-Based Solid State Electrochromic Device: Improved Performance and Multiwavelength Switching

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Perturbation-induced reversible color modulation materials are highly sought after in smart systems, which are useful for various applications, with significant interest in multiwavelength switchability. Nevertheless, the majority of current electrochromic technology, one member of the family, only offers single-wavelength optical switchability; it is still difficult to achieve multiwavelength-based color switchability using straightforward methods especially in inorganic materials. Here, an inorganic–organic hybrid electrochromic device was fabricated by combining the electrochemically deposited MnO₂ electrode with drop-casted viologen gel. This combination exhibits different advantages like multiwavelength switching, high color contrast, better stability, and fast response. The hybrid device shows multiwavelength (600 and 730 nm) color switching. The organic inorganic electrochromic device switches from pale yellow to dark blue reversibly under an external perturbation of ± 1.5 V with a fast coloration/bleaching time of 2 s/4.3 s at 600 nm. The in situ electrochemical measurements show that the hybrid device shows a high optical contrast of 90% and a change in transmittance of 21% at 600 nm (midwavelength of the visible region) and 730 nm (end-edge wavelength of the visible region), respectively, with excellent electrochromic stability at both wavelengths. Also, the device exhibits a high value of coloration/bleaching efficiency (112/380 cm²/C @600 nm and 35/80 cm²/C @730 nm). These results provide a pathway to improve the electrochromic performance of a single-layered device by combining it with complementary electrode materials for practical applications in smart windows.

Cobalt-Platinum Nanoparticle Encapsulated within Carbon Nanotube for Superior O₂ Reduction Reaction

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The high-cost platinum-based catalysts must be replaced by low-cost, non-noble metal-based electrocatalysts for improved ORR performance of fuel cells. In this study, we have explored the cobalt–platinum (CoPt) nanoparticle encapsulated by a carbon nanotube (CNT), e.g., CoPt@CNT material, as an efficient electrocatalyst for ORR by employing the first principles-based density functional theory (DFT) method. We studied the structural and electronic properties of the CoPt@CNT material. We found that the equilibrium structure of the CoPt@CNT system has zero electronic band gap ($E_g = 0$), showing a conducting nature. The ORR mechanisms have been investigated on the surface of CoPt@CNT by computing the change in adsorption energy (ΔE) and Gibbs free energy (ΔG) of each reaction intermediate. Our energy calculations demonstrate that the active sites on the CoPt@CNT material is thermodynamically and energetically favorable for the ORR mechanism. The active basal plane of the CoPt@CNT material exhibits excellent catalytic activity toward the ORR with high four-electron- reduction pathway selectivity. Hence, it will be a promising solution to use CoPt@CNT material as an efficient electrocatalyst for the ORR in fuel cells to substitute the Pt electrodes.

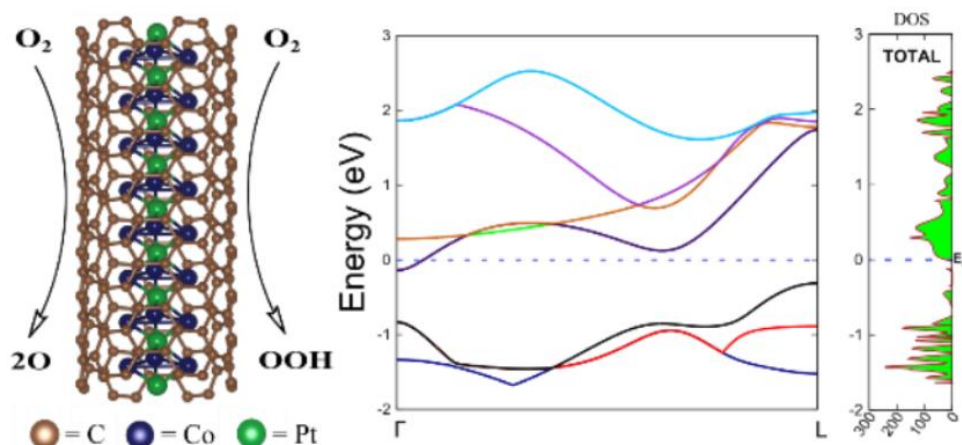


Fig. 1 Equilibrium structure of CoPt@CNT system, electronic band structure and total DOS of the CoPt@CNT.

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Survivability of QKD Enabled Optical Network During Link Failures

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Introduction: Quantum Key Distribution (QKD) provides information-theoretic secure symmetric key exchange for optical communication. The high adoption of QKD in modern Optical Network (ONs), necessitates ensuring network survivability against link failures. Survivability schemes for Wavelength Division Multiplexed Optical Network (WDM-ONs) cannot be directly applied to QKD-enabled Optical Network (QKD-ONs) as they ignore quantum-specific constraints such as secret key rate (SKR) depletion and quantum bit error rate (QBER) variations [1]. In WDM-ONs, survivability relies on two mechanisms: protection, which pre-allocates network resources along backup paths, and restoration, which dynamically re-allocates network resources in case of failures.

