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A newsletter on
Indian Quantum Technology Activities

The Quantum Era -Superconducting Electronics at the Forefront
Dr. Dhavala Suri, IISc. Bangalore

Superconducting Quantum Processors
Dr. Kameshwar Yadavalli, Rigetti

Colloidal Quantum Dots for Quantum Science and Technology
Dr. Anshu Pandey, IISc. Bangalore

Quantum Materials & Devices

India Celebrated
World Quantum Day
14th April 2024

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Contents

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Editor's Note

Five editions in, and the quantum revolution keeps accelerating! This time, the Q2 2024's Quantum Vibes edition dives deep into the fascinating world of quantum materials, particularly those powering the next generation of superconducting quantum processors. Readers can gain insights into the foundational components of this transformative technology.

Dr. Dhavala Suri from IISc Bangalore provides an in-depth explanation of the material aspects of superconducting electronics used in the development of quantum processors. In his article, Dr. Kameshwar Yadavalli from Rigetti Computing highlights the role of captive fabrication facilities in enhancing the performance of superconducting quantum processors. Additionally, Dr. Anshu Pandey from IISc Bangalore contributes an insightful article on Colloidal Quantum Dots for Quantum Science and Technology, exploring their potential applications and impact on the field.

The news section of this edition spotlights India's celebration of World Quantum Day on 14 April 2024, featuring messages from dignitaries and prominent researchers in quantum technology. Additionally, this edition covers other significant breakthroughs and developments in the field during this period, providing a comprehensive overview of recent advancements and key events in this important technology area.

The National Quantum Mission has taken off with an ambitious goal of establishing India as a leading hub for quantum technologies. This significant initiative has also aligned with the UN's declaration of 2025 as the International Year of Quantum Science and Technology, underscoring India's commitment to advancing in this cutting-edge field. I am confident that the National Quantum Mission will be a resounding success, delivering ground-breaking advancements in quantum science and setting the stage to redefine the future of technology, communication, and beyond.

Happy reading!

DR. S.D. SUDARSAN
Editor

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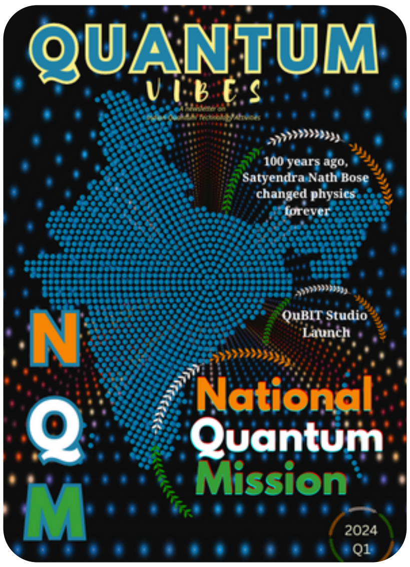
2023

2024



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The Quantum Era -Superconducting Electronics at the Forefront

Dr. Dhavala Suri, IISc. Bangalore

The synthesis of new materials has proven advantageous throughout history, starting with the discovery of bronze, one of humanity's earliest alloys. The drive to create new materials stems from their beneficial properties. In the contemporary era, particularly in the pursuit of functional quantum processors, specific classes of materials are indispensable. These include those with low noise levels, minimal dissipation, high charge carrier mobility, and extended coherence times. The limitations and capabilities of these properties are largely dictated by the chosen material platforms, prompting an ongoing quest for superior alternatives.

Because of complete loss of resistance, superconductors (SCs) are beneficial for non-dissipative electronics. Tapping into the device aspects of superconductors has been studied for a while – Josephson junctions, superconducting quantum interference devices (SQUID), field tunable superconducting devices etc.

Figure 1:
A superconducting strip with unidentical microstructures on the edges, result in the SDE

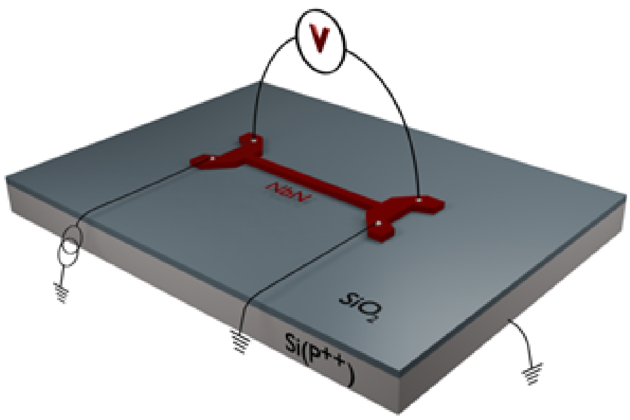


Figure 2:
A gate controllable superconducting micro-bridge. Illustration credit: Jagadish Rajendran

A class of materials called superconductors are materials whose electrical resistance drops close to zero, below a certain temperature, called the critical temperature. Although the discovery of superconductivity dates to 1911, the understanding of the mechanism of superconductivity took four decades to occur. The most accepted theory that explains the mechanism of zero resistance is the one put forth by Bardeen, Cooper and Schrieffer which proposes that two electrons of opposite spin and momenta pair up mediated by a phonon to form quasiparticles called as Cooper pairs.

One of the recent developments in this field has been the superconducting diode effect (SDE). It can be seen as analogous to a semiconductor diode but with the potential to serve as a novel non-dissipative circuit component, facilitating advancements in emerging superconducting technologies akin to how traditional diodes support dissipative semiconductor technologies. Diodes are fundamental components in technologies like current rectifiers, voltage-controlled oscillators, and photodetectors. Similarly, the SDE introduces analogous opportunities in superconducting electronics, superconducting spintronics, and quantum information and communication technology.

The Superconducting Diode Effect (SDE) is a phenomenon where a superconducting system—including single crystals, thin films, heterostructures, nanowires, and Josephson junctions—exhibits unequal magnitudes of critical current depending on the direction of the current bias/external magnetic field [1]. This non-reciprocity in critical current, defined as the current at which the superconductor transitions from the superconducting state to the normal state, occurs when both inversion symmetry and time-reversal symmetry are broken.

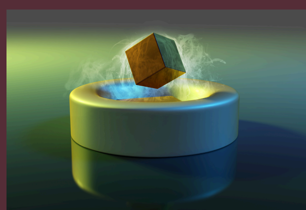
The simplest example of a superconducting diode is a strip of a superconductor on a substrate [2], where inversion symmetry is broken at the interface between the strip and the substrate. Time-reversal symmetry can be broken by applying an out-of-plane magnetic field, which induces vortex motion and leads to a resistive transition (Figure 1).

However, the diode effect in superconductors can arise from several distinct mechanisms, depending on the composition and structure of the device. Theories on the SDE has been studied by several research groups. For instance, by using mean-field, Bogoliubov–de Gennes (BdG) and Ginzburg–Landau theories, theoretical insights have recently been presented for SDE in junction-free bulk superconductors as well as for its Josephson junction version. However, another important concept is that of the proximity coupling where the Josephson junction is fabricated on top of high spin orbit coupling material; here the inversion symmetry is broken down not only by the heterogeneous composition of the device but also by the spin orbit coupling term; here the magnetic field required to break TRS is in the plane of the device. In recent times, intriguing experimental demonstrations of SDE in spin–orbit-coupled non-centrosymmetric superconductors have revived and stimulated theoretical research on nonreciprocal supercurrent transport. However, the idea of SDE has been there for a few decades.

Edelstein explicitly proposed [3] supercurrent nonreciprocity by studying the Ginzburg–Landau equation for superconductors of polar symmetry. When the applied magnetic field (B), electric current (I) and polar axis (r) are orthogonal to each other, the magnitude of the critical current Ic(B) depends on the sign of the mixed product ; the critical current should be different for two opposite directions. While breaking of the TRS (Time Reversal Symmetry) is achieved by an external magnetic field, another way that has been explored is to integrate with a ferromagnetic insulator. Here, the exchange coupling between the ferromagnet and the superconductor makes a superconducting diode with zero external field possible.

Did You Know?

Superconductor



A superconductor is a type of material that, when cooled below a critical temperature, exhibits perfect conductivity within a certain range. This means it can conduct electricity with no resistance or energy loss up to a critical current density. Beyond this limit, it loses its superconductivity and behaves like a normal conductor.

Semiconductor-based field-effect transistors, which have been pivotal in driving the silicon revolution, operate by modulating the resistance between the source and drain electrodes via an applied gate voltage. This modulation is achieved through a change in the charge carrier density caused by the electric field generated by the gate voltage. The relatively low carrier densities in semiconductors allow for substantial resistance modulation with reasonable gate voltages, enabling a wide range of functionalities. In contrast, such a field effect is not expected to work effectively with metals due to their very high charge density. The carrier densities in metals are significantly higher than what can be influenced by a gate voltage, rendering the modulation of resistance negligibly weak. Gate-voltage modulation of superconductivity is considered immensely valuable and has been pursued for some time.

This includes recent advancements in the gate tunability of superconductivity in van der Waals materials. Conventional superconductors have historically been controlled through interactions with magnetic fields rather than electric fields. In metallic superconductors, critical properties such as the critical temperature (Tc) have been found to be relatively insensitive to gate voltages, exhibiting only minuscule changes of about 10^{-3} %. In contrast, unconventional superconductors based on strongly correlated oxides allow for more efficient gate modulation due to their relatively low carrier concentrations. The gate-modulated carrier density changes the density of states at the chemical potential, thereby altering the superconducting order parameter. This qualitatively explains the experimental observations mentioned earlier.

