NATIONAL SCIENCE FOUNDATION
2415 EISENHOWER AVENUE
ALEXANDRIA, VIRGINIA 22314

**NSF 22-074**

# Dear Colleague Letter: Quantum Manufacturing

April 22, 2022

Dear Colleagues:

The potential of powerful quantum-based computing, sensing, and communications to revolutionize science and technology has been demonstrated in initial functioning quantum systems that enable applications and solutions that are currently impossible using conventional technologies. However, quantum systems, particularly quantum computers, are complex and generally require extreme operating conditions that impact their design, stability, and cost. New approaches to manufacturing quantum devices comprising quantum systems are needed to address the demanding requirements for potential operation at sub-1K temperatures, extreme precision in device fabrication and heterogeneous integration, reproducibility, scalability, packaging, and assembly. Additionally, novel device manufacturing approaches are needed to reduce the system cost of quantum systems to make them widely available.

Presently, there are several quantum platforms under development, and each has its own challenges. Solid-state defect, Si-based spin, topological platforms, superconducting and ion trap-based qubits and platforms all have unique challenges and material issues. Aside from research needs in the discovery and refinement of new quantum-based devices, there is a need for new processes for, and approaches to, the precision integration of new materials in production at scale.

With this Dear Colleague Letter (DCL), the National Science Foundation's (NSF) Directorate for Engineering (ENG) invites the submission of EArly-concept Grants for Exploratory Research (EAGER) proposals or standard research proposals which focus on new manufacturing innovations enabling and accelerating the manufacturing of quantum devices with emphases spanning from device fabrication to potential modes of system integration.

Research addressing scalable processes and process control of interest could address, among other topics:

- The controlled introduction in all three dimensions of specific defects in diamond and

other materials, aligned with their targeted function performance;
- Deposition of defect-free dielectric and superconducting films with low loss at cryogenic temperatures;
- Sources of decoherence in spin qubits originating from process-related sources.
- New methods of large area, high-throughput characterization of quantum-based materials and devices;
- The exploration of new materials platforms and their fabrication through techniques, such as epitaxial growth enabling pathways to protect and use quantum coherence in solid-state environments;
- Key processes enabling 3D integration of quantum and traditional electronic, such as high aspect ratio vias and flip chip bump bonding processes;
- Hybrid integration of quantum devices with photonics for the distribution of quantum information;
- New approaches to packaging that integrates quantum, photonic, and electronic functions in a vacuum environment; or
- Approaches towards the automated scalable manufacturing of devices applicable to quantum computers, sensors, and systems.

Proposed research projects that are responsive to this DCL should be based on the close collaboration between experiment and theory, and/or to novel, unconventional, and high-risk/high-reward ideas or strategies to address key scientific challenges in the manufacturing of quantum-based devices. Close collaboration between manufacturing and device scientists is strongly encouraged.

Standard research proposals can be submitted to the programs listed below at any time.

The EAGER type of proposal is described in Chapter II.E.3 of the NSF Proposal & Award Policies & Procedures Guide (PAPPG):

**Per the PAPPG, the submission of EAGER proposals is by invitation only; the process is initiated by the submission of a Research Concept Outline (RCO) describing the proposed high–risk / high–reward project that addresses this challenge.** The RCO must clearly describe the idea with a clear explanation of why it is exploratory, potentially transformative, or otherwise potentially impactful. RCOs are strictly limited in length to 2 pages, including references, plus a half-page justification of proposed budget, for a total of 2.5 pages. All correspondence, inquiries and RCOs must be via email to one of the Program Directors listed below.

**EAGER proposals submitted without prior submission of a corresponding RCO and subsequent invitation will be returned without review. Per the PAPPG, the email invitation from an NSF Program Director serves as documentation of approval to submit an EAGER proposal and must be uploaded in the Supplementary**

**Documentation section of the invited EAGER proposal.** The RCO and proposal titles must begin with "EAGER: Quantum Manufacturing:" followed by a brief descriptive title. For consideration by this DCL opportunity, RCOs must be submitted by June 1, 2022, and invited EAGER proposals must be submitted by July 31, 2022.

The following NSF programs are participating in this opportunity and will accept RCOs:

- Advanced Manufacturing (ENG/CMMI)
- Operations Engineering (ENG/CMMI)
- Electronics, Photonics, and Magnetic Devices (ENG/ECCS)
- Communications, Circuits, and Sensing-Systems (ENG/ECCS)

## KEY CONTACTS

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Sincerely,

Susan Margulies
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