Proposed Framework: We propose a Dynamic Key-Rate Aware (DKRA) survivability framework by extending WDM-ON survivability schemes to QKD-ON. DKRA integrates quantum-layer parameters into both protection and restoration schemes. It supports algorithms for dedicated and shared path/link protection as well as dynamic restoration. Within this framework, a heuristic Timeslot and Key-Rate Aware Shared Path Protection (TSKRA-SPP) algorithm is introduced, which identifies common timeslot ranges and different link-disjoint paths for multiple requests with identical end nodes while satisfying minimum SKR requirements and dynamically allocating a shared protection path providing survivability to multiple requests with minimal quantum resources.

Simulation Framework: Modern QKD network simulators often employ a centralized controller for path allocation, synchronization, and resource management. Our network is based on a centralized Software Defined Network (SDN) architecture and utilizes a dynamic Discrete Event Simulation (DES) for QKD-ON modelling. The SDN ensures network-wide synchronization and manages the TDM matrix for quantum key allocation. It comprises of three main modules: (i) Request Generator, which generates quantum requests following a Poisson distribution with arrival rates dependent on traffic load; (ii) Request Allocator, which assigns requests according to different algorithms within the DKRA framework; and (iii) Time-slot Processor, which processes and executes requests in the current timeslot and advances the simulation.

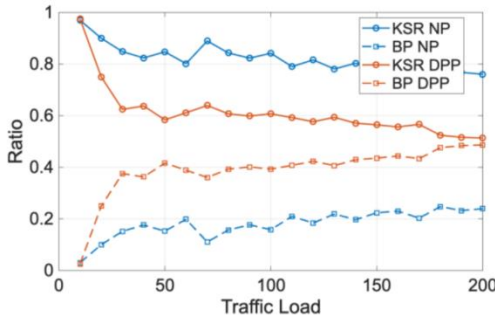


Fig. 1(a): KSR and BP in NFSNET

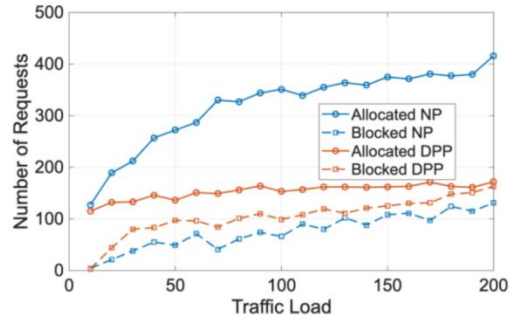


Fig. 1(b): Allocated and Blocked Requests in NFSNET

Performance Evaluation: The Key Success Rate (KSR) quantifies successful key exchanges, while Blocking Probability (BP) measures unserved requests. As shown in Fig. 1(a), a comparative evaluation shows Dedicated Path Protection (DPP), an approach aligned with the protection method in [2] yields higher BP than with No Protection (NP) scheme due to additional backup resource allocation. Whereas, Fig. 1(b), shows that NP achieves higher throughput at the cost of survivability. This trade-off underscores the need for a smart and resource-efficient scheme like our TSKRA-SPP, which is designed to approach the survivability of DPP while maintaining a BP closer to that of NP.

Conclusion: The proposed DKRA framework bridges a critical gap in QKD-ON survivability studies, while the TSKRA-SPP demonstrates improved quantum-resource utilization and reduced TDM fragmentation among all DKRA algorithms. Together, they provide a practical methodology for evaluating and enhancing quantum network resilience under dynamic link failures.

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Sensitive Fingerprints of Fano Effects on Phonon Energy and Lifetime Revealed by Raman Spectroscopy

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The Fano effect, arising from quantum interference between discrete states and a continuum of electronic states, can be effectively studied using Raman spectroscopy. This phenomenon plays a crucial role in understanding subtle microscopic physics in semiconductors. The quantum interference influences Raman spectral features, interference strength. These spectral changes directly affect phonon energy and phonon lifetime. Theoretical analysis of the Fano Raman line shape reveals that the interaction is particularly sensitive to variations in phonon lifetime, exhibiting a stronger effect compared to phonon energy shifts. Experimental investigations using wavelength-dependent Raman spectroscopy on heavily doped degenerate silicon corroborate these findings. This study provides insightful information on the impact of the Fano effect on Raman spectra and, consequently, on the physical properties of solid for optoelectronic and photonic applications.[1], [2]

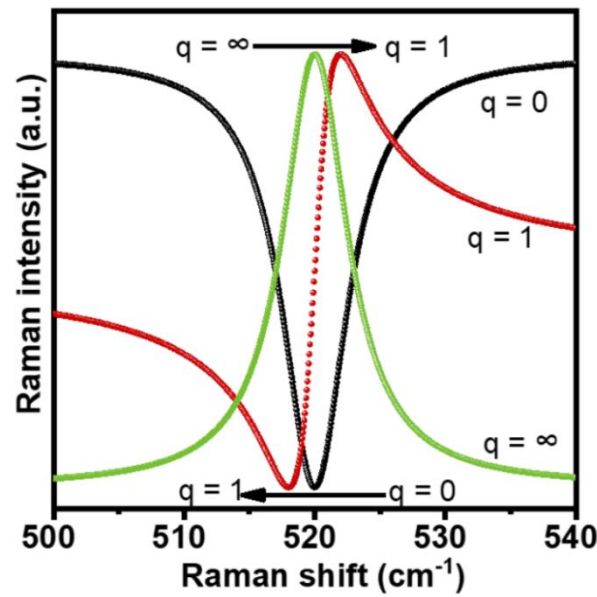


Fig. 1 Graphical representation of the abstract.