Consequently, superconducting properties such as Tc can be enhanced with an increase in carrier concentration via a positive gate voltage or reduced with a decrease in carrier concentration via a negative gate voltage. This indicates the potential for field-tunable superconductivity, opening avenues for more versatile and responsive superconducting devices. There is demonstrated gate-voltage-induced enhancement by up to 30% in Ic of NbN-based superconducting bridges- Figure 2 [4]. A qualitative plausible model is that of the vortex dynamics – critical current refers to that where the vortex dynamics set in the superconducting strip, applying a gate voltage varies the relative barrier between the vortex free energy and that of the surface barrier thereby enhancing or decreasing the critical current.

Did You Know?

Types of Superconductors

Type I Superconductors

These are usually pure metals that exhibit superconductivity at low temperatures.

Type II Superconductors

These are typically alloys or complex materials that can achieve superconductivity at higher temperatures compared to Type I superconductors.

Capitalizing on this voltage control, infinite electro-resistance and hysteretic resistance variation in these devices are demonstrated, making them promising candidates for logic and memory applications.

With superconducting diodes and transistors being demonstrated at research scale level, these demonstrations will play a pivotal role in futuristic cryogenic electronic peripherals for quantum technology.

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Dr. Dhavala Suri

Dr. Dhavala Suri is Assistant Professor at Indian Institute of Science, Bangalore. Her lab at CeNSE, IISc - Quantum Materials Lab, studies electronic properties of nano-devices of material interfaces that combine aspects of topology, superconductivity and magnetism for applications in quantum technology. Dhavala Suri's research interests are into synthesis of high quality epitaxial thin films of 3D topological insulators, magnetic semiconductors, and superconductors. She did her PhD at BITS Pilani, K K Birla Goa Campus, followed by postdoctoral tenure at MIT, USA, TIFR-H and TU-Munich, Germany. Her expertise spans over instrumentation, automation, epitaxial material synthesis and superconductivity.

FUN FACT

The Levitating Frog!

In 1997, scientists at the University of Nijmegen in the Netherlands used a powerful superconducting magnet to levitate a live frog. This quirky experiment, made possible by superconductors creating strong magnetic fields that counteract gravity, demonstrates the phenomenon of diamagnetic levitation. Sir Andre Konstantin Geim, who led this experiment, was awarded an Ig Nobel Prize in 2000 for levitating a frog. Later, in 2010, he and Konstantin Novoselov were awarded the Nobel Prize in Physics for their groundbreaking work on graphene.

Superconducting Quantum Processors

The Role of a Captive Fab in Driving Continuous Performance Improvement in a Full-Stack Product Company

Dr. Kameshwar Yadavalli, Rigetti

Quantum Computing:

Quantum Computing is expected to usher in exponentially more powerful computational systems due to the ability to use superposition state space upon entanglement of quantum bits (qubits). While Richard Feynman is credited with highlighting the opportunity in Quantum Computing in the early eighties, Peter Shor's quantum algorithm for finding the prime factors of a large integer gave the nascent field a rallying use case in the nineties. Interest in Quantum Computing among governments and funding agencies is currently at an all-time high with various governments across the world launching national missions for Quantum Computing including in India, with plans to invest many billions of dollars collectively in the next decade. Quantum Computing devices are being realized in several hardware platforms including superconducting, ion trap, neutral atoms, photonic, spin and topological insulators. The superconducting platform enables fast qubit gate times, with design flexibility and relies on fabrication processes well understood and developed in the semiconductor industry. The initial demonstration of Quantum Supremacy was achieved in the superconducting platform by Google in 2019 [1]. In each of the platforms above, Quantum Computing device realization is a testament to very innovative work that is bringing together physicists, engineers, computer scientists and other technologists. In the superconducting platform, most large-scale quantum processor implementations are based on transmon qubits [2].

Quantum Computing and Rigetti:

Rigetti Computing is a pioneer of superconducting full-stack Quantum Computing, founded in 2013, motivated with a vision to build the world's most powerful computers to help solve humanity's most important and pressing problems. From early on, Rigetti Computing recognized the value of a captive Fab in enabling accelerated R&D and rapid prototyping, and commissioned Rigetti Fab-1 in Fremont, California (USA) in 2016, which was the industry's first quantum foundry.

Superconducting qubits are engineered "artificial atoms" and utilize Josephson junctions (JJs) fabricated within a superconducting integrated circuit to emulate the relevant physics of quantum systems at the atomic or molecular level, at a macroscopic (hundreds of nanometers to micron) scale. The superconducting control circuitry includes elements like resonators, drive lines, fixed and/or tunable couplers, ground plane, superconducting vias, etc in addition to JJs. Typically, the control circuitry is fabricated from niobium, tantalum, aluminum, or some such reasonable superconducting transition temperature material. JJs are typically fabricated using aluminum/aluminum oxide/aluminum tunnel junctions utilizing shadow evaporation techniques employing a bilayer resist stack. JJs also happen to be quite sensitive to electrostatic discharge (causing them to become shorted) requiring care in handling the wafers on which they are fabricated and driving a need to understand and mitigate charge buildup and subsequent destructive discharges throughout the entire wafer flow in the fab and in subsequent packaging.

Performance optimization in superconducting Quantum Computing (the driving need for a captive fab):

In Quantum Computing, the ground state and the excited state of the qubits are used to encode information. The lifetime of the excited state is represented by the qubit relaxation time. Due to the small energy difference between the ground and excited states, qubits are sensitive to coupling with environmental degrees of freedom and need to be isolated from the environment and defects in materials (two-level systems or TLSs) to be viable computational devices. Another important parameter is qubit dephasing which is a measure of the loss of phase coherence, partially due to interaction with noise. The act of computing requires pairs or larger sets of qubits to be brought into a controlled interaction to represent different gate operations. Qubit initialization and readout also require interaction with control circuitry. Thus, the design of a quantum processor is a very involved exercise of balancing coupling to various circuit elements against the need for a long enough excited state lifetime and is an iterative process of continuous learning and model building over many years.

In addition to processor design, materials and their interfaces and the processes used to achieve device structures also play an important role in defining the performance of qubits and quantum processors. Qubit relaxation and dephasing, and the degree of qubit coupling to TLS defects are some of the critical qubit performance metrics that can provide an idea of the baseline design, material and process maturity. As qubit measurements show variation across devices and over time, and are inherently macroscopic parameters reflecting microscopic processes, qubit performance metrics are best described by statistical or aggregate analysis over a large sample size of qubits. To enable accurate design, model building, and to achieve computationally relevant relaxation and dephasing times, one needs to have a good control on materials and processes (and on the measurement setup). This ensures that design driven splits yield qubit performance data which are not impacted by uncontrolled or poorly understood variation coming from fabrication. This, combined with unique requirements to avoid specific contaminants, is the rationale behind the need for a captive fab. A captive fab accelerates R&D and prototyping by enabling a rapid design-to-fab-to-test flywheel with control on process outcomes and minimized process drifts.

Captive fab and its procedures:

A captive fab with a complete set of process and metrology equipment including for end-of-the-line cryogenic qubit measurement enables controlled development of a viable manufacturing process, with end-to-end ownership of run and measurement data enabling statistical process control (SPC). This leads to a steady process baseline with quantifiable qubit performance metrics. Coupled with a rigorous change control procedure, one can run a baseline process while simultaneously exploring process and/or materials design of experiments (DOE) and transition to a new improved process and/or material stack based on DOE outcomes with rigorous statistical data analysis (utilizing room temperature and cryogenic measurements) backing the change to a new baseline. A series of such process improvements over time can lead to continuous improvement in yield and device performance. Furthermore, by running design splits on the baseline process and rigorously comparing end of the line qubit performance metrics across these splits, one can continue to build and validate a model for design simulation. Finally, a captive fab with a high-performance baseline process provides a versatile foundry service which can support engagement with valuable external collaborations such as with the

Superconducting Quantum Materials and Systems center (led by Fermi National Accelerator Laboratory), where Rigetti is the lead industry partner. As part of the SQMS center collaboration, Rigetti Fab members have collaborated successfully for deeper characterization of multiple process and materials DOE experiments [3-6].

Qubit performance improvement:

A cross-sectional schematic of a typical transmon qubit is shown in Figure 1 to highlight the materials and interfaces that impact qubit performance, along with summarized results of qubit performance improvement from experiments which were done at Rigetti Fab [3-8].

wafer flow and handling procedures) we have realized remarkable improvements over the last few years with some of these results published in [3-8].

We have reduced our junction shorting rate more than tenfold to below 0.25% such that we can routinely yield 84-qubit (84Q)

