NSF 24-521

NSF – Future of Semiconductors (FuSe2)

February 2, 2024
1:00 – 2:30pm EST

NSF Future of Semiconductors (FuSe2) – Webinar

Use the Q&A panel in Zoom to send questions—we'll answer some at the end

After the webinar, send questions to fuse1@nsf.gov

Not a typo!

Live transcript is available through Zoom

Solicitation page:
https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf24521

FuSe2 (NSF 24-521) Program Directors

ENG


Nadia El-Masry

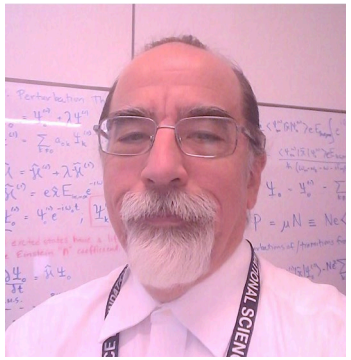

Prem Chahal


Rosa (Ale) Lukaszew

MPS


Paul Lane


Z. Charles Ying


Colby Foss

CISE


Sankar Basu


X. Sharon Hu


J. Hallstrom

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ChunSheng Xin


Eleanor Sayre

TIP

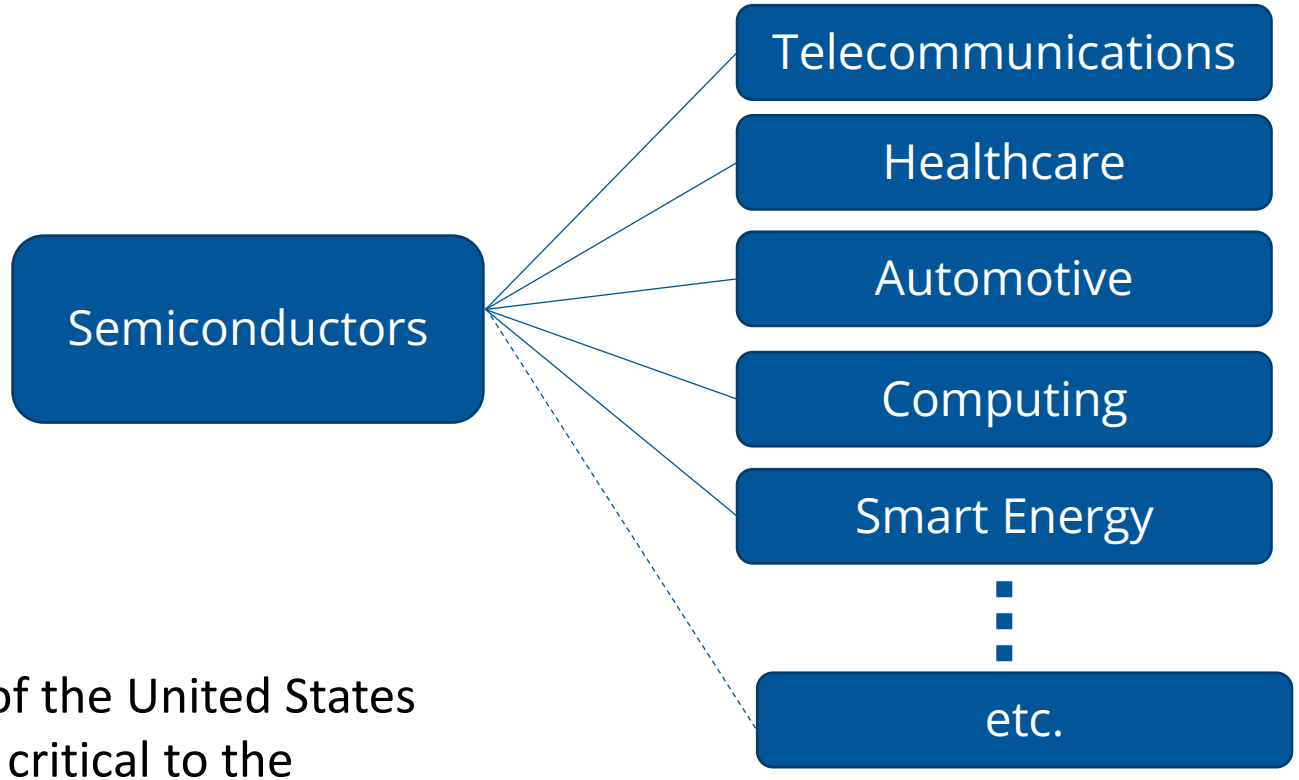

Geoffrey Brown


Michael Huff

All inquiries regarding this funding opportunity should be directed to email: fuse1@nsf.gov

Semiconductors

Semiconductors enable information processing that impacts all aspects of life, from **computing** to **finance**, to **sustainable environments** and **healthcare**.