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Enhanced Photonics Spin Hall Effect Temperature Sensor based on Nonlinear Magneto-Optic Induced Anisotropy & Plasmonic Resonance

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We propose an innovative hybrid temperature sensing system that integrates the Photon Spin Hall Effect (PSHE) with magneto-optic surface plasmon resonance (MO-SPR) technology in a Kretschmann configuration. The nanophotonic device incorporates graphene as a dynamically tunable plasmonic layer, delivering excellent desire sensitivity for nanoscale optoelectronic and environmental sensing applications.

The proposed device as shown in Figure 1(a), have an Au-layer supporting plasmon excitation while exhibiting thermally induced expansion along with varying electron–phonon and electron–surface scattering at elevated temperatures. The Drude–Lorentz model [1] is employed for Au to evaluate its permittivity components being a uniaxial medium under an external magnetic field. To further enhance the sensitivity, another temperature dependence phenomenon introduced through the uniaxially anisotropic graphene layer [2], where both the Fermi level and carrier relaxation time τ vary with temperature T . The graphene carrier density is controlled by the gate voltage. The magneto–optic coupling at the Au–TiO₂ and TiO₂–graphene interface is exploited to generate a transverse spin–dependent beam displacement, which provides an additional detection parameter for temperature– induced resonance variations [3]. The TiO₂ layer as depicted 1(a) shows negligible thermal expansion [4]. In this work we focus particularly to temperatures above room temperature, thus Landau quantization is negligible therefore the Kubo formalism is not required. The intraband surface and Hall conductivities of graphene are incorporated to account for carrier–induced anisotropy, leading to a uniaxial permittivity tensor representation in the overall magneto–optic model. And the fermi energy calculated based on equation[5], $E_F = \hbar v_F \sqrt{\pi n_s} (1 - \pi^2 (k_B T)^2 / 12 (\hbar v_F \sqrt{\pi n_s})^2)$. The effect of temperature results in a measurable shift of the SPR resonance angle which is exploited to generate a transverse spin–dependent beam displacement[6], characteristic of the Photon Spin Hall Effect (PSHE) as shown in Figure 1(b). This PSHE–induced shift is amplified by the magneto–optical effects yielding higher sensitivity compared to conventional SPR sensors. This hybrid PSHE–MO–SPR sensor thus demonstrates strong potential for nanoscale optoelectronic and environmental sensing applications.

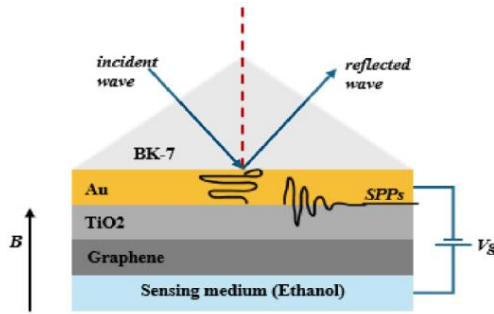


Figure 1 (a) Structure of device in Kretschmann configuration

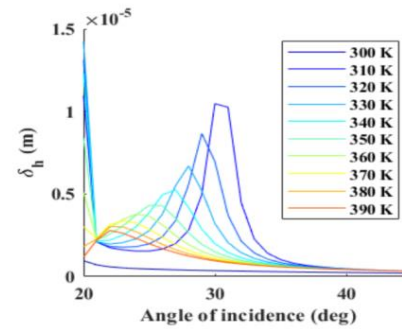


Figure 1(b) Spin dependent shift at different temperatures

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Photonic Spin Hall Effect-Based Voltage-Tunable Plasmonic Sensor for High-Sensitivity Refractive Index Detection

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This study presents a novel approach to high-sensitivity photonic sensing based on the Photonic Spin Hall Effect (PSHE), achieved through the integration of plasmonic and electro-optic property of liquid crystal (LC) material. The PSHE, arising from the spin-orbit interaction (SOI) of light, manifests as a transverse spin dependent shift (SDS) when circularly polarized light interacts with a refractive index (RI) gradient or anisotropic interface [1]. By manipulating this effect within engineered nanostructures, enhanced spin-controlled light-matter interactions can be realized for precise optical sensing applications. Building on this principle, an ultracompact, reconfigurable refractive index sensor is proposed, employing a multilayer structure composed of gold (Au), liquid crystal (LC), and Bio-Recognition Element (BRE) layers. The LC layer serves as an active medium whose anisotropic and electro-optic properties allow external voltage control of its RI, enabling dynamic tuning of the PSHE response. A small applied bias in the millivolt-to-volt range modulates the spin-dependent optical field, providing reconfigurable and highly sensitive detection capabilities.