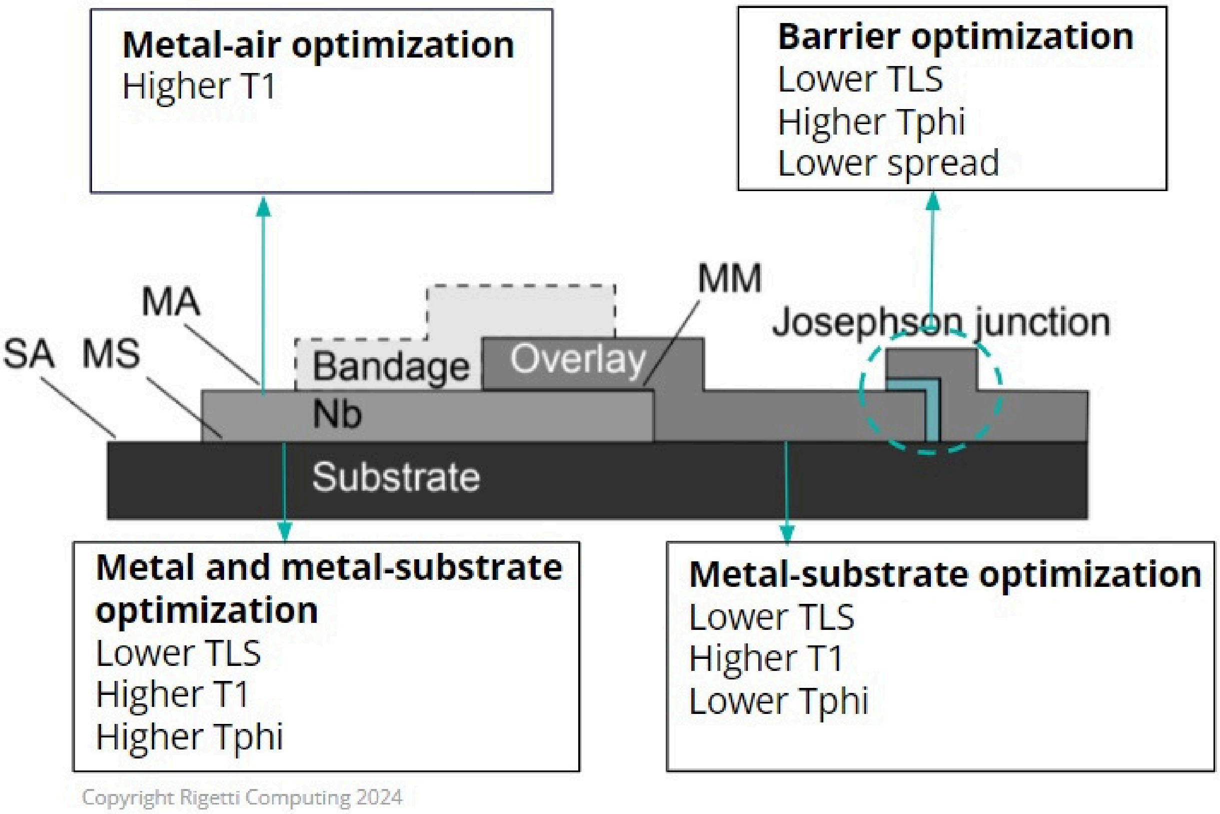

Figure 1: A cross-sectional schematic of a typical transmon qubit, along with summarized results of qubit performance improvement from experiments which were done at Rigetti Fab [3-8]

Sometimes, not all metrics improve simultaneously, and one must evaluate the tradeoffs inherent in a proposed change. SA denotes substrate-air; MS denotes metal-substrate; MA denotes metal-air; and MM denotes metal-metal. Schematic is from [9].

By targeted DOE (changing either the materials involved or optimizing the interfaces in the device or by optimized

quantum processors consisting of over 450 JJs! In conjunction with these yield improvements, we have increased baseline qubit relaxation and dephasing times, and achieved a tenfold reduction of defect (TLS) coupling and a tenfold reduction of median junction resistance spread.

The latter is a critical parameter in determining the qubit energy level spread and consequently, device performance. These improvements along with optimized design, packaging and control systems, among other parts of the full stack, have enabled Rigetti to improve quantum processor median two-qubit (2Q) gate fidelity in recent years and we aim to deploy an 84Q quantum processor with a 99% median 2Q fidelity over the cloud by the end of this year. Figure 2 below shows the recent median 2Q gate error rate evolution of 80Q or larger Rigetti quantum processors (from our investor presentation [10]). The performance depicted for upcoming Ankaa™-3, and future Ankaa™-4 quantum

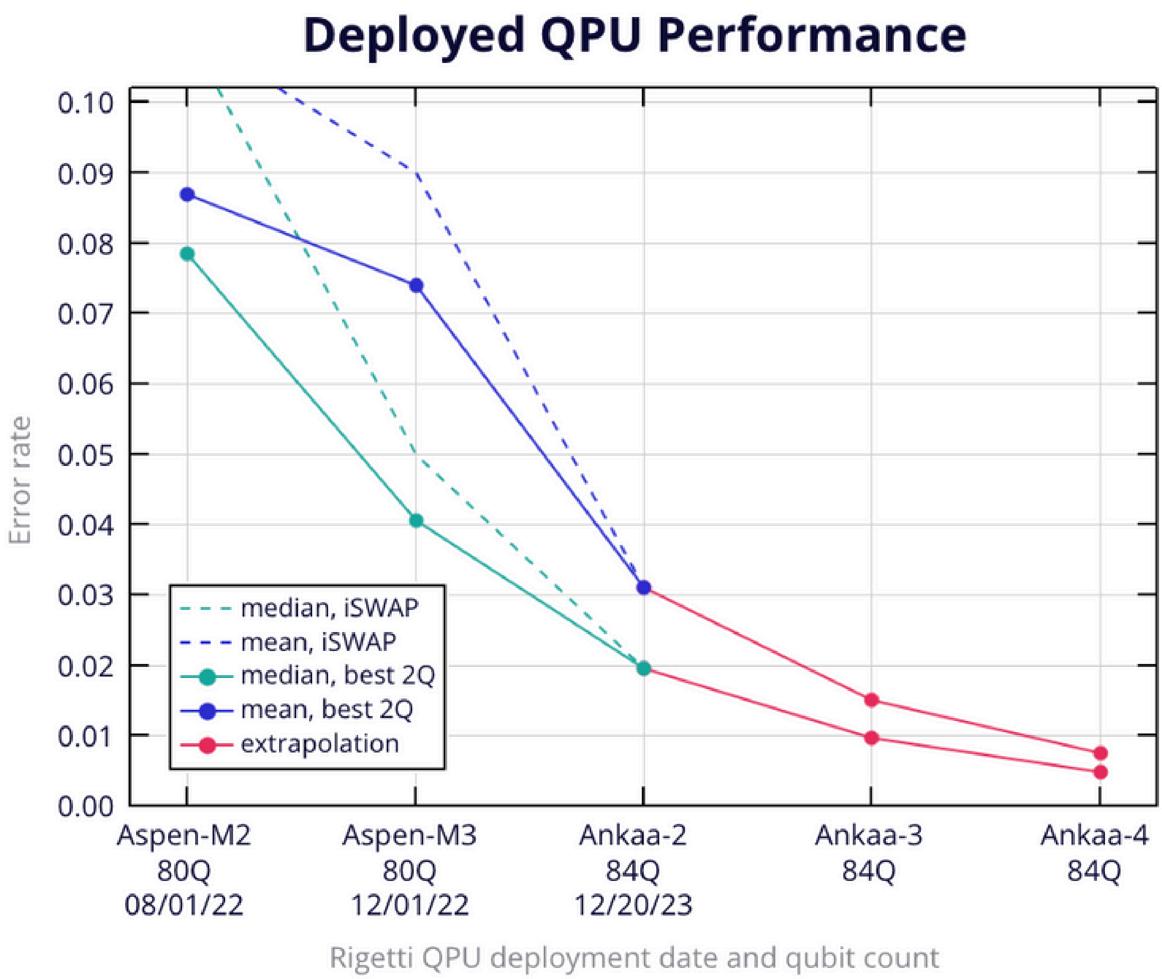

Figure 2: Median 2Q gate error rate data from 80Q or larger Rigetti quantum processors

processors are estimates based on current technology development trajectory. Rigetti Fab-1 thus has been an asset towards our technology roadmap execution and performance improvement. Rigetti Fab-1 driven performance improvement has also been leveraged by our partners like the SQMS center who are pursuing important R&D.

In conclusion, superconducting quantum processors are complex devices fabricated through a deep understanding of the underlying physics coupled with highly innovative engineering. With the aid of a captive fab and its rigorous application of DOE, SPC and change control procedures, one can drive accelerated R&D, rapid prototyping and continuous performance improvement of large qubit count superconducting quantum processors.

Summarizing the value of a captive fab:

- Enables very efficient design-to-fab-to-test flywheel
- Thorough experimentation on company-wide idea funnel
- Data driven decision making to aid model building
- Targeted capacity building aiding continuous improvement

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Dr. Kameshwar Yadavalli

Dr. Kameshwar Yadavalli is currently the Vice President of Fab at Rigetti Computing. He has worked for about 16 years in deep tech full stack system companies with innovative captive Fab development divisions. At Rigetti Computing, he led the development of improved Josephson junctions for high fidelity quantum computing processors prior to taking charge of Rigetti Fab-1. Prior to his work at Rigetti Computing, at Ostendo Technologies, he played a critical role in developing a photonic imager device consisting of 3 layers of micro-LED arrays functionalized on CMOS logic circuitry at wafer scale to create an RGB emitter for various applications including as smart glass displays. He received a BTech in Electrical Engineering from IIT Madras and an MS and PhD in Electrical Engineering from the University of Notre Dame. He did postdoctoral research at the University of California Los Angeles before commencing his industry career. He is a co-inventor of 8 granted US patents.

Colloidal Quantum Dots for Quantum Science and Technology

Dr. Anshu Pandey, IISc. Bangalore

Current progress in quantum science and technology has been spurred by the development of numerous device and material preparation techniques that have enabled experimental realization of several significant theoretical ideas. Among the several breakthroughs, the advent of quantum dots stand out as a particularly exciting development, with colloidal quantum dots (CQDs) holding promise for several aspects of quantum technology.

Quantum dots (QDs) are tiny semiconductor particles or nanocrystals, typically just a few nanometers in size—about 10,000 times smaller than the width of a human hair. At this minuscule scale, quantum mechanics becomes prominent, endowing these dots with unique optical and electronic properties. Unlike bulk materials, where properties remain constant regardless of size, quantum dots exhibit size-dependent properties. This means that by simply changing the size of the quantum dot, we can tailor its optical and electronic behaviour.

One of the most fascinating properties of quantum dots is their ability to luminesce, or emit light, of specific colours when exposed to shorter wavelengths of light. The colour emitted depends on the size of the dot: smaller dots emit blue light, while larger ones emit red. This tunability is due to quantum confinement, where the motion of electrons within the dot is restricted, leading to discrete energy levels. The effect achieved in quantum dots is thus conceptually similar to a particle in the familiar box system.