It is the sense of Congress that the leadership of the United States in semiconductor technology and innovation is critical to the economic growth and national security of the United States.

- *The CHIPS & Science Act*

National Science Foundation - Future of Semiconductors (FuSe2)

PROGRAM SOLICITATION
NSF 24-521

REPLACES DOCUMENT(S):
NSF23-552

National Science Foundation
Directorate for Engineering
- Engineering Education and Centers
- Division of Electrical, Communications and Cyber Systems
- Division of Civil, Mechanical and Manufacturing Innovation
- Division of Chemical, Bioengineering, Environmental and Transport Systems

Directorate for Mathematical and Physical Sciences
- Division of Materials Research
- Division of Chemistry

Directorate for Computer and Information Science and Engineering
Directorate for Technology, Innovation and Partnerships
Directorate for STEM Education

Future of Semiconductors (FuSe)

PROGRAM SOLICITATION
NSF 23-552

REPLACES DOCUMENT(S):
NSF 22-589

National Science Foundation

Directorate for Engineering
- Engineering Education and Centers
- Division of Electrical, Communications and Cyber Systems
- Division of Civil, Mechanical and Manufacturing Innovation

Directorate for Mathematical and Physical Sciences
- Division of Materials Research
- Division of Chemistry

Directorate for Computer and Information Science and Engineering
Directorate for Technology, Innovation and Partnerships
Directorate for STEM Education

new
Ericsson
Intel Corporation
Micron
Samsung

FuSe2 Industry Partners

Ericsson
Intel Corporation
IBM
Samsung

FuSe-2022, FuSe-2023, FuSe-2024

- ***2022: FuSe NSF 22-589 ("FuSe-2022")***
  - Focused on team building
- ***2023: FuSe NSF 23-552 ("FuSe-2023")***
  - Focused on research and development in semiconductors, ***emphasizing co-design***; education and workforce development; industry collaboration *encouraged*
- ***2024: FuSe2 NSF 24-521 ("FuSe-2024", "FuSe2")***
  - Continued focus on areas established under FuSe-2023

FuSe-2024 is independent of FuSe-2023 and FuSe-2022 Grants

FuSe NSF 23-552 and 24-521

- ***Research and Development***: Advanced research and development in semiconductor technology, exploring new materials, processes, and designs for future devices and systems; ***co-design is an essential element of successful proposals***
- ***Education and Workforce Development***: Interdisciplinary education / workforce development to prepare students for careers in the semiconductor industry
- ***Industry Collaboration***: Collaboration with industry is encouraged to address the current and future challenges facing the semiconductor industry

FuSe2

It is the sense of Congress that the leadership of the United States in semiconductor technology and innovation is critical to the economic growth and national security of the United States.

- The CHIPS & Science Act

FuSe

RAMP OF OPPORTUNITY

ENG CISE
MPS EDU

TIP

Valley of Death

FuSe Industry Partners

intel Micron SAMSUNG ERICSSON

LAB ⟵ **SOCIETY**

Foundational Research	Use-Inspired Research	Proofs-of-Concept	Prototype Development	Product/Solution Development	Societal Impact, Commercialization

Partner Profile – **Ericsson Inc.**

Representatives:

Stefan Adalbjörnsson, Senior Researcher, Ericsson Research
Ali Khayrallah, Senior Technical Advisor, Advanced Technology Group

Areas of Interest:

High Frequency Systems, Data Converters, Energy Management, Novel Compute Concepts, and Sensors

Why are you interested in this program?

The evolution of wireless communications has been outpacing Moore's law for decades, much driven by semiconductor innovation. The step to 6G will be no exception. Ericsson believes in an open environment where industry and academia can learn from each other and believes FuSe2 is an excellent vehicle for this.

What do you expect the program to achieve?

Ericsson believes FuSe2 will (1) lay the foundation and develop disruptive concepts that will enable the 6G vision, (2) be an opportunity to share visions and concepts between world leading teams in industry and academia, and (3) strengthen the U.S. talent pool in semiconductors.

What resources can you make available to the projects?

Ericsson has a global research organization and will engage top U.S.-based and international researchers in selected projects. Other resources such as test chambers, equipment, and other lab resources could also be considered based on relevance, availability, and timing.

Partner Profile – Intel Corporation

Representatives:

Melissa Cowan, Program Director, Intel University Research & Collaboration
Gabriela Cruz Thompson, Director, Intel University Research & Collaboration

Areas of Interest:

Full Scope of FuSe2 / All Research Areas - Across the stack, from materials, devices, circuits, packaging, architectures & applications + sustainable manufacturing & design automation

Why are you interested in this program?