Three configurations are investigated: a pure plasmonic system, an unbiased LC-integrated sensor, and a voltage-biased LC sensor. In the optimized Au/LC/BRE structure, a SDS of $166.633 \mu\text{m}$ is achieved—approximately 40 times higher than conventional gold-based plasmonic systems at an LC thickness of 13 nm under an applied voltage of 6.671 V. This significant enhancement arises from the strong interactions between plasmonic resonance and the electro-optic modulation of the LC layer, producing pronounced field localization and tunable resonance behavior. The proposed structure demonstrates a spin-dependent sensitivity of $20,794 \mu\text{m}/\text{RIU}$, corresponding to a 92 times improvement at a RI of 1.33 RIU compared to standard plasmonic structure. The sensor exhibits excellent refractive index sensing performance in the 1.330–1.340 RIU range, achieving an ultra-low limit of detection (LoD) of $4.81 \times 10^{-8} \text{ degree} \cdot \text{RIU}/\mu\text{m}$. The sensitivity increases exponentially as the refractive index of the sensing medium rises within this range, confirming strong light matter coupling and voltage tunability. As a practical demonstration, the proposed device is applied for detecting heavy metal ions (Hg^{2+} , Pb^{2+} , Cu^{2+} , and Zn^{2+}) in water [2]. The sensor achieves a maximum amplitude sensitivity of $2,122,010 \mu\text{m}/\text{RIU}$ for the H-polarized mode shown in fig. 1 (b), highlighting its capability to precisely monitor water quality.

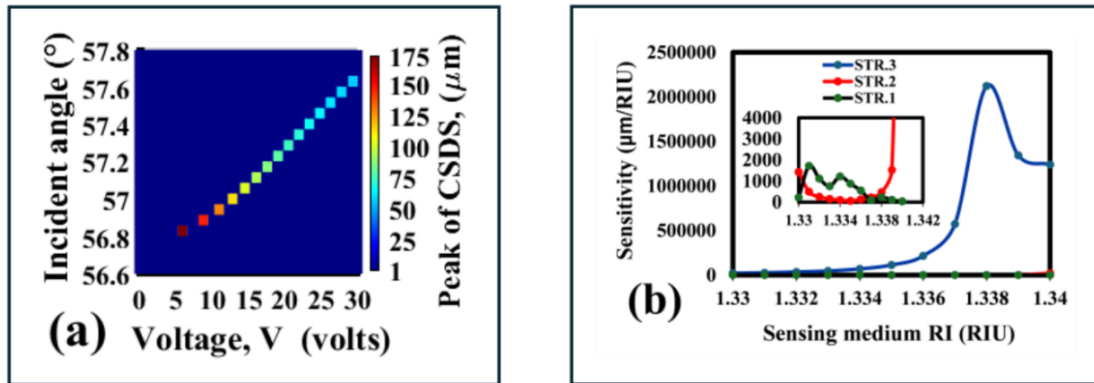


Fig. 1 (a) Tuning of CSDS Through Variation of Bias Voltage and Incident (b) Comparative sensitivity of pure plasmonic, unbiased proposed and biased proposed structure.

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Multiwavelength Nanophotonic Circuit with Optically Readable Resistive Switch

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We demonstrate a reconfigurable multiwavelength nanophotonic circuit using an optically readable Ag-SiO₂-ITO resistive switch on a silicon rib waveguide, exhibiting 27 dB extinction at ± 2 V. The device enables low-voltage, high-speed, and programmable optical functionality for memory, communication, and neuromorphic computing applications.

Nanoscale optical functionalities are promising for unconventional computing, including neuromorphic and quantum information processing. Resistive switching devices with optical readability have drawn significant research interest for high-density non-volatile memory and unconventional computing. We propose a multiwavelength nanophotonic circuit consisting of resistive switches based on Ag-SiO₂-ITO on silicon rib structure with a capability to electrically remove any wavelength channel(s) at wish. The device features four-layered structure with a SiO₂ region positioned between an Ag top electrode and an ITO bottom electrode on p-Si and confines hybrid plasmonic mode within the SiO₂ region. The external voltage's application, conductive filaments forms/rupture in the SiO₂ layer, affecting optical absorption through hybrid mode interactions. Experimental results show 27 dB extinction ratio for a $10\ \mu\text{m} \times 500\ \text{nm}$ active device operated at ± 2 volt. Additionally, the circuit achieves multiwavelength functionality using identical sources and 2×1 couplers, enhancing reconfigurability. The higher work function of ITO helps reduce energy barrier for ion-migration, overcoming the intrinsic resistance of the SiO₂ layer. This engineered nanophotonic circuit, with its high-extinction ratio, excellent retention, low-voltage operation, and rapid switching speed, is suitable for advanced memory devices, high-speed optical communication, neuromorphic and quantum computation, and programmable photonic circuits.