Colloidal Quantum Dots

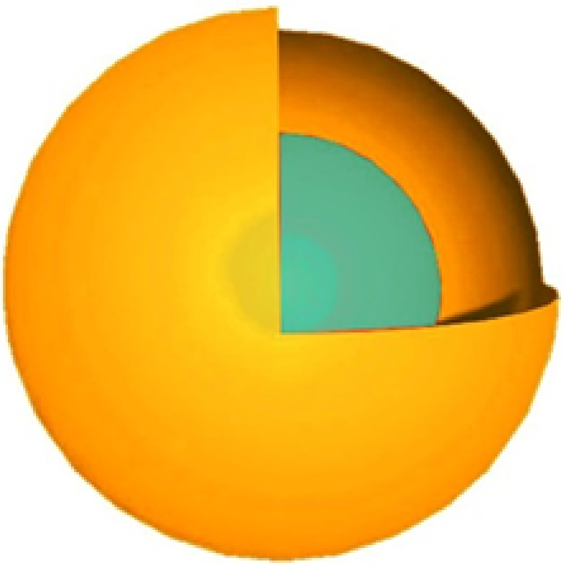
In our laboratory at the Solid State and Structural Chemistry Unit (SSCU), Indian Institute of Science, we are specifically interested in colloidal quantum dots (CQDs). Colloidal quantum dots are a subtype of quantum dots that are prepared using chemical methods reliant on colloidal solution chemistry. These wet-chemically produced CQDs can be further processed in solution itself, thereby allowing for easy manipulation and application to various fields. Further, CQDs can be produced in large quantities with precise control over their size and surface properties.

The preparation of CQDs involves creating a solution where the quantum dots form and grow to the desired size. This process typically involves heating a precursor solution containing the necessary elements in the presence of surfactants that control the growth of the nanocrystals. The resulting CQDs are then purified and can be further functionalized by attaching various molecules to their surface, which can improve their stability, solubility, and compatibility with different environments and materials. This surface modification is crucial for tailoring CQDs to specific applications. Once synthesized, CQDs can be deposited onto various substrates to prepare devices.

Unlike QDs grown by physical deposition methods such as MBE, CQDs are inexpensive to manufacture. Further, the chemical synthesis of CQDs can be easily scaled up, making technologies built from these materials scalable and easy to translate from laboratory to industry. Besides these advantages in technology translation of research, CQDs have fundamental scientific advantages as well. First, CQDs are simpler to engineer and customize than other types of QDs. This enables the development of precisely tailored quantum materials to suit specific quantum applications. Second, CQDs offer significantly greater quantum confinement compared to physically grown QDs. This potentially enables realization of a host of physical phenomena that are harder to observe in other QD types. Examples of such effects include the phonon bottleneck effect that were convincingly demonstrated only in CQDs.

These unique advantages of CQDs have led to their exploration for a range of quantum technologies. Prominent among their potential uses is the possibility of being employed as quantum light sources particularly single photon sources [1]. Single photon sources are devices or systems that emit photons one at a time, with applications spanning quantum computing, quantum cryptography, and quantum communication. These sources are crucial for ensuring the security of quantum key distribution protocols and for performing precise quantum measurements. Typically, single photon sources are realized using quantum dots, colour centers in diamonds, or single molecules, where careful manipulation and control of the quantum states enable the emission of one photon at a time. Achieving high purity and efficiency in photon emission is a significant challenge, requiring advanced materials and sophisticated techniques to isolate and manage the quantum states involved.

Early variants of CQDs lacked photostability and had a pronounced tendency to blink [2, 3]. The blinking phenomenon refers to luminescence intermittency whereby the emission from a single CQD fluctuates between on and off states even under constant excitation. Recently developed CQD variants however address this challenge and do not exhibit intermittency [4, 5, 6]. Encouraging studies demonstrating quantum interference phenomena using CQDs have also emerged [7], thus laying the ground for harnessing more complex phenomena using these materials. Our group has further worked extensively towards improving the fidelity of these materials as quantum light sources [8]. This has been done through the development of methods that enable emission statistics of CQDs to be improved.



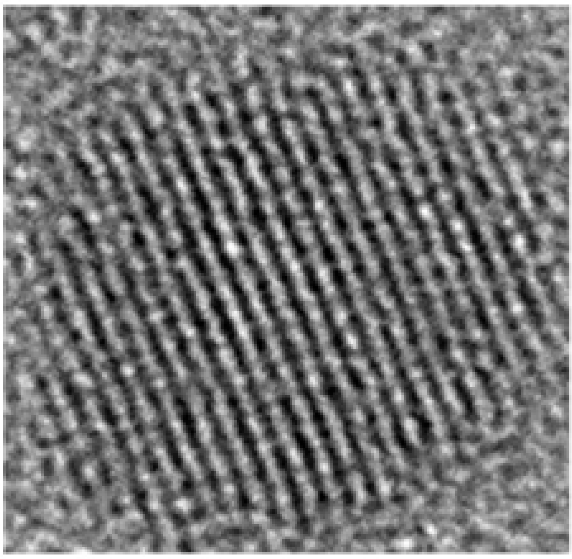


Figure: Colloidal Quantum Dot: Schematic and actual Particle

Another attractive possibility for the use of CQDs is their direct application as qubits for computation. The use of QDs to implement quantum operations has been demonstrated, however arguably, the field is still in its infancy. Research is nonetheless still underway to explore the use of CQDs directly in quantum computing. Their discrete energy levels and ability to interact with light make them potential candidates for qubits, the fundamental units of quantum computers.

Colloidal quantum dots represent a fascinating intersection of chemistry, physics, and engineering, offering transformative potential across multiple aspects of quantum technology. As research progresses, outstanding hurdles are being rapidly overcome, paving the way for a future where CQD-based quantum technologies gain prominence.

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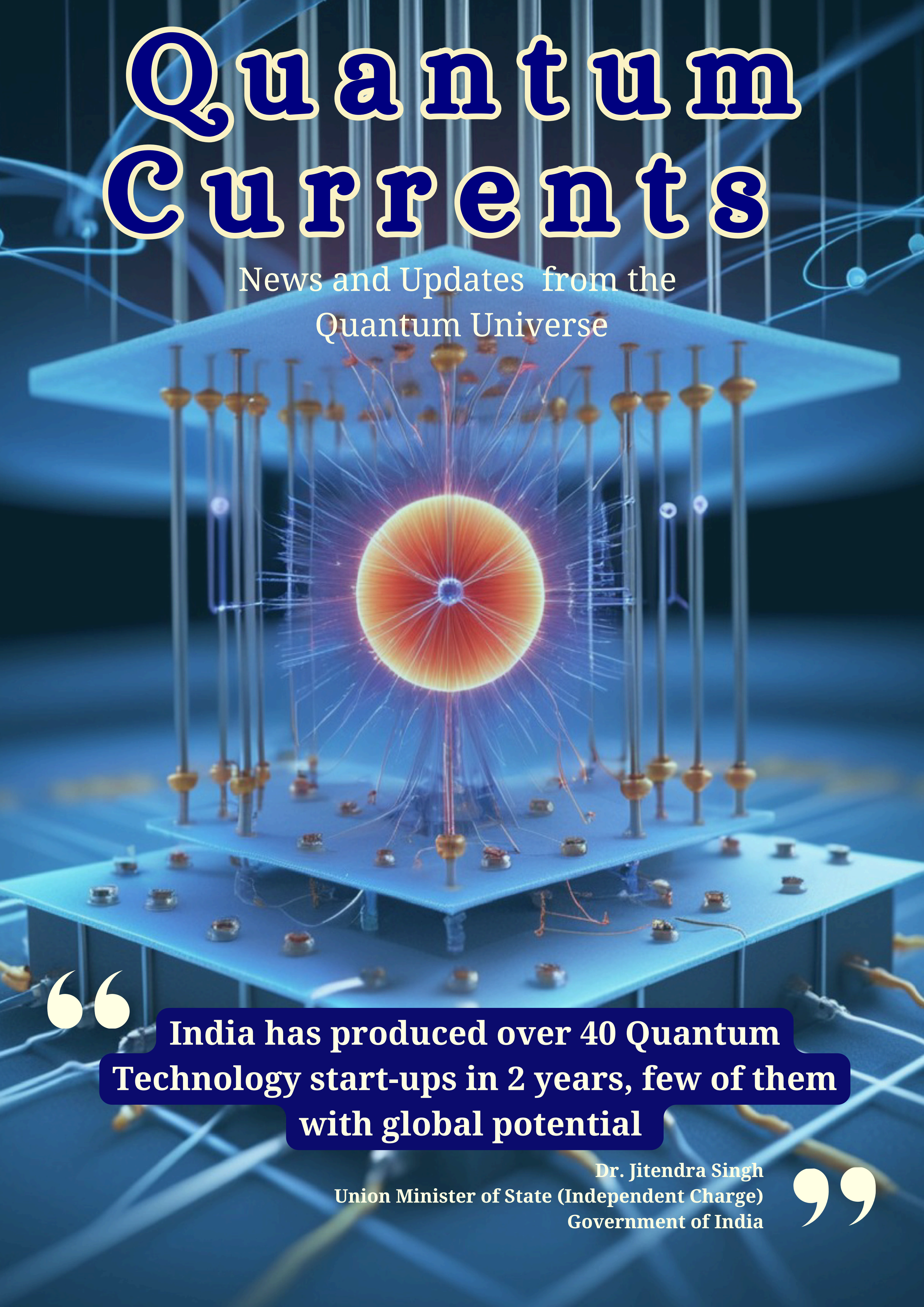
Dr. Anshu Pandey

Quantum Currents

News and Updates from the Quantum Universe



"India has produced over 40 Quantum Technology start-ups in 2 years, few of them with global potential"

Dr. Jitendra Singh
Union Minister of State (Independent Charge)
Government of India

April 13, 2024

India Celebrated World Quantum Day 2024 - Aspires to lead in Quantum Science and Technology

India celebrated World Quantum Day 2024 on April 14, 2024, with aspirations to become a global leader in various fields of Quantum Science and Technology.