Intel is pleased to partner in the FuSe2 solicitation in recognition of the importance of investing significantly in basic/applied research and workforce education and training to advance semiconductor design and manufacturing.

What do you expect the program to achieve?

Explore the convergence of new materials, devices, and system integration technologies via cross-disciplinary systems prototyping to drive technology breakthroughs in sustainable manufacturing & compute efficiency. Ease system design effort for new domains, hardware design made simple, workforce impacts at all levels (technician to research scientist).

What resources can you make available to the projects?

Facilitate access to Intel technical mentors with expertise in all areas of FuSe2 to identify collaboration & maturation pathways. Access to Intel university shuttle program, tools and IPs, & compute environments for research. Student internships & experiential learning opportunities.

Partner Profile – Micron Technology

Representatives:

Akira Goda, Fellow Pathfinding
Mark Helm, Senior Fellow Pathfinding and Strategy

Areas of Interest:

Memory-centric Computing, Emerging and Shared Memory Architectures, 3D Heterogeneous Integration of Memory and Compute, Advanced Packaging Technology, Novel Materials and New Physics for Memory Devices

Why are you interested in this program?

FuSe's diverse expertise and activities create the perfect ecosystem to innovate the next computing paradigm.

What do you expect the program to achieve?

Explore vertically integrated solutions across the entire computing stack, including materials, devices, circuits, microarchitecture, operating systems, software layers and applications. Innovate and prove first principles in each domain toward the holistic goal of enabling the new computing paradigm with high performance and power efficiency.

What resources can you make available to the projects?

We look forward to opportunities to collaborate on research projects. As an industry expert in memory and storage solutions, we provide industry insights, internship opportunities, and access to relevant tools and IP.

Partner Profile – Samsung

Representative:

Stephen Chae, Open Innovation Group

Areas of Interest:

Next Generation Computing Broadly, e.g., Scalable/Heterogeneous Architectures, HPC, Accelerators, Quantum Computing, AI for Semiconductor Industry, Device Heterogeneous-Integration, Low-Energy High-Density Embedded Memory Devices, New or Improved Memory Technologies, Novel Enabling Materials/Devices/Processes

Why are you interested in this program?

Samsung is excited to partner in the FuSe solicitation given the need for strong investment in basic/applied research and workforce training, which will accelerate future semiconductor technology development and ultimately lead to broad societal benefits.

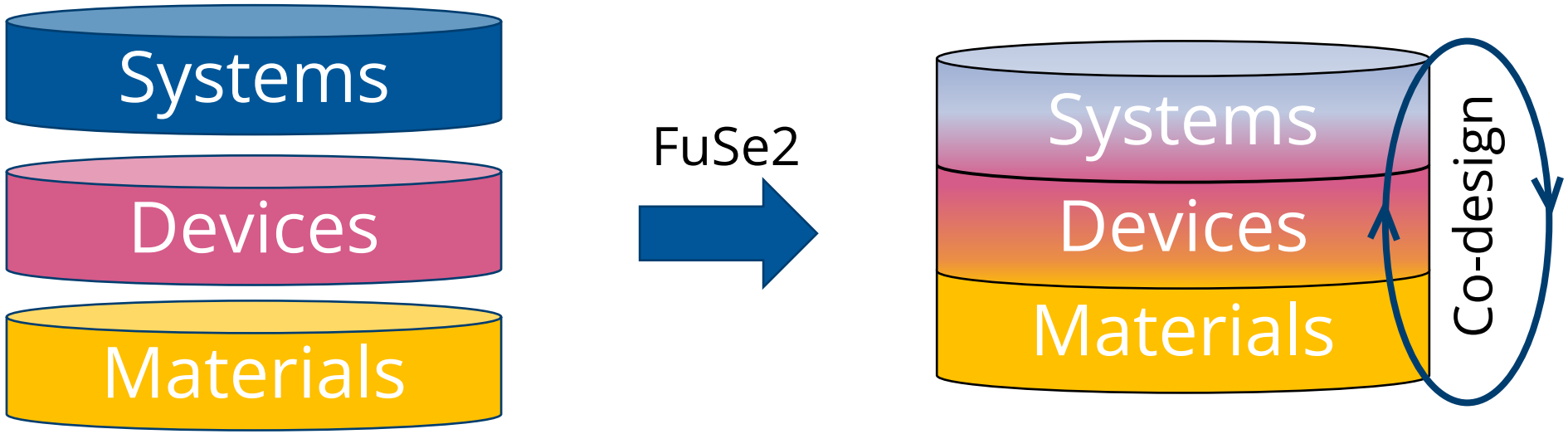
What do you expect the program to achieve?

We expect the strong emphasis on co-design across the computing stack will identify new ways to compute with high efficiency, speed, and density, as well as provide significant advancements to existing computing technologies.