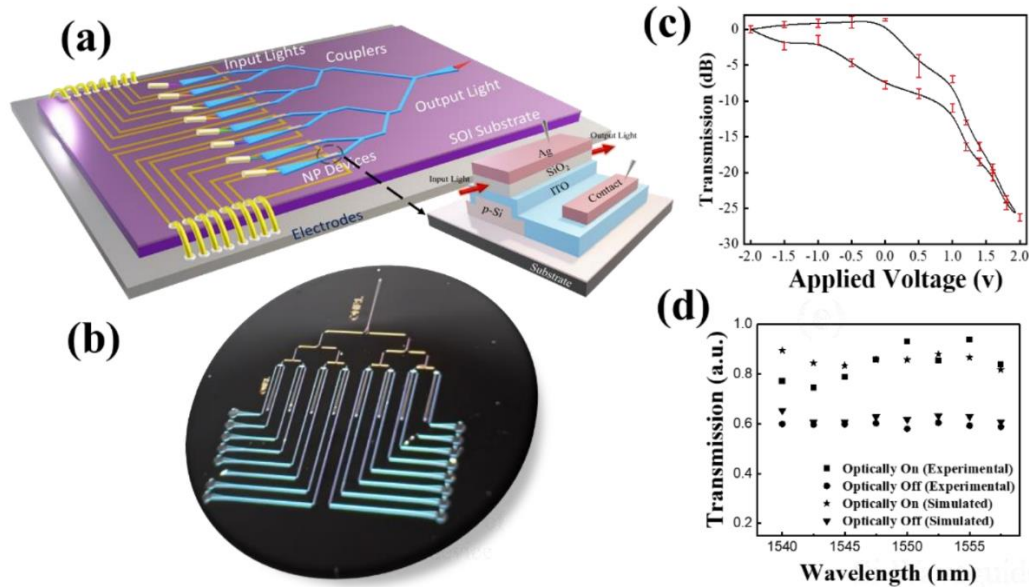


Fig. 1 (a) 3D schematic of multiwavelength nanophotonic circuit based on low-operating voltage optically readable engineered resistive switches consist of an Ag-SiO₂-ITO rib shape p-Si structure on a silicon-on-insulator platform. Inset shows the cross-section view of nanophotonic resistive switch. (b) microscopic image of fabricated device. (c) Variation in the measured optical transmission intensity on the application of external voltage ranging from -2 V to 2 V. (d) Experimentally measured and simulated optical transmission for the ON and OFF states across all eight channels.

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Enhanced Absorption in MoS₂ based UV Photodetector using Cu Nanoridge Arrays

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Abstract: Silicon photonics has gained significant attention and research focus for future requirements of huge bandwidth and high-speed communications along with cost-effective integration using existing complementary metal-oxide-semiconductor (CMOS) technology. In the realm of silicon photonics, extensive research projects have been dedicated to exploring photodetectors that utilize 2D materials. [1] These photodetectors have garnered significant attention due to their unique structures and remarkable electronic and optoelectronic properties. Atomically thin 2D materials have gained considerable attention due to their mechanical and structural characteristics, along with their potential to operate at extremely low power consumption and offer superior optical and electrical properties compared to bulk materials. In various available 2D materials, Monolayer molybdenum disulfide (MoS₂) has recently gained significant attention due to its promising electronic and optoelectronic properties. [2] The combination of strong light absorption and moderate carrier transport properties makes layered transition metal dichalcogenide semiconductors in the form of 2D materials highly promising for applications in low intensity photodetection. We propose a photodetector with high absorption based on a monolayer of MoS₂. The placement of the monolayer MoS₂ over a nano-ridge array made of copper, enhances the interaction between light and matter, leading to increased absorption and a higher generation of excitons. The proposed device exhibits high absorption across a wide wavelength range, specifically from 200 nm to 400 nm. Through optimization, we have explored various materials such as gold, silver, and copper as nano-ridges. Our findings demonstrate that copper outperforms silver and gold in terms of absorption coefficient, especially at lower ridge widths.