Quantum Mechanics, the study of atoms and sub-atomic particles, has now advanced to such an extent that it has now moved to the engineering domain and is leading to novel and varied applications. Researchers worldwide have utilized its principles to develop technologies such as LEDs, lasers, and ultra-precise atomic clocks used in the Global Positioning System. Considerable attention is now being paid to controlling and manipulating quantum systems for Quantum Computing, Quantum Communications, and Quantum Sensing applications. To advance the awareness and appreciation of quantum science and technology among the public worldwide, an international initiative was taken in 2022, commemorated annually as the World Quantum Day on April 14th.

Prof. Ajay Kumar Sood, Principal Scientific Adviser to the Government of India emphasized the global impact of quantum technology: "Quantum Technology is the new technology frontier, reached after decades of fundamental research leading to our ability to exploit the principles of superposition, entanglement, and measurement. It promises to lead to applications with immense potential for the global economy in areas ranging from medicine to the discovery of advanced materials, and from safe communication to extremely sensitive sensors."

Discussing quantum technology's global reach and the need to eliminate potential threats by quantum computers, Prof. Sood said, "Governments and private players in almost all scientifically advanced nations are investing heavily in its development and exploitation to tap its immense potential for enhancing computing, communication, and sensing capabilities with significant implications for national prosperity and security. The threat emerging from quantum computers that breaches the encryption algorithms used by conventional computing systems needs to be addressed by PQC and QKD to make the world quantum-safe. Ensuring ethical development and deployment of quantum technology will also become important as newer applications get developed, and for this, engagement with a wide range of stakeholders —scientists, policymakers, industry leaders, civil society organizations, and the public — must continue."

Regarding India's plans to excel in quantum technology on the global stage, Prof. Sood expressed optimism and confidence and mentioned that India's National Quantum Mission (NQM) will bolster India's competitiveness by leveraging the national strengths built through previous R&D initiatives and strengthening them further in a focused and directed manner.

The National Quantum Mission (NQM), conceptualized by the Prime Minister Science Technology Advisory Council (PM-STIAC) received Cabinet approval on April 19, 2023 with a total outlay of Rs 6003.65 Crore for a period of eight years. The Mission aims to seed, nurture, and scale up scientific and industrial R&D and create a vibrant & innovative ecosystem in Quantum Technology (QT). This will accelerate QT-led economic growth, nurture the ecosystem in the country, and make India one of the leading nations in the development of QT and applications.

Being implemented by the Department of Science and Technology (DST), NQM envisages well-orchestrated and synergistic efforts through a hub-spoke-spike model, involving Centres of Excellence (CoEs), consortia projects, individual scientist-centric projects, etc. This mission is guided by a Mission Governing Board (MGB) chaired by Dr. Ajai Chowdhry and assisted by the Mission Technology Research Council (MTRC) chaired by the PSA to the Government of India.

The Mission aims to establish four Thematic Hubs (T-Hubs) in domains such as (i) Quantum Computing, (ii) Quantum Communication, (iii) Quantum Sensing & Metrology, and (iv) Quantum Materials & Devices. A Call for Pre-Proposals to establish T-Hubs was given on January 20, 2024, inviting contributions from academic institutions and R&D labs.

Underscoring DST's pivotal role in taking India's quantum mission forward, Prof. Abhay Karandikar, Secretary, DST, said, "India is one of the few countries making concerted efforts to leapfrog in quantum technologies and has reasons to be optimistic to become a leader in the area as it is still evolving. DST has taken up the challenge to build a world-class R&D capability in quantum technologies. Central to its efforts is the setting up of four hubs in Quantum Computing, Quantum Communication, Quantum Sensing & Metrology, and Quantum Materials & Devices."

Prof. Karandikar also underlined that NQM will be a consortium of academia and R&D labs in collaboration with startups and industry. This will help bring talents in the relevant areas across the country to work together for the development of the technology and its translation in myriad areas.

Dr. Ajai Chowdhry, Chairman, MGB and Founder HCL Technologies highlighted the importance of quantum technology in the digital economy and geopolitics for India: "On this World Quantum Day, the nation's decision to embark on the National Quantum Mission and seize the opportunities presented by the quantum revolution is a source of immeasurable hope and delight. The imminent economic potential and consequential effects of quantum computing on worldwide digital economies are critical considerations for geopolitical strategies. The substantial financial investment of ₹6,000 crore in the National Quantum Mission will undoubtedly facilitate the advancement of research and innovation across numerous sectors, benefiting scientists, researchers, and startups throughout the country."

Dr. Chowdhry also stressed the importance of quantum cryptography and encryption as an indispensable component of protecting critical institutions such as Banks and Electrical grids which will be required to implement quantum cryptography to improve security. He reiterated his confidence that the country will endeavour to achieve predetermined standards in the realm of QT by NQM.

Prof. Urbasi Sinha, Quantum Information and Computing Lab, Raman Research Institute and India Representative on the World Quantum Day Network shared her remarks on NQM: "As a country representative for the World Quantum Day network, I am very excited with the boom in quantum technologies that the country is currently witnessing with the impetus that has been received through the National Quantum Mission and look forward to contributing majorly to all the above efforts as a part of the Mission."

Asserting the importance of research and development on Quantum Communications, Prof. Sinha said, "India has made significant advances in the domain of secure quantum communications, both in fibre as well as free space domain with several ground-based milestones achieved over the last few years. Through the National Quantum Mission and beyond, we are looking forward to further leaps in long-distance quantum communications. We are aiming to have a country-wide free space quantum key distribution (QKD) network by using a satellite as a trusted node as well as a fibre-based QKD network. We will also make advances towards multi-node quantum repeater networks for entanglement distribution-based quantum communication. Going forward, India envisages being a lead player in the quest towards the global quantum internet, which would involve connecting India with other countries through quantum communication links."

Conveying his good wishes on the occasion of World Quantum Day, Prof. R Vijayraghavan, Tata Institute of Fundamental Research said, "With the launch of the National Quantum Mission, India is gearing up to develop not only quantum software but also build state-of-the-art quantum computing hardware for practical applications. Happy World Quantum Day!"

Source: PIB

"With the launch of the National Quantum Mission, India is gearing up to develop not only quantum software but also build state-of-the-art quantum computing hardware for practical applications. Happy World Quantum Day!"

Prof. R Vijayraghavan, TIFR

India is one of the few countries making concerted efforts to leapfrog in quantum technologies and has reasons to be optimistic to become a leader in the area as it is still evolving.

**Prof. Abhay Karandikar,
Secretary, DST**

Quantum Technology is the new technology frontier, reached after decades of fundamental research leading to our ability to exploit the principles of superposition, entanglement, and measurement.

**Prof. Ajay Kumar Sood
Principal Scientific Adviser, GOI**

April 20, 2024

IISER Pune starts Master’s programme in Quantum Technology

With the launch of the National Quantum Mission, there is a pressing need for a skilled workforce in Quantum Technologies. With this goal in mind, the Indian Institute of Science Education and Research, Pune (IISER Pune) has announced the launch of a new Masters programme in Quantum Technology.

IISER Pune launches a master's programme in quantum technology with 20 students, including industry overlap, entrepreneurship, and patenting courses.

The first batch of master’s programme in quantum technology launched by the Indian Institute of Science Education and Research (IISER) Pune will have 20 students. The two-year programme will include industry overlap and courses on entrepreneurship and patenting.

Professor Sudarshan Ananth, chair, physics department at IISER Pune, said, “Two new quantum-labs are being set up exclusively for this programme. The programme has been designed as per the New Education Policy (NEP) 2020. At least 12 faculty from the physics department will be part of the programme.”

Prof. Ananth said that IISER Pune is ideally placed to offer such a Masters because it is host to the DST Technology-Innovation-Hub on Quantum Technologies with 12 faculty members from the physics department working actively in sub-fields of Quantum Technology.

Source: https://www.iiserpune.ac.in/news/

May 21, 2024

Dr. Kameshwar Yadavalli Highlights Superconducting Quantum Processor Advancements at C-DAC Bangalore's Quantum Outreach Webinar Series

C-DAC Bangalore, in association with IEEE, recently hosted the 15th installment of its Quantum Outreach Webinar Series, themed "Superconducting Quantum Processors and Their Performance Improvement Through Material and Process Optimization." This engaging session featured Dr. Kameshwar Yadavalli, Vice President Fab at Rigetti Computing, who offered an in-depth exploration of the latest advancements and future prospects in quantum computing.

The event began with an address by Dr. S.D. Sudarsan, Executive Director of C-DAC Bangalore, where he explained the importance of such events and highlighted other activities of C-DAC.

Dr. Yadavalli provided a comprehensive overview of superconducting quantum processors, emphasizing how material and process optimization can significantly enhance their performance. His insights highlighted the transformative potential of these advancements in tackling complex computational problems that classical computers cannot efficiently solve.

The event was conducted in a hybrid mode, accommodating both physical and virtual attendees. This inclusive format drew a diverse audience of researchers, students, and industry

professionals, all keen to stay abreast of cutting-edge developments in quantum technology. The interactive session concluded with a vibrant Q&A segment, where Dr. Yadavalli addressed a range of questions, fostering a deeper understanding of the performance improvement of superconducting quantum processors and the current challenges facing the field.

C-DAC Bangalore's Quantum Outreach Webinar Series aims to disseminate knowledge and foster collaboration within the quantum computing community. The partnership with IEEE for this initiative underscores a shared commitment to advancing technological education and innovation.

Following the event, Dr. Kameshwar participated in a ceremonial tree planting, where he planted a sapling at C-DAC Bangalore, EC Campus. This act symbolized the commitment to growth and sustainability, reflecting the organization's dedication to fostering a greener future.

