# NSF Future of Semiconductors (FuSe) – 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

Live transcript is available through Zoom

Solicitation page:
https://beta.nsf.gov/funding/opportunities/national-science-foundation-future-semiconductors

**NSF 23-552**

# NSF – Future of Semiconductors (FuSe)

*Feb. 23, 2023*
*1:00 – 2:30 PM EST*

# Semiconductors

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



Semiconductors

- Telecommunications
- Healthcare
- Automotive
- Computing
- Smart Energy
- etc.

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*

**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

Intel Corporation

Ericsson Inc.

IBM Corp.

Samsung

FuSe Industry Partners

- Letters of Intent: Not required

- Preliminary Proposal Submission: Not required

- Proposal Deadline: April 24, 2023, 5PM local time

# FuSe-2022 and FuSe-2023

- ***Yr. 2022: FuSe NSF 22-589 ("FuSe-2022")***

  - Focused on team building (for research and education)

- ***Yr. 2023: FuSe NSF 23-552 ("FuSe-2023")***

  - ***Focuses on:***

    - Advanced research and development in semiconductor technology

    - Education and workforce development

    - Industry collaboration (*encouraged*)

  *FuSe-2023 is independent of FuSe-2022 Teaming Grants*

# FuSe NSF 23-552

- ***Research and Development***: Focus on advanced research and development in semiconductor technology, exploring new materials, processes, and designs for future devices and systems.

- ***Education and workforce development***: Provide interdisciplinary education/workforce development to prepare students/participants for careers in the semiconductor industry.

- ***Industry Collaboration***: Collaboration with industry is encouraged to address the current and future challenges facing the semiconductor industry.

# NSF Directorates – FuSe NSF 23-552

- Engineering (ENG)
  - https://www.nsf.gov/dir/index.jsp?org=ENG

- Mathematical & Physical Sciences (MPS)
  - https://www.nsf.gov/dir/index.jsp?org=MPS

- Computer and Information Science and Engineering (CISE)
  - https://www.nsf.gov/dir/index.jsp?org=CISE

- STEM Education (EDU)
  - https://beta.nsf.gov/edu

- Technology, Innovation and Partnerships (TIP)
  - https://beta.nsf.gov/tip/latest