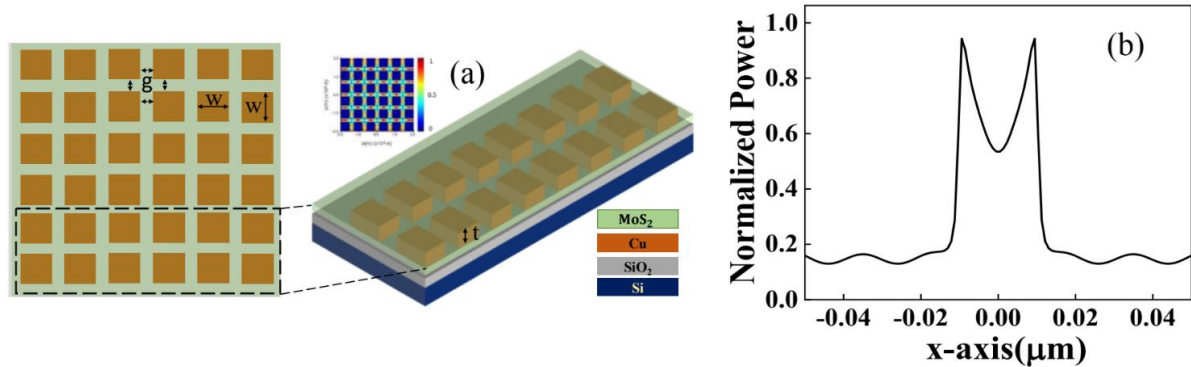


Fig. 1. (a) Top-view and 3D schematic of the MoS₂-based UV photodetector integrated with Cu nano ridge array ($g=100$ nm, $w=500$ nm, $t=50$ nm) for enhanced light absorption. The inset illustrates the optical mode confinement within the device. (b) Showing the enhanced absorption localized at the edges between adjacent Cu nanoridge.

Keywords: Photodetector, TMDs, Cu nanoridge array.

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Voltage-Controlled Phase Modulation in Silicon Nitride (Si₃N₄)-ITO Hybrid Waveguide Platform

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Abstract: We proposed a novel electro-optic phase modulator based on Si₃N₄-ITO platform. A π phase shift is obtained over a 73.1 μm length with a modulation efficiency of $V\pi L$ is 0.366 V $\cdot$ mm. The strong mode confinement at the active interface enables compact, low-power, and high-speed operation.

A fast, compact, and energy-efficient optical modulator is essential for next-generation photonic systems. From a materials engineering perspective, transparent conducting oxides (TCOs) are particularly promising for improving optical modulation performance and thus have widely explored for electro-optic Modulation using its free carrier dispersive effect¹, when integrated with SiN making it CMOS compatible fabrication design. ITO being with SiN, in particular, offers unique benefits such as broader optical transparency², lower losses², and improved thermal stability², making it highly attractive for emerging applications in quantum and nonlinear optics³, microwave photonics, and optical phased arrays used in LIDAR and free-space communications.

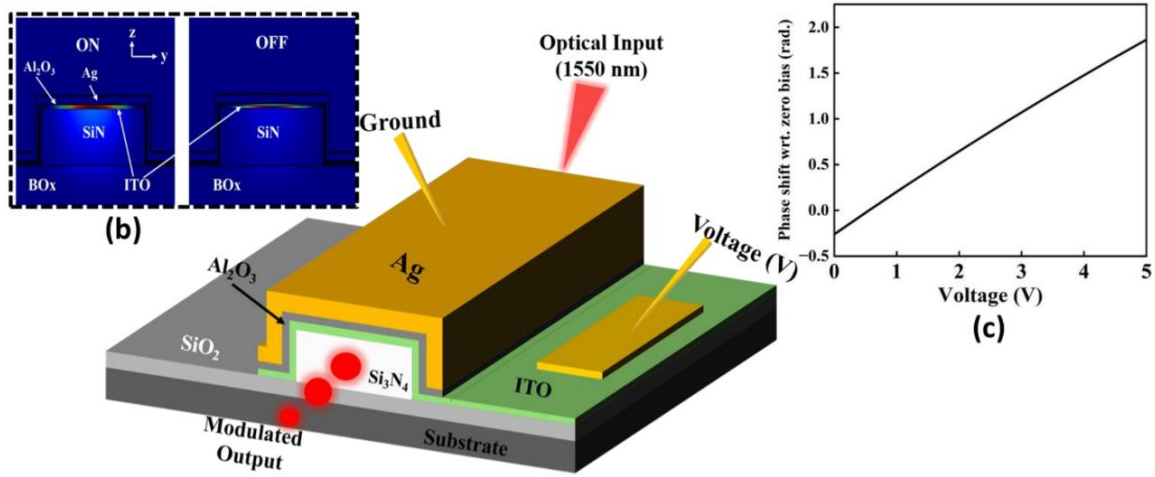


Fig. 1(a) Cross-section of the proposed Si₃N₄-ITO based optical modulator. The structure consists of a silicon nitride waveguide having dimensions as $h = 300$ nm and $w = 1.5$ μm . Thickness of the Ag, gate oxide (Al₂O₃) and ITO thin films are 50 nm, 10 nm and 10 nm respectively. (b) mode field profiles for the ON and OFF state. (c) Change in phase with respect to applied voltage for a device length of 50 μm .

The proposed device as shown in Fig.1, an electro-optic phase shifter based on hybrid Si₃N₄-ITO platform engineered and optimized numerically to operate efficiently in telecom wavelength. It demonstrates a novel integration of SiN and ITO for efficient electro-optic phase modulation. The inset (b) in Fig.1, shows the mode confinement of two conditions. The ON condition when we have not applied any potential, the mode shows light propagation in SiN too while the OFF condition is when there is an external applied potential in between the junction. In this case mode shows the light propagation inside the SiN has highly reduced resulting in very tight confinement in the ITO region which is desirable. By taking advantage of the epsilon-near-zero effect in ITO, the device achieves an effective index change of 0.01059 with a bias range of just 0 to 5 V as shown in inset (C) of Fig.1. A π phase shift is realized over a 73.1 μm length, delivering a modulation efficiency of $V\pi L$ is 0.366 V $\cdot$ mm.