Source: C-DAC

May 21, 2024

UN Declares 2025 International Year Of Quantum Science And Technology

The United Nations proclaimed 2025 as the International Year of Quantum Science and Technology (IYQ). According to the proclamation, this year-long, worldwide initiative will "be observed through activities at all levels aimed at increasing public awareness of the importance of quantum science and applications."

Recognizing the importance of quantum science and the need for wider awareness of its past and the need for wider awareness of its past and future impact, and the need for wider awareness of its past and future impact, dozens of national scientific societies gathered together to support marking 100 years of quantum mechanics with a U.N.-declared international year. Led by the nation of Mexico, in May 2023 the Executive Board of the United Nations Educational, Scientific, and Cultural Organization (UNESCO) endorsed a resolution encouraging official UN proclamation, followed by an endorsement of the full UNESCO General Conference in November 2023, which was co-sponsored by nearly 60 countries.

In May 2024, the nation of Ghana formally submitted a draft resolution for official proclamation of the International Year to the U.N. General Assembly that garnered co-sponsorship from six countries before its approval. On June 7, 2024 the U.N. General Assembly officially declared 2025 to be The International Year of Quantum Science and Technology.

The year 2025 was chosen for this International Year as it recognizes 100 years since the initial development of quantum mechanics

The U.N. declaration is a signal for any individual, group, school, institution, or government to use 2025 as an opportunity to increase awareness about quantum science and technology. The IYQ Steering Committee is planning global initiatives and events, particularly those that reach audiences unaware of the importance of quantum science and technology. As 2025 approaches, this website will spotlight events, resources, and activities focused on quantum science.

Looking forward, quantum science and technology will be a key cross-cutting scientific field of the 21st century, having a tremendous impact on critical societal challenges highlighted by the U.N.'s 2030 Sustainable Development Goals, including climate, energy, food safety and security, and clean water. The most important step in finding new insights and new solutions will be inspiring young people, drawn from all over the world, to be the next generation of quantum pioneers who see beyond the surfaces and screens around them and use quantum science to make a positive difference in the lives of others. This International Year is an opportunity for young people — and curious people of any age — to learn more about all the ways quantum science underpins the physical world around us, drives technological innovation, affects government policies, impacts the global economy, and influences art and culture.

100 years of quantum is just the beginning...

Source: https://quantum2025.org/en/

June 15, 2024

Dr. Jitendra Singh, Union Minister for Science & Technology (Independent charge) chaired a review meeting of Department of Science and Technology (DST)

"India has produced over 40 Quantum Technology start-ups in 2 years, few of them with global potential," says Dr. Jitendra Singh, Union Minister of State (Independent Charge) for Science and Technology, Minister of State (Independent Charge) for Earth Sciences, MoS PMO, Department of Atomic Energy and Department of Space and MoS Personnel, Public Grievances and Pensions, today in New Delhi.

Chairing a review meeting of Department of Science & technology the union minister Dr. Jitendra Singh directed the officials to focus on the flagship National Quantum Mission and work on development of quantum technologies and quantum communication. As India is currently on an equal pedestal with other nation in terms of Quantum technologies are concerned, he added. According to him our mission and vison should be to establish India as a global leader as far as Quantum technologies are concerned.

Dr, Jitendra Singh highlighting the role of startups and private sector in development of Science and Technology shared the success story of 'QuNu Labs', a Bangalore based startup incubated by 'IIT Madras' which has signed a MoU with the Technology Development Board 'TDB' for development of security products based on Quantum Technologies.

Dr. Jitendra Singh said "Women's Participation in extramural research and development (R&D) doubled in the last 10 years" on the increased participation of women after the special efforts by the government in the last decade and promote women scientists and researchers through fellowship STEM programme. He also recalled the 'ease of applying' by referring to 'Common Fellowship Portal' recently inaugurated by him. Going further he shared that around 300 women scientists are going to receive research grants for 3 years from government under ASPIRE scheme.

The Science and technology Minister expressed his satisfaction that India's is becoming the 'Startup capital of the world' from few hundreds before 2014 to more than 1.25 lakh in 2024 and more than 110 unicorns with startups doing excellent work even in critical areas such Space sector. Dr. Singh also highlighted massive jump in India's ranking in Global Innovation Index from 81st in the year 2015 to 40th in 2023. He emphasized on the fact that

India ranks 3rd in terms of number of Publications and number of PhDs awarded in Science and Engineering.

"Prime Minister Narendra Modi's resolve to empower and provide ease of living to the last man standing should be the aim of our innovation" said Dr. Jitendra Singh while motivating the team DST on their future course of action. He categorically mentioned that it is the best time for development of science and technology in India due to the conducive environment under the leadership of PM Modi. He shared that Indian government has invested around 900 crores from 2016- 2023 in National Initiative for developing and Harnessing Innovations(NIDHI) which is supporting budding entrepreneurs in the field of S&T.

The meeting was attended by Prof. Abhay Karandikar, Secretary, Department of Science and Technology; Shri.Sunil Kumar, Additional secretary; Shri Hitesh Kumar S. Makwana, Surveyor General of India; Directors of Institutes under DST, Head of various departments along with senior scientists and officials.

India ranks 3rd in terms of number of Publications and number of PhDs awarded in Science and Engineering.

The union Minister also enquired on the progress of existing National geospatial mission, Interdisciplinary Cyber Physical Mission. He also highlighted the government's efforts on bringing legislation on Anusandhan NRF.

Source: PIB

June 17, 2024

DoT announces two significant calls for proposals aimed at catalyzing innovation and technological advancement in telecommunications sector

In a signification move towards Jai Anusandhan, aimed at promoting innovative Start-ups in the country and to establish an ecosystem of research and entrepreneurship the Department of Telecommunications (DoT) has announced two significant calls for proposals aimed at catalyzing innovation and technological advancement in the telecommunications sector. These initiatives underscore DoT's commitment to fostering indigenous R&D, promoting IP creation, and achieving inclusive digital growth across India.

These proposals are under the categories- '5G Intelligent Village' and 'Quantum Encryption Algorithm' and invites participants from industry, MSMEs, Start-ups, academia and government departments involved in technology design, development, commercialization of telecommunication products and solutions.

These proposal shall be funded under Telecom Technology Development Fund (TTDF) scheme of the DoT and represent pivotal steps towards harnessing advanced technologies for societal benefit and reinforcing India's leadership in telecommunications innovation.

Call for proposals on the 'Quantum Encryption Algorithm' to advance cutting-edge methods for securing digital communication.

5G Intelligent Village

The 5G Intelligent Village Initiative responds to the pressing need for equitable technological advancement by harnessing the transformative power of 5G technology to uplift rural communities. The Call for Proposals-"From Connectivity Gaps to Smart Solutions: Designing 5G Networks for Rural Innovation-5G Intelligent Villages"- aim to addresses critical pillars such as agriculture, education, healthcare, governance, and sustainability.

Quantum Encryption Algorithm (QEA)

The call for proposals is for developing an India specific Quantum Encryption Algorithm (QEA) that will represent a cutting-edge approach to securing digital communication channels by leveraging the principles of quantum mechanics. The algorithm should ensure Unparalleled Security; Advanced Encryption Capabilities; Ultrafast and Efficient Encryption etc. More details at https://ttdf.usof.gov.in/users/quantumencryption

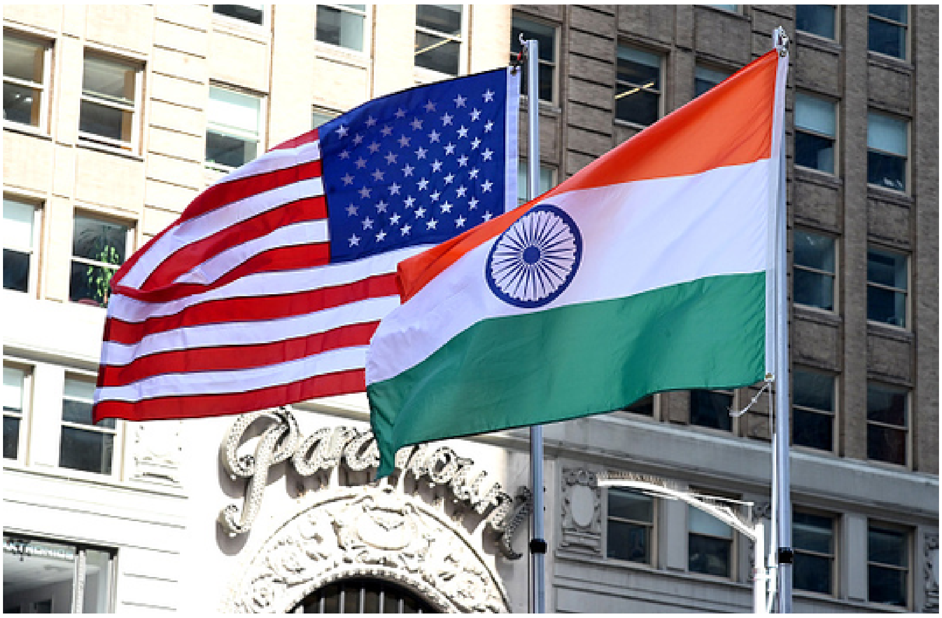
Source: PIB

Deadline: The Last date of submission of applications is 31.07.2024

June 18, 2024

India, US to launch new cooperation in quantum technology, biomanufacturing; announce cooperation on telecommunications

India and the United States have agreed to launch new collaborations in the field of quantum science and technology and develop a joint strategic framework to build biopharmaceutical supply chain optimization.



The two countries released a joint fact sheet after the second meeting of the US-India Initiative on Critical and Emerging Technology (iCET) in the national capital on Monday.

