Empowering Faculty for India's Quantum Leap – Faculty Development Program on Quantum Materials & Devices

Venue: IRD Conference Hall, IIT Delhi
Dates: 25th – 26th September, 2025
Sponsored by: QMD Foundation, National Quantum Mission
Project Director: Prof. Rajendra Singh
FDP Coordinator: Prof. Nirat Ray

Day 1: 25th September 2025

Inaugural Session

The program commenced with registration followed by a welcome address. Prof. **Rajendra Singh** introduced the **Quantum Materials and Devices Hub**, highlighting its vision under the National Quantum Mission. He emphasized the strategic role of quantum materials in shaping next-generation devices for computing, communication, and sensing, setting the stage for the technical sessions ahead.

Session 1

1. **Introduction to Quantum Materials and Devices Hub**
   Speaker: **Prof. Rajendra Singh, IIT Delhi**
   Prof. Singh outlined the objectives of the Hub: fostering interdisciplinary research, enabling faculty development, and establishing India's leadership in quantum materials. He stressed collaborations between academia, industry, and government in building indigenous quantum technologies.
2. **CMOS Technology for Quantum Computing**
   Speaker: **Prof. Samaresh Das, IIT Delhi**
   Prof. Das discussed the compatibility of existing **CMOS (Complementary Metal-Oxide-Semiconductor)** platforms with quantum device fabrication. He explained the challenges of scaling quantum devices, fabrication constraints, and prospects of hybrid CMOS-quantum systems that could bridge conventional electronics with quantum architectures.

Session 2

1. **Vapor Phase Synthesis of Epitaxial Transition Metal Dichalcogenides**
   Speaker: **Prof. Tanushree H. Choudhury, IIT Bombay**
   Prof. Choudhury presented methods of vapor phase epitaxy for high-quality 2D materials. She discussed crystal growth parameters, challenges in achieving large-area uniformity, and potential applications in optoelectronics and quantum devices.
2. **Microring Resonators for Classical and Quantum Applications** *(Online)*
   Speaker: **Prof. S. K. Varshaney, IIT Kharagpur**
   Prof. Varshaney explained the principles of microring resonators and their dual role in classical optical communication and quantum photonic circuits. His lecture highlighted integration challenges and opportunities in scaling up photonic quantum technologies.
3. **Quantum Dots for Emission: Insights from Computational Simulations**
   Speaker: **Prof. Dibyajyoti Ghosh, IIT Delhi**
   Prof. Ghosh elaborated on computational modeling of quantum dots, addressing their tunable emission spectra, role in quantum light sources, and importance for secure quantum communication.

Session 3

1. **High-Speed Interface Circuit Design**
   Speaker: **Prof. Ankesh Jain, IIT Delhi**
   Prof. Jain explained high-speed circuit designs required for quantum device readout and control. He emphasized the role of low-noise electronics, scalable architectures, and integration with cryogenic systems.
2. **Tutorial 1: Probing Quantum Materials—Modern Characterization Methods**
   Speaker: **Prof. Nirat Ray, IIT Delhi**
   Prof. Ray delivered an in-depth tutorial on state-of-the-art techniques such as scanning tunneling microscopy, ultrafast spectroscopy, and advanced electron

microscopy. He illustrated how these tools help in uncovering quantum material properties at atomic scales.

3. **Tutorial 2: Introduction to AI/ML Techniques in Quantum Materials**
   Speaker: **Prof. N. S. Harsha Gunda, IIT Delhi**
   Prof. Gunda demonstrated how **artificial intelligence (AI)** and **machine learning (ML)** are accelerating discoveries in quantum materials. He presented case studies where ML was used for predicting material phases, optimizing synthesis routes, and analyzing large datasets from experiments.

Day 2: 26th September 2025

Session 4

1. **Ultrafast Spin and Magnetization Dynamics in 2D Material/Ferromagnet Heterostructures** *(Online)*
   Speaker: **Prof. Anjan Barman, S. N. Bose National Centre for Basic Sciences**
   Prof. Barman highlighted cutting-edge research in spintronics, focusing on ultrafast magnetization processes in 2D heterostructures. He stressed their potential in quantum information storage and spin-based logic.
2. **Noncollinear Magnets: A New Platform for Quantum Spintronics**
   Speaker: **Prof. Prasanta Kumar Muduli, IIT Madras**
   Prof. Muduli introduced noncollinear magnetic systems as promising platforms for topological spin transport. He linked their properties to applications in **quantum spintronics** and **neuromorphic computing**.

Session 5

1. **Oxide Quantum Materials: Why They Matter and How to Perfect Them**
   Speaker: **Prof. Suvankar Chakraborty, INST Mohali**
   Prof. Chakraborty emphasized the multifunctional properties of oxide quantum materials, such as superconductivity and ferroelectricity. He explained experimental methods to optimize their synthesis and integration.
2. **Micron-Size Superconducting Quantum Interference Device (SQUID) as a Nano-Magnetism Probe**
   Speaker: **Prof. Anjan Kumar Gupta, IIT Kanpur**
   Prof. Gupta discussed the design and applications of SQUIDs in probing quantum magnetism at microscopic scales. He demonstrated their role in precision quantum sensing.

Session 6

1. **Quantum Materials to Quantum Hall Resistance Metrology**
   Speaker: **Prof. Anjana Dogra, CSIR-NPL**
   Prof. Dogra explained the transition from quantum materials research to practical standards in electrical resistance. She highlighted how the **quantum Hall effect** underpins resistance metrology.
2. **Quantum Materials for Computing Devices**
   Speaker: **Prof. Satyabrata Patnaik, JNU**
   Prof. Patnaik presented the challenges and opportunities in integrating quantum materials into device architectures for quantum computing. His lecture emphasized materials-engineering approaches for scalability.

Panel Discussion and Closing Session

The event concluded with a **panel discussion** featuring:

- Prof. **Satyabrata Patnaik** (JNU)
- Dr. **Shiv Kumar** (QMD Foundation)
- Prof. **Samaresh Das** (IIT Delhi)
- Dr. **Mamta Khaneja** (SSPL, DRDO)

The panel deliberated on India's roadmap in **quantum technologies**, covering policy, funding, and collaborations with global initiatives. They emphasized **capacity building, industry partnerships, and translational research**.

The program formally ended with high tea and a **tour of the NRF facilities** coordinated by the NRF team.

Conclusion

The FDP successfully brought together experts from leading institutions to provide an immersive learning experience on **quantum materials and devices**. Faculty participants gained exposure to **state-of-the-art experimental methods, theoretical insights, and emerging applications**. The two-day program not only enriched academic knowledge but also opened avenues for research collaboration and innovation aligned with India's **National Quantum Mission**.


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Quantum Materials and Devices
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