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Optical Sensing for the Assessment of Bone Fracture Healing Progression in External Fixator Mediated Stabilization

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Abstract

Accurate monitoring of bone fracture healing is essential to ensure successful clinical outcomes. Conventional imaging modalities such as X-ray and computed tomography (CT) remain the gold standards for assessing fracture union; however, repeated radiation exposure presents potential health risks. Interfragmentary strain (IFS) serves as a critical biomechanical parameter regulating callus formation and bone remodeling, making it a promising indicator for tracking healing progression. The present study proposes a novel optical sensing approach for non-invasive monitoring of bone healing through IFS measurement. An in vitro tibial fracture model was developed using a synthetic tibia stabilized with a Limb Reconstruction System (LRS) external fixator. A transverse fracture gap was created and filled with Agilus polymer materials (Agilus 30, 60, and 95) of varying stiffness to simulate progressive stages of callus development. Fiber Bragg Grating (FBG) sensors (1526–1550 nm) were mounted on the Schanz pins of the LRS to record strain induced under controlled static loading applied at the distal end of the tibia. Wavelength shifts obtained using an S-line Sentinel optical interrogator were converted into strain using a calibration coefficient of 1.2 pm/ $\mu\epsilon$. Experimental results revealed that IFS decreased with increasing callus stiffness, indicating progressive consolidation of the fracture site. The softest callus analogue (Agilus 30) exhibited the highest IFS, while stiffer materials (Agilus 60 and 95) showed markedly reduced strain responses (Fig. 1). These findings demonstrate that the integration of FBG sensors with an LRS fixator enables precise, radiation-free, and quantitative evaluation of bone healing progression under controlled mechanical loading.

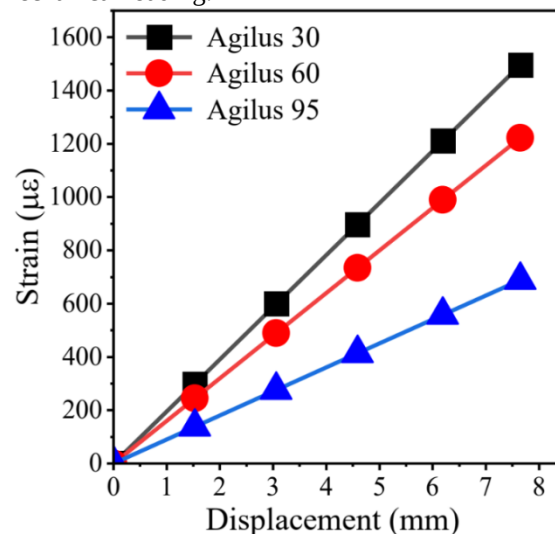


Fig.1: Displacement vs. strain graph showing reduced strain with increase in stiffness of callus replicas (Agilus 30, 60, and 95)

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Design Optimization of Si-ITO Heterojunction based Microring Resonator for Tunable Photonic Devices

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Silicon microring resonators are widely explored for compact modulators and tunable filters due to their high spectral selectivity and CMOS compatibility [1-2]. Incorporating transparent conducting oxides, such as indium tin oxide (ITO), enables strong electro-optic tunability near the epsilon-near-zero regime [3-4]. However, achieving a balance between high Q-factor and tunability remains a key challenge, as both are dependent on device parameters. Addressing this trade-off is crucial for realizing high-speed and low-power integrated photonic devices.

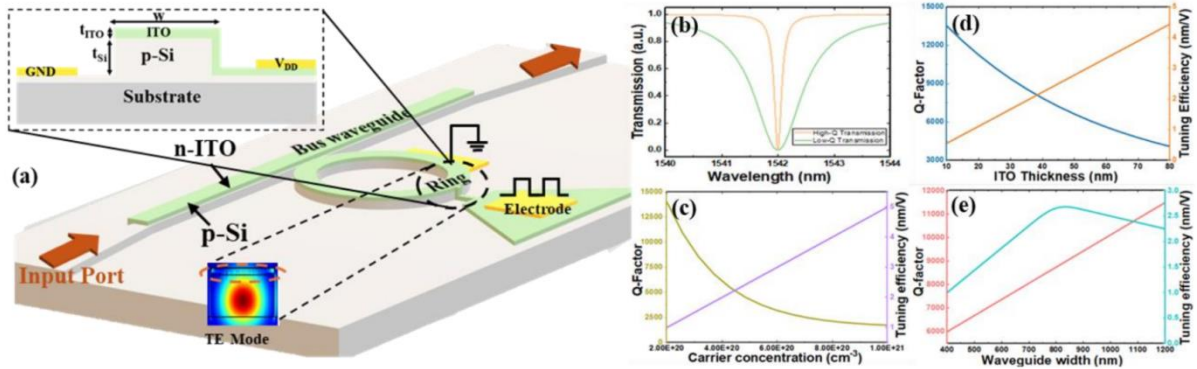


Figure- (a) Schematic of the Si-ITO microring resonator with ITO on top of a 180 nm Si waveguide. (b) Simulated high-Q and low-Q transmission spectrum showing resonance dip. (c-e) Optimization of key design parameters.

