"The Quantum Factory"
&
Highlights of the 2022 IEEE International Conference on Quantum Computing and Engineering (QCE22)

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The 3rd IEEE International Conference on Quantum Computing and Engineering (QCE) was held on 9/18-23 in Broomfield, CO (https://qce.quantum.ieee.org/2022/). QCE bridges the gap between the science of quantum computing and the development of its ecosystem. After two successful virtual Quantum Week events during the pandemic, this year's meeting attracted over 1000 attendees (about 700 in-person and 300 virtual). Besides live exhibits, QCE22 offered 9 Keynote talks, 70 technical papers, 60 posters, 16 workshops, 25 tutorials, 13 panels, and 5 Birds-of-a-Feather sessions. All the talks were recorded and made available on-demand on the Hubb virtual platform to all the registrants until November 15, 2022.

EPS is one of five IEEE technical co-sponsors of the conference (EPS, TEMS, Signal Processing, EDS, and CT Soc.). The IEEE financial co-sponsors included IEEE Quantum (https://quantum.ieee.org/about), Computer Society, ComSoc, Photonics Society, and Council on Superconductivity.

Here are the key highlights of the conference:

- Plenary keynotes:
  - "Quantum computing with atoms," C. Monroe (IonQ & Duke University)
  - "Closing the gap between quantum algorithms and machines with hardware – Software co-design," F. Chong (ColdQuanta & U. Chicago)
  - Fault-tolerant quantum computing with photonics," M. Gimeno-Segovia (PsiQuantum)
  - "Making quantum error correction practical with quantum control infrastructure software," M. Biercuk (Q-CTRL & U. Sydney)
  - "Quantum networks: From a physics experiment to a quantum network system," S. Wehner (QuTech & Delft U. of Technology)
  - "The continuous path towards quantum advantage," Katie Pizzolato (IBM)
  - "Azure quantum and the road to scalable quantum computing," W. van Dam (Microsoft)
  - "A measured approach to quantum computing," T. Uttley (Quantinuum)
  - "Superconducting quantum materials and systems – a DOE National Quantum Information Science Research Center," A. Grassellino (Fermilab)
- Full-day educational workshop on quantum science and engineering education organized in four tracks: K-12, university, industry, and community-based education.

- Many workshops, panels, and papers on the application of quantum computing to hardware engineering and architectures, benchmarks and performance metrics, AI, machine learning, renewable energy, chemical design, financial modeling, and climate control.

Of direct relevance to EPS was the lively discussion in the panel on "The Quantum Foundry." Moderated by B. Horning (Quantinuum), the panelists included the following:

- Michael Biercuk, CEO and Founder of Q-CTRL, Prof. of Quantum Physics, U. Sydney
- Ted Letavic, Corp. Fellow, Global Foundries
- Michael Geiselmann, Co-founder and Managing Director, Ligentec
- Steve Kosier, CTO, Skywater Technology
- Celia Merzbacher, Executive Director, QED-C at SRI International
- Daniel Stick, DMTS, Sandia National Laboratories
- Charles Tahan, Director, National Quantum Coordination Office, White House Office of Science and Technology Policy (OSTP)

Regardless of the qubit technology (superconducting, ion trapping, or photonic), the quantum processor relies on adapting existing materials, tools, and processes from semiconductor integrated circuits (IC) or photonic IC (PIC) fabrication. Would scaling the qubit count require a more specialized foundry – the "Quantum Foundry"? The panel addressed three questions: 1. "What are the unique technical challenges confronting the "Quantum Factory?"; 2. "What are the challenges for scaling the processors to 10^4-10^6 qubits?"; 3. "What will it take to get from where we are today to this 10-year vision?".

Commonalities in technical challenges encompass new fab metrology to ensure reliability and yield, I/O access, GHz bandwidth modulation, design software tools, heterogeneous integration, and low-temperature electronics. Cross-fertilization between quantum and other enabling technologies (sensing, LIDAR, telecom, packaging) is already happening and needs to be leveraged. The traditional fab operating model of moving from university research to a consortium project to final production is no longer viable. For timely results, the middleman – the consortium – is removed completely. Existing foundries have a delicate balancing act between research-oriented tasks and production loads. Funding allocation and prioritization must happen.

IEEE Quantum Week brings together researchers, educators, entrepreneurs, and quantum enthusiasts to network, share research results, and collaborate. QCE23 will be held next year in Bellevue, Washington.