What resources can you make available to the projects?

We look forward to engaging with funded projects to provide industry insights and identify complementary collaboration opportunities, as well as facilitating knowledge exchange via visiting Samsung researchers, where possible. We hope to find opportunities for other tangible types of engagement to support validation of the technologies developed in FuSe.

Semiconductor Technology Stack



- Growing need for materials, devices, and system architectures
- Research occurs mostly independently within these areas

- Future manufacturing empowered by **co-design**
- Stronger coordination and integrated research
  - Parallel process with feedback between levels in the stack

FuSe2 NSF 24-521

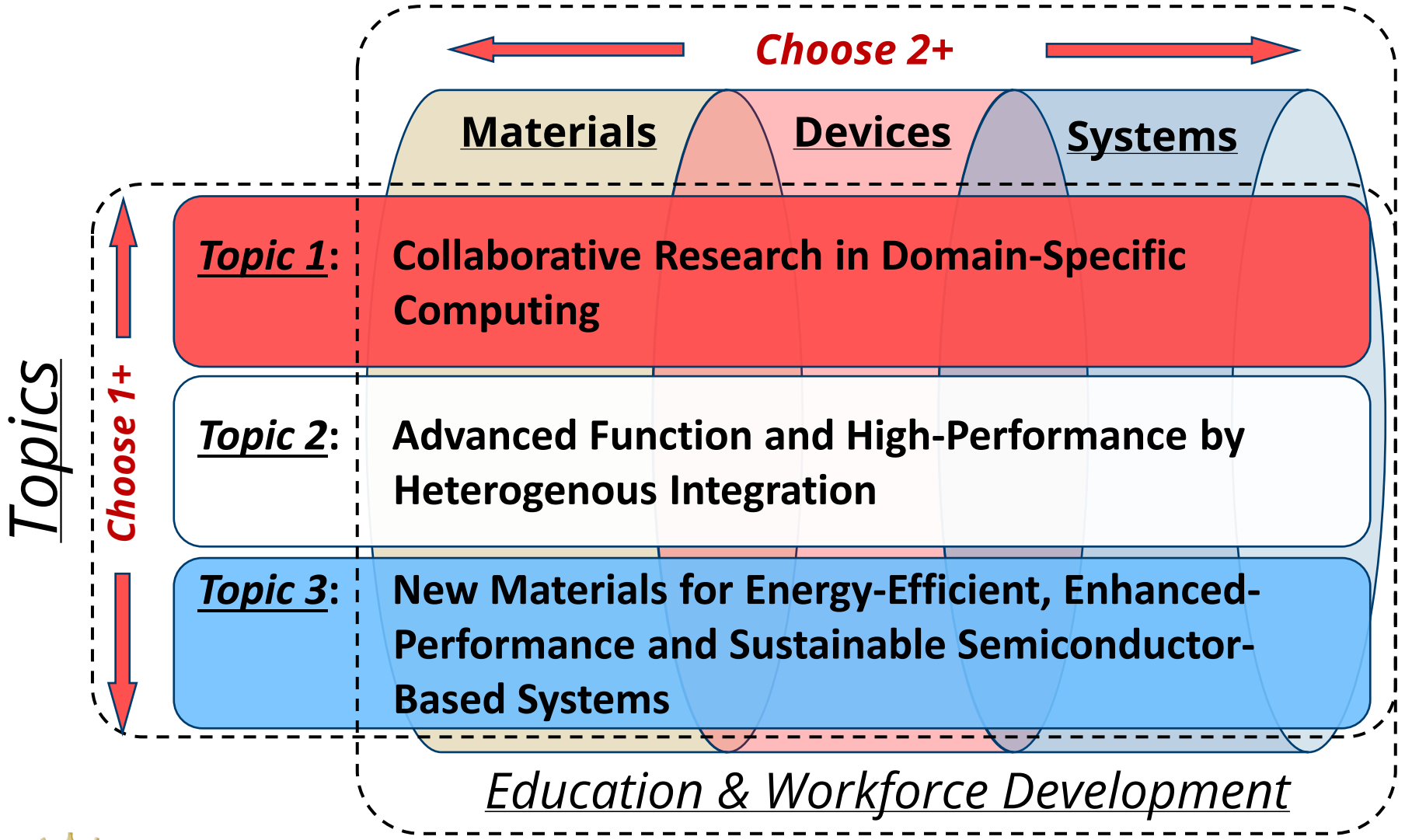
Three topic areas identified in FY 2024 under this solicitation:

Topic 1. Collaborative Research in Domain-Specific Computing

Topic 2. Advanced Function and High-Performance by Heterogenous Integration

Topic 3. New Materials for Energy-Efficient, Enhanced-Performance and Sustainable Semiconductor-Based Systems