In this work, we present a simulation-based optimization of Si-ITO based MRR with a Si waveguide (180 nm) and atop ITO layer directly interfaced without a dielectric spacer. Unlike earlier studies that primarily focused on maximizing tunability, we analyzed three critical parameters: ITO thickness, carrier concentration, and waveguide width- to find a design window that simultaneously preserves Q and enhances tunability. Our analysis shows that while increased ITO thickness and carrier density improve refractive index modulation, they also introduce free- carrier absorption. Conversely, thin ITO layer and lower doping maintain higher Q but reduce tunability. Importantly, the waveguide width plays a dual role: wider width mitigate leakage losses and strengthen vertical modal overlap with ITO, thereby enhancing tuning efficiency.

An optimal regime is identified at ITO thickness $\sim 30\text{-}40$ nm, carrier concentration $\sim 2\text{-}3 \times 10^{20} \text{ cm}^{-3}$, and waveguide width $\sim 700\text{-}900$ nm, where the device achieves a loaded Q above 8,000 alongside an expected tuning efficiency of $\sim 1\text{-}2$ nm/V. This represents a significant improvement in the Q-tunability trade-off compared to conventional Si-only microring and previously reported ITO-based designs, providing concrete design guidelines for MRR based on Si-ITO heterojunction targeting modulators, tunable filters, and integrated microwave photonic applications.

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ANN-Based Prediction of Slow Light Dispersion in Ring-Hole Photonic Crystal Waveguides

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Photonic crystal waveguides (PCWs) are essential for achieving precise control over light propagation in integrated photonic circuits, particularly in slow light applications. However, conventional numerical methods such as the plane wave expansion (PWE) and finite-difference time-domain (FDTD) techniques are computationally intensive when exploring large design spaces involving subwavelength geometries. In this work, an artificial neural network (ANN)-based predictive model is developed to accurately estimate the dispersion curve of a ring-hole PCW (RPCW) engineered for slow light operation. A supervised feedforward multilayer perceptron (MLP) architecture with optimized hyperparameters is trained on a dataset generated through simulations of RPCW structure as shown in Fig. 1 on FEM based COMSOL Multiphysics software. The trained model effectively reproduces the slow light dispersion band with minimal mean absolute and percentage errors, significantly reducing computational cost compared to traditional methods. The proposed ANN framework demonstrates its capability for fast and reliable prediction of dispersion characteristics in complex PCW geometries, offering a powerful tool for inverse design and optimization in next-generation photonic integrated systems.

The artificial neural network (ANN) developed in this work accepts two input parameters, derived from COMSOL Multiphysics simulations, representing key geometric or optical characteristics of the PCW. It consists of four hidden layers designed for high-precision learning: the first two layers have 512 neurons each, followed by layers with 256 and 128 neurons, respectively as shown in Fig. 2. All layers use the ReLU with He-normal initialization to facilitate stable training. To enhance generalization and prevent overfitting, batch normalization is applied after each dense layer, and dropout (10%) is introduced in the first two layers. The model generates two outputs, namely the normalized frequency (f_{norm}) and the group index (n_g), which are critical for analyzing dispersion characteristics and slow-light effects in PCWs. The network is trained using a supervised learning approach with mean squared error (MSE) minimization, providing a stable and accurate prediction framework. This configuration achieves an optimal balance between computational efficiency and predictive accuracy, enabling rapid and reliable evaluation of dispersion-engineered PCWs for slow-light applications.



Fig. 1 Supercell structure simulated in COMSOL Multiphysics to generate dataset

The performance metrics of the proposed model for prediction of dispersion curve and group index are summarized in Table 1 and Table 2 respectively.

Table 1. Summary of Performance Metrics (f_{norm})

Sr. No.	Metric	Test Data (f_{norm})	Untrained Data (f_{norm})
1	MAE	0.00025	0.000283
2	RMSE	0.000311	0.000339
3	MAPE (%)	0.096514	0.109632

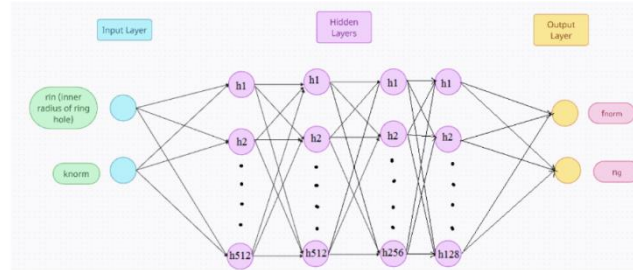


Fig. 2 Schematic of the ANN used for the prediction

Table 2. Summary of Performance Metrics (n_g):

Sr. No.	Metric	Test Data (n_g)	Untrained Data (n_g)
1	MAE	3.609029	2.782326
2	RMSE	23.336092	13.768112
3	MAPE (%)	5.388204	6.097636

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