The meeting was chaired by National Security Advisor Ajit Doval and visiting US National Security Advisor Jake Sullivan. iCET was launched by New Delhi and Washington in January 2023. The Biden administration has confirmed reducing barriers to US exports to India for high-performance computing and source code technologies.According to the joint statement, the two countries will form a public-private collaboration between India's India 6G Alliance and the US Next G Alliance for open RAN field trails and roll-out in both countries.

The two countries have also decided to expand cooperation in quantum communications, post-quantum migration and security and digital twins technology. They will also work to promote joint research and development to generate public interest through commercialization of the technology. India and the US have a long-standing collaboration and “Quantum Technologies and AI for Transforming Lives” competition, promoting joint R&D for public good. Commercialization of technology.

The project will be supported by US funding. The two countries have agreed to "launch new collaborations in quantum science and technology, including launching a workshop on post-quantum cryptography at the University of California, Los Angeles and collaborating with academic and private sector Indian "Includes travel facilities for technical experts." U.S. National Laboratories and the Quantum Institute," according to the joint fact sheet.

He also welcomed the membership of the Indian Center for Advanced Computing Development in the Multilateral Information Exchange Mechanism, the US Accelerated Data Analytics and Computing Institute, as the Biden-Harris Administration works with the US Congress to reduce barriers to US exports to India. Continues. High-performance computing and source code.

Source: The Indian Community

June 25, 2024

Quantum Security Research Lab launched on 23rd Foundation Day of SETS in Chennai

Professor Ajay Kumar Sood, Principal Scientific Adviser to the Government of India and Dr. Parvinder Maini, Scientific Secretary, today (June 25, 2024) attended the 23rd Foundation Day of the Society for Electronic Transactions and Security (SETS) in Chennai. Prof. Sood also inaugurated the Quantum Security Research Lab on the occasion. Conceived by Dr. A.P.J. Abdul Kalam in 2002, SETS, an initiative of the Office of Principal Scientific Adviser o the Government of India, is a cybersecurity R&D organization pursuing research in the core areas of cyber security, cryptology, hardware security, quantum security, and network security.

The celebration kicked off with Dr. N Subramanian, Executive Director, SETS extending a warm welcome and delivering a brief on SETS' research and development activities. He mentioned that SETS has developed futuristic solutions like Post Quantum VPN, Quantum Random Number Generator (QRNG), Key Distillation Engine (KDE) for Quantum Key Distribution, PKI solution, Ransomware Early Detection Solution, Security for Blockchain, etc. SETS is working with various academic institutions including IITs and IISc Bangalore, government agencies, national R&D organizations, and user agencies such Department of Atomic Energy (DAE), Department of Defense Research and Development Organisation (DRDO), and state governments for collaborative research and innovation.

Delivering the presidential address, Prof. Sood congratulated SETS for their efforts in developing and deploying indigenous cybersecurity solutions in areas such as cryptography, secure quantum communication, hardware security, and network security. He also lauded SETS' success in translating lab research into field applications, including the deployment of VPNs for the strategic sector and the Quantum Random Number Generation (QRNG) solution for industry and strategic agencies.

Prof. Sood encouraged SETS to leverage its expertise to lead national efforts in Post Quantum Cryptography and to deepen the collaboration with industry, R&D labs, and academia to ensure the nation's computing and communication infrastructure is quantum-safe. He emphasized on scaling up successful projects like hardware security testing and post-quantum cryptography.

In her special address, Scientific Secretary Dr. Maini commended the scientists and staff of SETS for their impactful contributions. She stressed the importance of continuously upgrading cybersecurity measures to address new vulnerabilities and dynamic threat landscapes, citing recent cyber threat incidents. Dr. Maini recognized recent enhancements in SETS' infrastructure for undertaking the upcoming challenges as these advancements are crucial for SETS to effectively tackle cybersecurity challenges and develop robust solutions.

Dr. Maini also noted SETS's involvement in cutting-edge projects, including AI for cybersecurity under the National Supercomputing Mission. She asserted the importance of standard-based development for international collaborations in areas like quantum communication and 6G. She also highlighted the need for SETS to collaborate with industry to advance its technologies from research to field deployment.

Dr. Sanjay Bahl, Director General, Indian Computer Emergency Response Team, Ministry of Electronics and Information Technology (MeitY), in his address, mentioned the evolving concerns of cybersecurity in the context of AI, the proliferation of the Internet of Things (IoT), and drones. He urged that SETS should evolve a roadmap to address these challenges and develop innovative solutions.

This was followed by Prof. Sood inaugurating the Quantum Security Research Lab of SETS. He appreciated the demonstrations carried out by the SETS team on QRNG, post-quantum implementation in Arm-Cortex, True Random Number Generator (TRNG), and KDE. The team also demonstrated the Metro Area Quantum Access Network (MAQAN), jointly being implemented by SETS, IIT Madras, and the Centre for Development of Advanced Computing (C-DAC).

The Foundation Day celebration also witnessed Technology Sessions hosted by SETS' scientists and provided a technical deep dive into topics including post-quantum cryptography, side-channel analysis & hardware security, quantum communication security, security for blockchain, and network & IoT Security areas.

Source: PIB

June 27, 2024

IBM Quantum Connect Event Highlights India's Quantum Computing Prowess

The Quantum Connect event was held on 27th June 2024 at the IBM India Research Lab, Bangalore drawing over 60 faculty members and industry experts from India's top institutes. The attendees gathered to hear insights from Jay Gambetta, Vice President of IBM Quantum, and to learn about the diverse research and teaching efforts in quantum computing across India, some of which are in collaboration with IBM.

Jay emphasized India's significant role in the quantum computing landscape, noting that the country has the second-highest number of open-access quantum computing users globally, with around 77,000 users, trailing only the United States.

There is algorithm discovery yet to be done in the scientific area to understand how to model different concepts using quantum computing. The next step would be to extend it to real-world use cases," Jay said.

During his visit to the IBM Research Bengaluru office, Jay engaged with faculty members from India's premier universities to discuss special research and development collaborations. He expressed his excitement over witnessing India's impressive quantum growth story firsthand and reiterated IBM Quantum's commitment to supporting India's National Quantum Mission (NQM).

India has the second-highest open access quantum computing users after US

He highlighted the vast opportunities for the Indian industry to lead in quantum computing applications in high-priority areas such as sustainability, energy, green hydrogen, efficiency of CO_2 recapture processes, nitrogen optimization in agriculture, and logistics.

In October last year, IBM and the Centre for Development of Advanced Computing (C-DAC) forged a collaboration to advance NQM. This partnership aims to build competency in quantum computing technology, develop applications in areas of national interest, and cultivate a skilled quantum workforce.

Jay concluded by stating that India leads the world in participation in IBM Quantum events, surpassing the US and all other countries. "India is a global hot spot of quantum work, quantum learning, and excitement about this technology and its possibilities," he said.

The event underscored India's burgeoning role in the global quantum computing arena and highlighted the collaborative efforts driving this growth. As India continues to make strides in this cutting-edge field, events like Quantum Connect play a crucial role in fostering innovation and collaboration.

India leads the world in participation in IBM Quantum events, surpassing the US and all other countries.

"India is a global hot spot of quantum work, quantum learning, and excitement about this technology and its possibilities,"

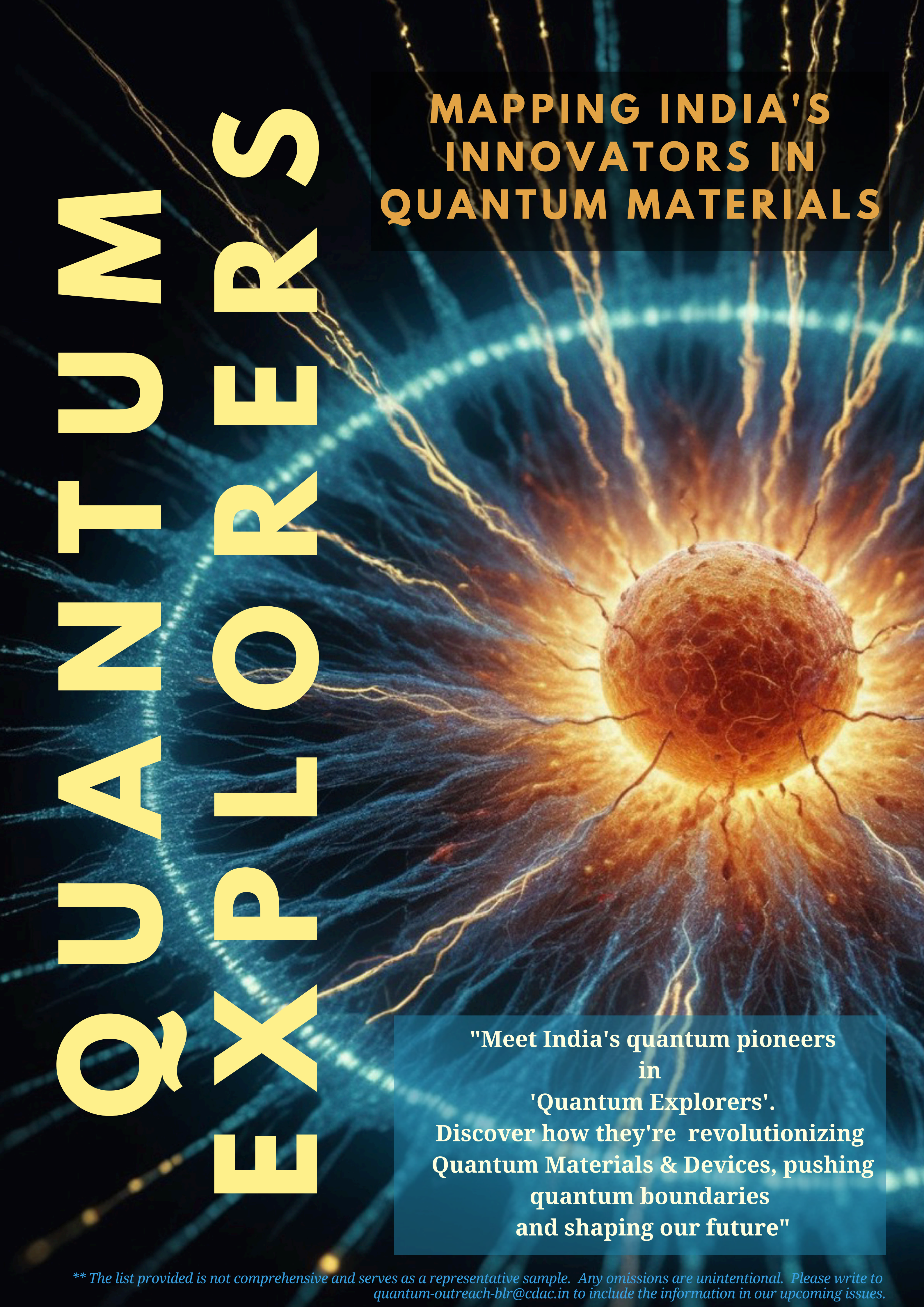
Their initiatives focus on workforce enablement, industry and startup development, research and development (R&D), and quantum services and infrastructure.