Technology Stack



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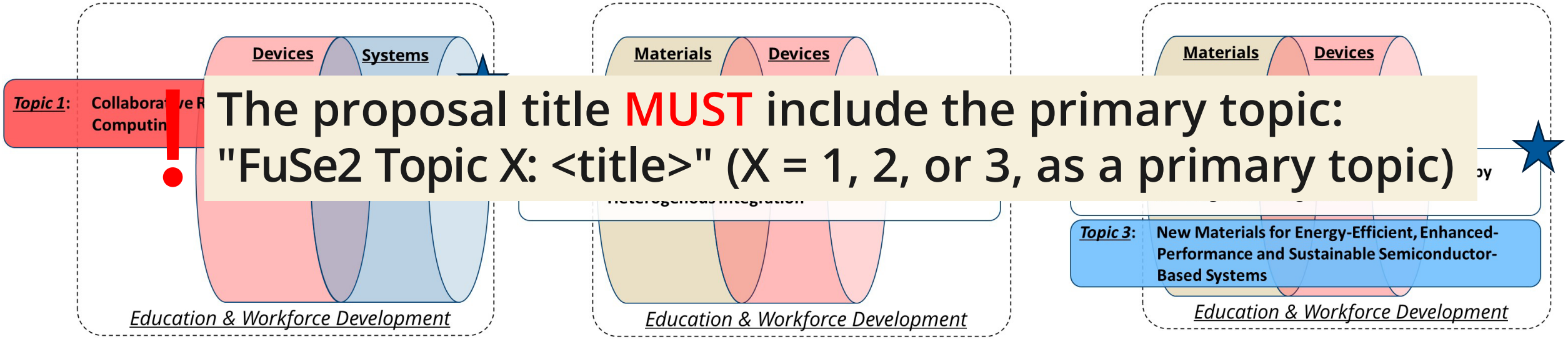
Precisely ONE topic area must be identified as primary

FuSe2 NSF 24-521

Examples of Permissible Submissions



The proposal title MUST include the primary topic: "FuSe2 Topic X: <title>" (X = 1, 2, or 3, as a primary topic)

FuSe2 NSF 24-521

- Awards in **FY 2024 will be up to $2M per award for up to three years**, commensurate with scope and team size

- This program seeks to fund **collaborative research and education** that transcends the traditional boundaries of individual disciplines to achieve program goals

FuSe2 NSF 24-521

Topic-1

Collaborative Research in Domain-Specific Computing

- Overall goal is to increase performance, energy efficiency, usability, sustainability, and other aspects of computing systems through co-design approaches that leverage characteristics of specific domains
- Example domains of interest include (but are not limited to) **Application Domains**, **Computing Strategy Domains**, and **Technology Domains**

See solicitation for more details

FuSe2 NSF 24-521

Topic-2

Advanced Function and High-Performance by Heterogenous Integration

- Accelerate the adoption of advanced electronic, memory, photonic, energy, or sensing devices and components in semiconductor technology to enable cutting-edge functionality
- Examples include (but are not limited to):
  - Heterogeneous Integration & Heterogeneous Technology Ingredients
  - Package Platform Heterogeneous Integration
  - Heterogeneous Integration System Design and Characterization Technologies

See solicitation for more details

FuSe2 NSF 24-521

Topic-3

New Materials for Energy-Efficient, Enhanced-Performance and Sustainable Semiconductor-based Systems

Areas of interest include (but are not limited to):

- Novel materials or innovative combinations of materials enabling novel, energy-efficient logic and/or memory functions, including non-von-Neumann logic
- Novel materials or innovative combinations of materials for next-generation interconnect, heterogeneous integration in devices and packaging at the relevant dimensions
- Materials to enable patterning with the next generation of extreme ultraviolet (EUV) and high-numerical-aperture EUV lithography photoresists, as well as novel bottom-up patterning approaches, such as directed self-assembly
- Development of new characterization methods and/or high-resolution imaging technologies for the characterization of materials at the electronic-device or chip level (e.g., electrical or thermal transport, or defect mapping at the atomic/molecular level in a functioning electronic device)

See solicitation for more details

Education and Workforce Development

- All proposals must include *within the Broader Impact description* a section titled "**Education and Workforce Development Plan**" that articulates:
    - Education and workforce development goals
    - Plans for recruitment, retention, and graduation of students from underrepresented groups
    - Plans for assessing the effectiveness of the EWD plan
    - Plans to integrate research and EWD components
- PIs are encouraged to engage experts in education, curriculum development, and academic assessment, as appropriate

See solicitation for more details

Timelines for FuSe2 NSF 24-521

Only a full proposal submission is required

Full Proposals – 15 page Project Description

- **Due March 14, 2024**, 5PM local time
- Submit through Research.gov or Grants.gov

