AVS Quantum Science Workshop and Panel on Quantum Industry & Workforce Development
Room 123 - Session AQS-SuA

AVS Quantum Science (AQS) Workshop and Panel on Quantum Industry & Workforce Development (INVITED SESSION)

Moderators: Charles R. Eddy, Jr., Office of Naval Research Global - London, UK, **Dave Pappas**, Rigetti Computing, **Andre Schleife**, University of Illinois at Urbana-Champaign, **Sean Jones**, Argonne National Laboratory

3:00pm **AQS-SuA-1 Quantum Information Science at the Air Force Research Laboratory***, Kathy-Anne Soderberg,* Air Force Research Laboratory **INVITED**

Harnessing the power of quantum mechanics may lead to significant advances in quantum timing, sensing, networking, and computing.This talk will highlight the Air Force Research Laboratory's quantum information science portfolio that includes quantum timing, sensing, networking, and computing, and discuss what future capabilities may be enabled by these technologies.We will discuss the research thrusts within each topic area and provide an overview of the research efforts.The talk will also highlight a few recent out-of-the-lab demonstrations focused on operating quantum technologies outside of a well-controlled laboratory environment.The talk will conclude with a discussion on workforce development and how to connect with AFRL.

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3:30pm **AQS-SuA-3 Review of AVS Educational Outreach Activities in the Context of an Evolving Quantum Industry and its Related Workforce Development Needs***, Timothy Gessert,* AVS Education Committee Chair **INVITED**

The AVS has provided various types of education opportunities to its members and others since the mid 1960's. One important component of these activities has been public and private short courses on topics consistent with the needs of various high-technology sectors. Indeed, for many technologists, engineers, and scientists now working in these high-tech industries, their initial exposure to areas such as basic vacuum technology, vacuum-process development, and characterization, often began with an AVS short course. In the mid 1980's, AVS education outreach expanded to include training high-school teachers through the *AVS Science Educators Workshop* (SEW). Through this activity, many hundreds of high-school teachers throughout the U.S. have now received not only basic vacuum training, but also a working vacuum system designed for the needs of a high-school classroom. In addition to the SEW helping these teachers convey the extensive uses of vacuum processes in many industries, another goal of the SEW has always been to possibly help "spark" student interest in considering post-secondary education (i.e., college), and possibly even toward an STEM career involving vacuum technology. Recently, and encouraged by the realities of COVID, many AVS education outreach activities now also include the option for virtual training, including virtual short courses, webinars, and You-Tube videos that can often align better with changing workplace and workforce needs. Additionally, in partnership with the American Institute of Physics (AIP), the AVS is now actively exploring how to better provide this type of education outreach to communities that have been historically underrepresented in the high-technology sectors.

In this presentation, the ~60 years of AVS experience with educational outreach will be briefly reviewed, emphasizing how these ongoing activities and experiences might be leveraged to benefit the workforce needs of a rapidly evolving Quantum Industry. It will also be discussed how, while the workforce of the Quantum Industry will certainly require many skilled individuals with advanced academic degrees, (and similar to the needs of the existing semiconductor industry) the workforce of the new Quantum Industry will also require many individuals with hands-on technology skills in areas such as process development/optimization and equipment operation/maintenance. Because of the long-term AVS experience with training involving all these different workforce sectors, it is believed that much of the established AVS education outreach activities can significant benefit the evolving Quantum Industry.

4:00pm **AQS-SuA-5 Broadening Participation in Quantum Information Science and Engineering as a Generator of Qualified Workforce***, Tomasz Durakiewicz,* National Science Foundation **INVITED**

The highly specialized area of Quantum Information Science and Engineering (QISE) is composed of several convergent disciplinary areas from computer sciences to materials sciences, chemistry, engineering, mathematics and physics. The ongoing explosion of interest in QISE includes new industrial opportunities and preparing for future markets, but also involves a heavy component of fundamental research characteristic to our early and evolving ability to translate QISE discoveries into practical solutions. Within this landscape, the government, industrial partners, academics and educators together express the need for qualified workforce generation. I propose that novel approaches to broadening participation in QISE, including special attention to diversity and inclusion, offer a solution to insufficient workforce while also providing direct benefit to taxpayer by expanding the STEM research and education base across the nation. This point will be illustrated using examples of actual need and corresponding programs, with identification of gaps and areas of future focus.

