



Workshop on 'Enabling solutions for Quantum Technologies development' – a Report

The UK-based **Oxford Instruments (OI) plc**, a leading provider of high technology products and services to the world's leading industrial companies and scientific research communities in the field of Nanotechnology, Quantum technologies, Semiconductors etc. and **IIT Delhi** organized a one-day workshop on '**Enabling Solutions for Quantum Technologies development**' with the aim of '**Accelerating the research on Quantum devices**' on June 21, 2023. This workshop was organized by **Mr Gurpal Singh** from OI and **Prof. Rajendra Singh** from IIT Delhi. The venue was IRD conference hall, seventh floor, main building of IIT Delhi. This workshop was organized in hybrid mode and it received 76 registrations for in person attendance and 97 registrations for online attendance from all over India.

The workshop was also recorded and will be made available to watch online for anyone interested, by Oxford Instruments.

1. Mr. Mangesh Kulkarni, Country Director for OI in India, inaugurated the one-day workshop.

- Gave an overview of OI, including its early beginnings, founder, worldwide offices, and broad areas of work.
- Highlighted OI's key collaborators and its presence and commitment in India.
- Discussed the role of the Mumbai office in maintaining stocks and spares for customers in India.
- Mentioned 'Science Prizes' and award instituted by OI globally and in INDIA to incentivize the research into Nanotechnology

2. Prof. Rajendra Singh, Associate Dean R&D, IIT Delhi, welcomed all present and discussed IIT Delhi's past involvement with OI in the Nanoscience space.

- Informed about the "National Quantum Mission," an initiative of the Government of India.
- Described the four verticals identified for work at IIT Delhi: Quantum Computing, Quantum Communication and Cryptography, Quantum Sensing and Metrology, and Quantum Materials & Devices.
- Emphasized the need for establishing a Fabrication facility dedicated to Quantum devices at IIT Delhi.

3. Dr. Russ Renzas, Quantum Technology segment Manager at Oxford Instruments Plasma Technology, introduced OI's quantum technology solutions.

- Provided an overview of the key working verticals in quantum technology at OI, including Quantum Computing, Quantum Communication, Quantum Sensing, and Fundamental Science.
- Explained various technology options available for fabricating quantum devices, such as superconductors, Ion Trap, Photonics, Colour Centres, and Cold atom.
- Stressed the vast opportunities in the field of quantum technology and OI's role in fabrication, measurement, testing, and global outreach.
- Highlighted OI's involvement in conceiving ideas and writing research proposals in quantum technology.



4. Prof. RK Sharma (ex-DRDO Director):

- Highlighted the challenge of low coherence time in quantum systems.
- Explored methods to increase the lifetime of quantum systems.
- Discussed the importance of sensitive systems for quantum radar.
- Emphasized the sensitivity of quantum aperture to electric fields.
- Introduced the concept of vector magnetic sensors for low magnetic detection.
- Discussed the need to filter out the Earth's magnetic field in certain applications.

5. Dr Harriet van der Vliet, (Oxford Instruments Nano Sciences) : Enabling quantum technology research in a multi-user and multi-system environment

- Presented about ultra-low temperature Dilution Refrigerators for Quantum Technologies, flexible and scalable systems such as ProteoxQX .
- Discussed the need for advanced software controls for such systems.
- Highlighted the use of multiple interchangeable secondary inserts to enable multiuser environment and bottom loaders for faster sample exchange.
- Mentioned about some of the leading Companies such as Rigetti Computing, AWS involved in quantum computing utilizing Oxford systems
- Discussed about, Quantum Microwave Communication and Sensing, Gas-gap heat switches, Electrical transport measurement, magnets etc.

6. Dr. Ruzz Renzas (Oxford Instruments plasma technology): Making better quantum devices with atomic scale processing.

- Presented four areas of focus: computing, communication, sensing, and fundamental science.
- Mentioned major technology companies such as Intel, IBM, Google, and Amazon in the context of computing.
- Highlighted the need for secure communication.
- Discussed challenges in navigation without GPS, particularly in cave environments.
- Emphasized the importance of maintaining the encoded state to avoid problems.
- Mentioned plasma technology and its applications, including an application lab in Taiwan and Shanghai.