Who May Serve as PI:

By the submission deadline, any PI, co-PI, or SP must hold:

- A tenured or tenure-track position, or a primary, full-time, paid appointment in a research or teaching position with exceptions granted for family or medical leave, as determined by the submitting institution
- Individuals with primary appointments at for-profit non-academic organizations, or at overseas branch campuses of U.S. IHEs **are not eligible**.
- Researchers from foreign academic institutions who contribute essential expertise to the project may participate as SP or collaborators **but may not receive NSF support**

NSF 23-552 recipients cannot be a PI or co-PI for the FuSe2 solicitation, but may serve as Senior Personnel

Proposals violating this limitation will be returned without review

FUSE NSF 24-521 Award Information

Anticipated Type of Award:
Standard or Continuing Grant

Estimated Number of Awards:
Approximately 20 Awards under this solicitation; each award provides up to 3 years of project support

Anticipated Funding Amount:
$40M total, up to $2M per grant

No. of awards and award size/duration will depend on responsiveness to the solicitation and is subject to the availability of funds

Full Proposal Preparation Instructions
(1/3)

- PIs must hold primary, full-time, paid appointments in research or teaching positions at U.S.-based campuses
- Individuals with primary appointments at for-profit non-academic organizations, or at overseas branch campuses of U.S. IHEs are not eligible
- An individual may appear as PI, co-PI, or Senior Personnel on **only ONE** proposal
- There is no limit on the number of proposals per organization
- This solicitation allows **only a single proposal** submission with subawards administered by the lead organization

Full Proposal Preparation Instructions (2/3)

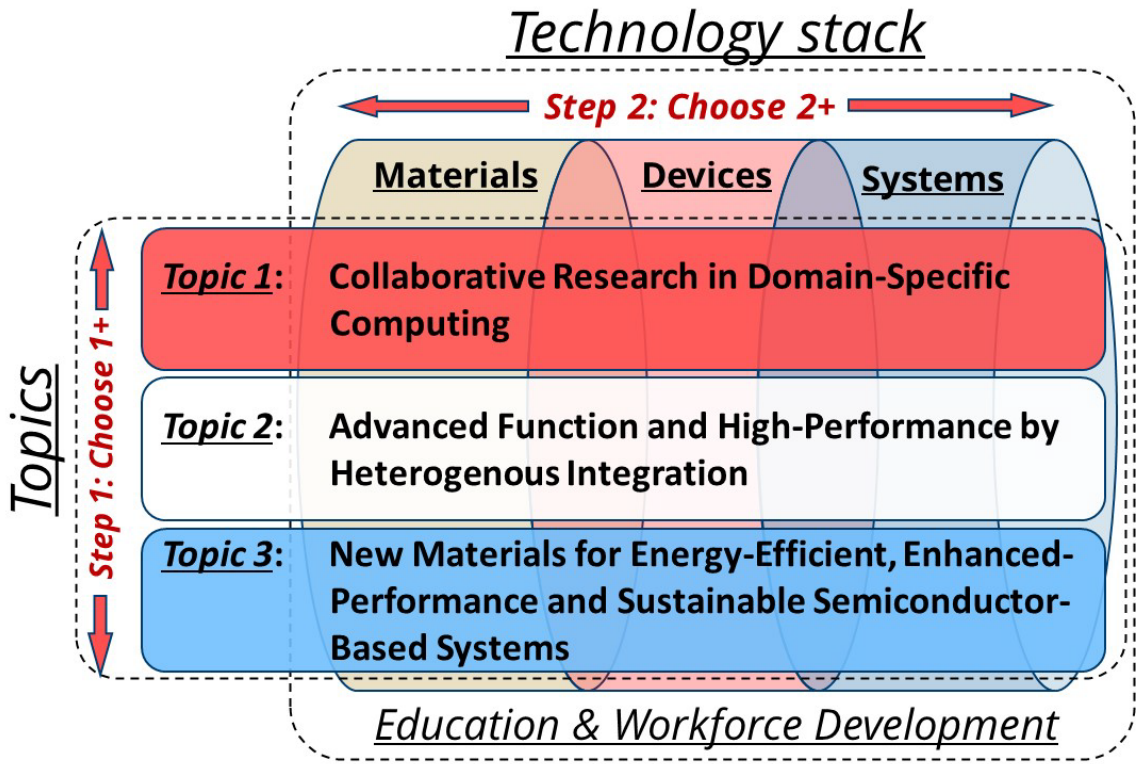
Proposers responding to this solicitation must include a "Project Management and Collaboration" section

FuSe2 proposals must address:

- The need for sustained support of a multidisciplinary team using a convergence research approach
- Why the project team is appropriate to realize the project's goals and how the team will ensure effective collaboration in the co-design process
- A compelling rationale for a multi-organization project structure

Inclusion of minority serving and EPSCoR institutions is encouraged

Full Proposal Preparation Instructions (3/3)



The proposal title MUST include the primary topic:

- "*FuSe2* ***Topic X*****: <title>"**
  (X = 1, 2, or 3, as a primary topic)

In the first sentence of the project summary, **note the topic(s) and the technology stack layers** that your project plans to tackle

- e.g., "This proposal focuses on Topic 1, Devices and Systems."