4:45pm **AQS-SuA-8 The Quantum Industry: Status and Gaps***, Jonathan Felbinger,* SRI **INVITED**

This talk presents a snapshot of the quantum industry: economic trends, perspective on near-term use cases for quantum technologies, the importance of benchmarking quantum solutions, and the need for a diverse workforce. The mission of the Quantum Economic Development Consortium (QED-C®) is to grow the quantum economy via community-building, collaboration, and commercialization. QED-C's approximately 250 member organizations enable the real-world application of quantum technology and, in turn, grow a robust commercial industry and supply chain. QED-C is managed by SRI, an independent nonprofit research institute.

5:15pm **AQS-SuA-10 Alternating Bias Assisted Annealing of Amorphous Oxide Tunnel Junctions***, **Josh Mutus***, Rigetti Computing, Canada*; D. Pappas, M. Field, C. Kopas,* Rigetti Computing*; L. Zhou,* Ames Laboratory*; X. Wang,* Rigetti Computing*; J. Oh,* Ames Laboratory **INVITED**

We demonstrated a novel method for tuning the tunnel barrier of a Joshephson junction by applying a series of alternating bias pulses. While this process allows for significant tuning at room temperature, the rate of resistance change increases with temperature, at 80C we achieve a resistance change of over 70%. The technique was also applied to transmon qubit junctions. The results align with the Ambegaokar-Baratoff relation, indicating a correlation between shifted resistance and critical current. Moreover, the treated junctions exhibited reduced losses and fewer defects compared to untreated samples. Observation through high-resolution TEM imaging, showed a more uniform distribution of aluminum coordination across the barrier. This innovation is anticipated to have broad applications in devices using amorphous aluminum oxide and similar metal-insulator-metal structures in modern electronics.

5:45pm **AQS-SuA-12 Progress Towards Merged-Element Transmons with Si Fins – the Si FinMet***, Chris Palmstrøm,* University of California, Santa Barbara **INVITED**

A merged-element transmon (MET) device combines the capacitor and the Josephson Junction in a superconducting transmon qubit into a single device, which can reduce the size of a qubit by several orders of magnitude[1,2]. We have utilized anisotropic etching of Si(111) relative to Si(110) to define atomically flat, high aspect ratio Si tunnel barriers with superconductor contacts on the parallel side-wall surfaces. By utilizing low-loss, intrinsic float-zone single crystal Si as the barrier material rather than commonly used, amorphous Al_2O_3, the Si FinMET is expected to overcome problems with standard transmons by (1) reducing dielectric losses; (2) minimizing the formation of two-level system spectral features; (3) potentially exhibiting greater control over barrier thickness and qubit frequency spread, (4) reducing the footprint, and (5) allowing scalable fabrication.

We havefabricated and demonstrated low loss Si fin capacitors on Si(110) substrates with shadow-deposited Al electrodes[3]. Lumped element resonators using ~300nm thick fin capacitors have Qi $>5\times10^5$ at low power at 30mK. By adding a Josephson Junction in parallel, transmon devices have been fabricated with T1 times ~20 µs. Recent efforts have been made to make fins thin enough to exhibit tunneling. Preliminary tunneling measurement yield I_cR_n values ~900µV. These results indicate great progress towards the development of Si FinMet devices.

In this presentation, the process and progress in developing a Si fin based merged element transmon – the FinMET, will be discussed.

1R. Zhao, et al., Phys. Rev. Appl. **14**, 064006 (2020).

2H. J. Mamin, et al., Phys. Rev. Appl. **16**, 024023 (2021).

3A. Goswami, et al., Applied Physics Letters **121**, 064001 (2022).

This work has been done in collaboration with T.A.J. van Schijndel, J. K. Nangoi, W. Yánez-Parreño, J.T. Dong, and C. G. Van de Walle at UCSB, A. Goswami at MIT, and A.P. McFadden and R. Simmonds at NIST. The work was supported by ARO W911NF2210052 and UCSB NSF Quantum Foundry funded via the Q-AMASE-i program under award DMR-1906325

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