"Dozens of Indian students have taken quantum internships at IBM facilities in Delhi and Bengaluru," Jay noted, adding that IBM Quantum has already certified about 615 quantum professionals from India, a figure second only to the US. "We know that there is tremendous grassroots interest in quantum computing in India," he said.

Since 2021, more than 200,500 people in India have accessed IBM Quantum learning resources. Additionally, over 1,000 students from more than 130 institutions across India have completed lessons through IBM's learning platform since 2023. The Qiskit YouTube channel has garnered over 13,000 subscribers and 1.2 million views from India, showcasing the country's enthusiastic engagement with quantum learning. "In all these statistics, India is second only to the US," Jay said.

Source: ET

Source: IBM



QUANTUM EXPLORERS

MAPPING INDIA'S INNOVATORS IN QUANTUM MATERIALS

"Meet India's quantum pioneers
in
'Quantum Explorers'.
Discover how they're revolutionizing
Quantum Materials & Devices, pushing
quantum boundaries
and shaping our future"

*** The list provided is not comprehensive and serves as a representative sample. Any omissions are unintentional. Please write to quantum-outreach-blr@cdac.in to include the information in our upcoming issues.*

QUANTUM EXPLORERS

Quantum Materials & Devices

Prof. Arindam Ghosh

IISc, Bangalore

Prof. Arindam Ghosh is leading the Quantum Materials and Devices Group at the IISc., focusing on two-dimensional hybrid material-based Optoelectronics and Spintronics. Research delves into quantum effects, carbon-based electronics, critical behavior in smart materials, and novel nano/micro-electromechanical sensing Q techniques.

Dr. Bivas Saha

JNCASR

Dr. Bivas is an Assistant Professor, Chemistry and Physics of Materials Unit (CPMU), Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR) His research areas include heterostructure and thin film, metal/semiconductor superlattice, refractory plasmonics and radiative cooling, and artificial synapse.

Prof. Bhaskaran Muralidharan

IIT Bombay

Prof. Muralidharan is a faculty member in the Department of Electrical Engineering at IIT Bombay, where he leads the Computational Nanoelectronics & Quantum Transport Group (CNQT). His expertise lies in the area of computational quantum transport, with a focus on the microscopic simulation of non-equilibrium phenomena.

Prof. Satish Patil

IISc. Bangalore

Prof. Satish Patil is a Professor at the Indian Institute of Science, Bangalore, heading the Organic Materials for Molecular Electronics group. His research focuses on exploring various aspects of molecular electronics, including organic photovoltaics, light-emitting diodes, and field-effect transistors.

Dr. Akshay Singh

IISc, Bangalore

Dr. Akshay is an Assistant Professor at IISc., Bangalore. He specializes in geochemistry and geophysics, condensed matter experimental physics, and material synthesis. His research focuses on ultrafast time-resolved spectroscopy, quantum materials synthesis, two-dimensional semiconducting materials, and the fundamental dynamics in semiconductors.

Prof. Indranil Sarkar

INST Mohali

Prof. Indranil Sarkar is a Professor and the Dean of Administration at Institute of Nano Science and Technology (INST). He heads the Experimental Physics Group, focusing on understanding and developing quantum materials and spintronic platforms.

QUANTUM EXPLORERS

Quantum Materials & Devices

Dr. Ashish Arora

IISER Pune

Dr. Arora is an Assistant Professor of Physics specializing in experimental condensed matter physics. His research interests include 2D materials, layered semiconductors, magneto-optics, high magnetic fields, quantum materials and devices, magnetism at the nanoscale, semiconductors and their nanostructures, and low-dimensional physics.

Prof. Abir De Sarkar

INST, Mohali

Dr. Abir De Sarkar is a Professor (Scientist G) at the Institute of Nanoscience and Technology (INST). His research focuses on energy conversion using 2D materials, aiming to address critical challenges in energy and advanced electronics.

Dr. Chandni U

IISc, Bangalore

Dr. Chandni is an Assistant Professor, Department of Instrumentation and Applied Physics, Indian Institute of Science (IISc), Bangalore. Dr. Chandni's research interests focus on studying electron transport in various low-dimensional semiconductor and metallic systems.

Dr. Pavan Nukala

IISc, Bangalore

Dr. Pavan Nukala is an Assistant Professor at the Centre for Nanoscience and Engineering at IISc Bangalore. His research focuses on correlated systems, with a particular interest in ferroic oxides and phase-change materials. His work significantly advances the field of nanoscience and engineering.

Prof. Vidhyadhiraja

JNCASR

Prof. Vidhyadhiraja N S is a Professor at the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR). His research group employs techniques of quantum many-body theory to understand materials within the framework of simple models.

Prof. Surjeet Singh

IISER Pune

Prof. Surjeet Singh is a Professor of Physics at IISER Pune.Quantum Materials Lab, where his research focuses on exploring unconventional ground states in quantum materials. His work investigates competing magnetic interactions on various frustrated and low-dimensional lattices, including triangular, Kagome, pyrochlore, and zigzag chains.

QUANTUM EXPLORERS

Quantum Materials & Devices

Prof. Srimanta Middey

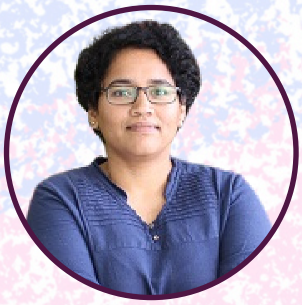
IISc, Bangalore

Prof. Srimanta Middey is an Associate Professor at the Indian Institute of Science, Bangalore. His research focuses on emergent phenomena in oxide heterostructures, strongly correlated systems, metal-insulator transitions, superconductivity, magnetism, and X-ray spectroscopy and scattering.

Dr. Anshu Pandey

IISc, Bangalore

Dr. Anshu Pandey is an Associate Professor at Indian Institute of Science Bangalore. focused on researching new physical properties emerging in nanoscale matter. Her interests include Quantum Dot Microscopy and Spectroscopy, Photodetectors, and Plasmonic Materials.



Dr. Dhavala Suri

IISc, Bangalore

Dr. Dhavala Suri is Assistant Professor at Indian Institute of Science, Bangalore. Her lab at CeNSE, IISc - Quantum Materials Lab, studies electronic properties of nano-devices of material interfaces that combine aspects of topology, superconductivity and magnetism for applications in quantum technology.

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Dr. Anindya Das is an Associate Professor in the Department of Physics at the Indian Institute of Science, Bangalore. His research interests include Quantum Hall and Superconductivity, Edge dynamics, Thermal transport, Shot noise, p-n junctions, and Twisted bilayer graphene.

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Dr.R.R.Hawaldar

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Dr. R.R. Hawaldar works at the EPG, Centre for Materials for Electronics Technology (CMET), Pune. His research focuses on Materials Chemistry, Nanotechnology, and Green Chemistry.

PUBLICATIONS

List of selected publications in Quantum Technologies during April to June 2024

Verifiable blind quantum computing with trapped ions and single photons. *April 2024*	Physical Review Letters, 132(15), 150604 *Drmota, P., Nadlinger, D. P., Main, D., Nichol, B. C., Ainley, E. M., Leichtle, D., ... & Lucas, D. M.*
Error-corrected quantum repeaters with Gottesman-Kitaev-Preskill qudits *April 2024*	Physical Review A, 109(4), 042427 *Schmidt, F., Miller, D., & van Loock, P.*
Experimental property reconstruction in a photonic quantum extreme learning machine *April 2024*	Physical Review Letters, 132(16), 160802 *Suprano, A., Zia, D., Innocenti, L., Lorenzo, S., Cimini, V., Giordani, T., ... & Paternostro, M*
Creation of memory–memory entanglement in a metropolitan quantum network *May 2024*	Nature, 629(8012), 579-585 *Liu, J. L., Luo, X. Y., Yu, Y., Wang, C. Y., Wang, B., Hu, Y., ... & Pan, J. W.*
Entanglement of nanophotonic quantum memory nodes in a telecom network *May 2024*	Nature, 629(8012), 573-578 *Knaut, C. M., Suleymanzade, A., Wei, Y. C., Assumpcao, D. R., Stas, P. J., Huan, Y. Q., ... & Lukin, M. D.*
Quantum Data Assimilation: A New Approach to Solve Data Assimilation on Quantum Annealers *June 2024*	Nonlinear Processes in Geophysics Discussions, 2023, 1-16 *Kotsuki, S., Kawasaki, F., & Ohashi, M.*

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