7. Prof. Arindam Ghosh (IISc Bangalore): 2D materials based devices for emerging electronics and quantum technology

- Presented qubits, superconductors, detectors, and peripheral classical electronics as areas of study.



- Explained the use of Si and hBN defects at high temperatures.
- Discussed thermoelectric devices, single photon detectors, and neuromorphic devices.
- Highlighted the high optical gain in 2D materials.
- Mentioned the challenges of avalanche photon detection and the use of bi-layer graphene to reduce dark counts.
- Explored neuromorphic computing and its potential applications.

8. Dr. Santanu Manna (Assistant Professor IIT Delhi): GaAs and InP based quantum devices for classical/quantum emitter

- Introduced the concept of quantum cascade lasers (QCL).
- Discussed the generation of single and entangled photons using quantum dots (QD).
- Explained the fabrication process using droplet etching for lattice-matched, strain-free QD structures.
- Presented the creation of a quantum key distribution (QKD) system.
- Mentioned the Purcell factor and count rates achieved in their research.

9. Dr. Colin Coates (Oxford Instruments Andor): Advanced detector solutions for quantum optics

- Provided solutions for quantum optics, including imaging of entangled photons, quantum gases, and quantum materials.
- Presented various detector types for quantum imaging, such as CCD, EMCCD, sCMOS, and intensified cameras.
- Discussed the capabilities of EMCCD in correlated photon detection and its unique features.
- Mentioned intensified cameras for broad spectral response and fast kinetics imaging.
- Highlighted single-photon sensitivity and its application in measuring fluorescence from discrete atoms.
- Characterized detectors at different temperatures, including liquid nitrogen and helium.

10. Dr. Poornendu Chaturvedi (SSPL Delhi): Fabricating Ultra deep cavities for alkali vapour cells

- Discussed the development of an ultra-small atomic clock using rubidium atoms.
- Presented the fabrication of a silicon based alkali vapour cell.
- Highlighted the challenge of sidewall roughness in deep cavity fabrication.
- Described different etching approaches, including wet etching and laser milling, to improve roughness.
- Mentioned the use of optimized photoresist and laser release of alkali atoms.



11. **Prof. Somabrata Acharya (School of applied and interdisciplinary sciences, Indian Association for the cultivation of Science): Probing 2D molecular crystals formation for luminescence enhancement**
 - Explored crystal growth control through bond manipulation.
 - Discussed the measurement of 2D structure coverage.
 - Mentioned the use of TEM-EDS for FinFET transistor analysis.
 - Highlighted the capabilities of EDS imaging, layer probing, EBSD, and WDS for characterization.
 - Emphasized the non-destructive nature of layer thickness measurement.

12. **Dr. Lucia Spasevski (Oxford instruments Nanoanalysis): Oxford instruments Nanoanalysis solutions for semiconductor advanced inspection and metrology**
 - Presented an instrument capable of multiple characterizations, including EDS, WDS and EBSD.
 - Mentioned the analysis of a FinFET transistor using TEM-EDS.
 - Highlighted the rapid analysis and non-destructive nature of layer probing.
 - Introduced a new pattern-matched analysis mode in EBSD.
 - Discussed the superior detection limit in WDS measurement.
 - Mentioned automated analysis and location capabilities. Briefly mentioned BEX detectors for X-ray imaging

Closing remarks: The workshop featured several speakers who covered a diverse range of topics related to quantum technologies, materials, detectors, and characterization techniques, providing valuable insights into the advancements and challenges in these fields.

While concluding, Mr. Gurpal Singh gave the vote of thanks and acknowledged the help and support from various individuals for the organization of this workshop, with special thanks to Dr. Nahid Choudhary and the office staff from Associate Dean, RnD, IIT Delhi. It was also recommended that such focused workshops/meetings in the areas of 'Quantum Devices' shall be held regularly in the future for the benefit of the quantum community that is coming up in various Institutions and industries across India and outside.

If you need more information about workshop or link to online recording of workshop please contact,

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Enjoy Some Photos from the workshop