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Broad Collaboration is Encouraged

Collaboration:

- Industry*
- National Laboratories

These organizations are all qualified to participate, but see the FuSe2 solicitation and Proposal and Award Policies and Procedures Guide regarding funding eligibility

Encourage Participation:

- Institutions within EPSCoR States / Jurisdictions
- Minority-Serving Institutions, HBCUs, HSIs, TCUs

*** Industrial Collaborations - *Grant Opportunities for Academic Liaison with Industry* (GOALI) mechanism may be used in conjunction with this solicitation**

Merit Review Criteria

(see solicitation for details)

Intellectual Merit: The Intellectual Merit criterion encompasses the potential to advance knowledge

Broader Impacts: The Broader Impacts criterion encompasses the potential to benefit society and contribute to the achievement of specific, desired societal outcomes

+ FuSe2 Specific Review Criteria

FuSe2-Specific Review Criteria

- Does the project identify an overarching foundational problem which requires a co-design approach?
- Are energy-efficient, sustainable device manufacturing processes using earth-abundant and nontoxic materials, minimizing water usage, and striving for zero waste emphasized?
- Does the proposal identify an integrated multi-disciplinary research agenda that defines the roles of all participants? Is the composition of the multi-disciplinary team appropriate for the scope of the proposed activities?
- How are the research tasks synergistically integrated across the identified research focus area? Does the proposal address the associated research risks and present mitigation plans?
- How effectively does the proposal present a compelling argument that the proposed educational activities will equip students and other workforce participants with the skills to engage in the evolving semiconductor industry and broaden participation by building on best practices and evidence-based approaches?

FuSe2 Industry Partners

(Ericsson, Intel, Micron, Samsung)

- Proposals may not list or describe any kind of agreed or assumed arrangement to use the contributions by, or any other collaborative arrangement with, this solicitation's industry partners
- Proposers are not restricted from making use of the widely accessible products or services of FuSe2 industry partners
- Proposers should **not contact the four FuSe2 industry partners** with questions pertaining to their company's participation in this solicitation; all questions should be directed to NSF
- Read eligibility section of this solicitation

FuSe2 Industry Partners – Prior to Awards

FuSe2 Industry partners **will not participate** in or observe the review of proposals

NSF **will share** some of the proposals which are under consideration for funding, along with reviews and panel summaries

NSF **will take into consideration** the input of all FuSe2 industry partners prior to making final funding decisions

NSF will **retain final authority** for making all award decisions

Proprietary / privileged information provided in the "Single Copy Documents" section **will not be shared** with reviewers or industry partners

FuSe2 Industry Partners – Post-Award

NSF **will administer awards** under the program in accordance with standard NSF policies and procedures

FuSe2 industry partners **will not oversee** the activities or use of funds by grantees

FuSe2 industry partners **may** make available direct contributions of resources

Examples: *software, datasets, computing infrastructure*

No awardee will be required to use any industry partner's offered direct contributions

A FuSe2 industry partner **may** arrange to fund its own personnel as researchers to directly participate with awardee project personnel

These arrangements will be optional and upon the mutual consent of the industry partner and respective awardee institution(s)

No awardee will be required to accept an industry partner researcher

NSF **will share** annual and final project reports with FuSe2 industry partners after those reports have been reviewed and accepted by the cognizant NSF Program Officer

FuSe2 Industry Collaboration – IP

Award terms and conditions

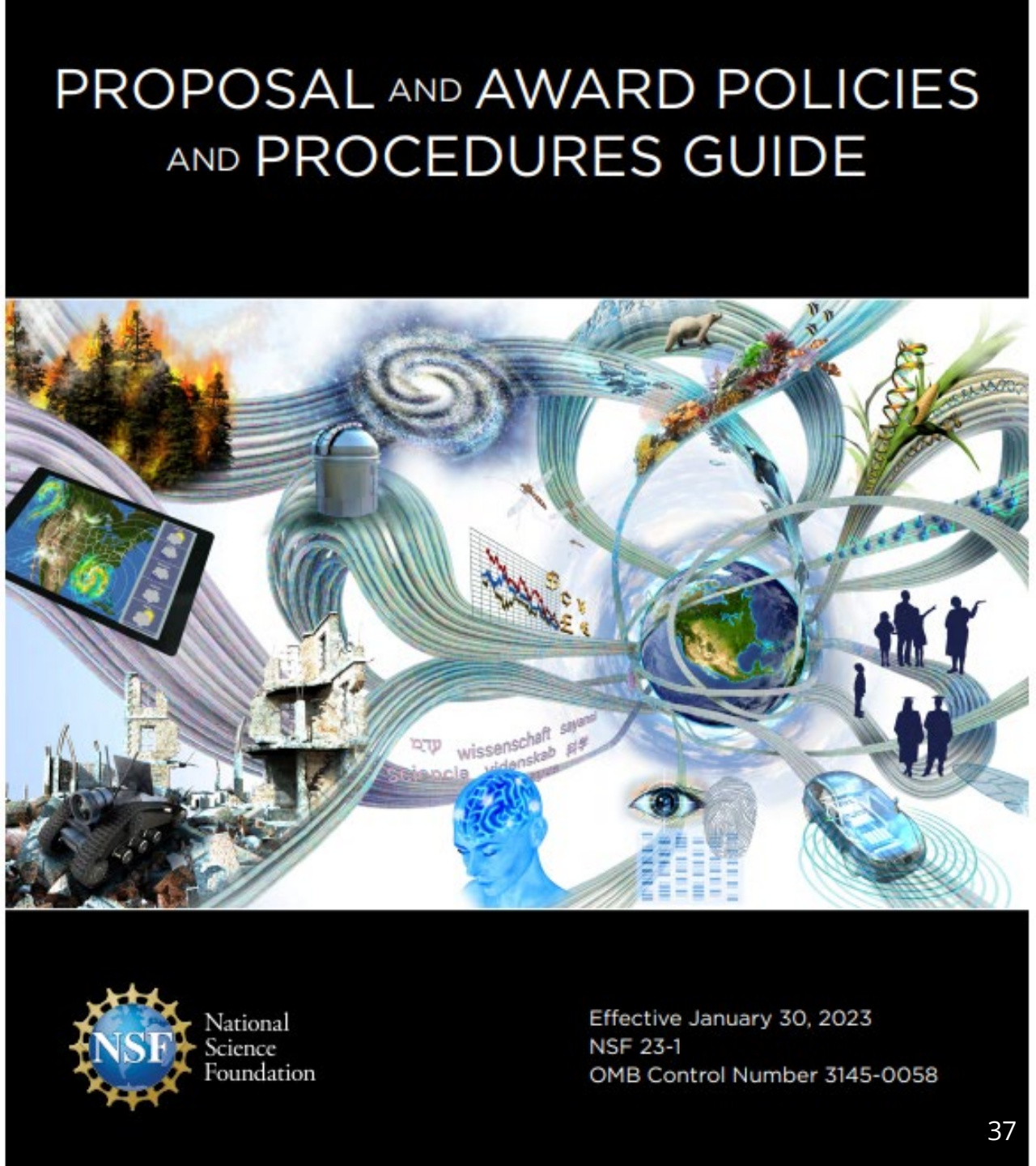
- Awardees shall grant to the sponsoring parties a non-exclusive, worldwide, paid-up, non-transferable, irrevocable royalty-free license to all intellectual property rights in any inventions conceived or first reduced to practice in the performance of the program work under the funding agreement
- Awardees shall grant the license to each industry partner named in the award letter unless the industry partner opts to decline the license
  - Such license shall not extend to awardees' background intellectual property
    - Intel, Micron, and Samsung will be named as sponsors for all awards.
    - Ericsson will be named as sponsor in a partial set.

No rights or licenses are granted by the FuSe2 industry partners

Awardees may delay the publishing of data and software describing inventions to first permit the filing of patent applications

Resources and Program Officers are available to help!

- Be sure to fully read the FuSe2 solicitation NSF 24-521
- Be sure to fully read the PAPPG
  - PAPPG Part 1-Chapter 2
    - Proposal Preparation Guide
  - PAPPG Exhibit II-1:
    - Proposal Checklist
- Email: fuse1@nsf.gov



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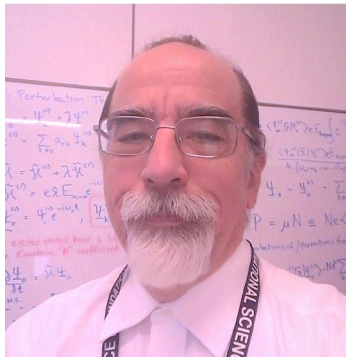
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Q&A

Please use the **Q&A** panel in Zoom to submit questions

After the webinar, email your questions to fuse1@nsf.gov

THANK YOU