# FuSe Program Directors

**ENG**



Nadia El-Masry

Prem Chahal
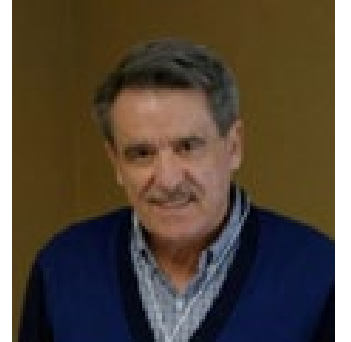
Rosa (Ale) Lukaszew

**MPS**

Birgit Schwenzer

Z. Charles Ying

George Janini

**CISE**

Sankar Basu

Erik Brunvand

Jason Hallstrom

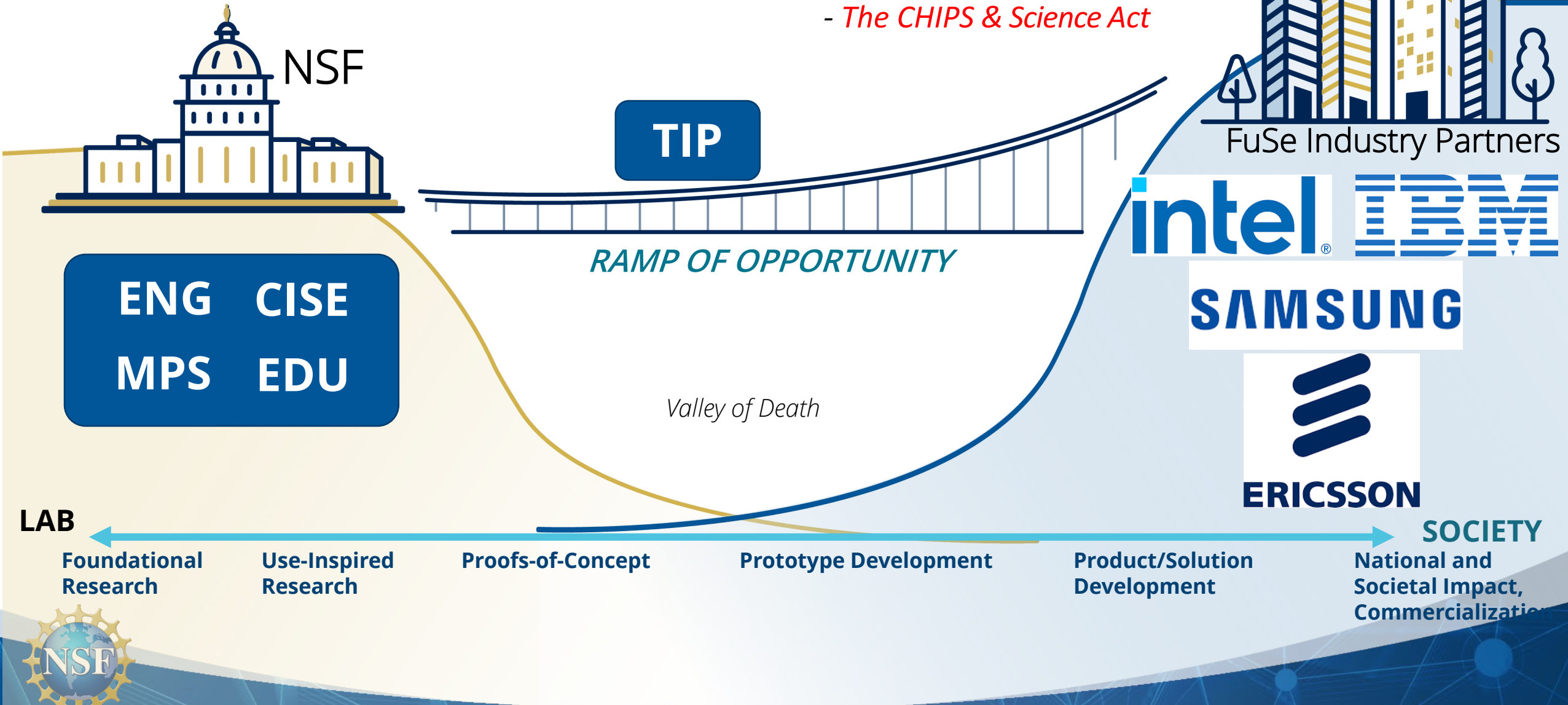**EDU**

Vinod K. Lohani

Eleanor Sayre

**TIP**

Geoffrey Brown

**General and specific inquiries regarding this funding opportunity are directed to email:** fuse1@nsf.gov

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# Partner Profile – Ericsson Inc.

**Representatives:**
**Björn Ekelund, Ali Khayrallah**

**Areas of interest:**
**High frequency systems, Data converters, Energy management,**
**Novel compute concepts, and Sensors**

**ERICSSON**

## 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 FuSe is an excellent vehicle for this.

## What do you expect the program to achieve?
Ericsson believes FuSe will lay the foundation and develop disruptive concepts that will enable the 6G vision 2. will be an opportunity to share visions and concepts between world leading teams in industry and academia 3. will strengthen the US talent pool in semiconductors.

## What resources can you make available to the projects?
Ericsson has a large and global research organization and will engage both US-based and international top 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
Tanay Karnik, Senior Principal Engineer, Lead Technical Investigator
Gabriela Cruz Thompson, Director, Intel University Research & Collaboration

**Areas of interest:** Full scope of FuSe / 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 FuSe 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 of 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 FuSe to identify collaboration & maturation pathways.
Access to Intel university shuttle program, tools and IPs, & compute environments for research. Student internships & experiential learning opportunities.

# Industry Partner – IBM
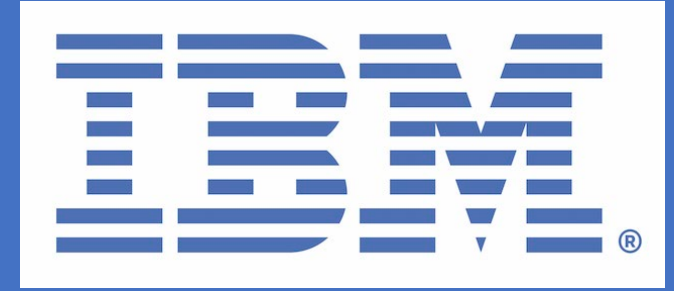
**Representatives:**
**Sudhir Gowda, Director, Academic Research Programs.**
**Griselda Bonilla, Senior Technical Staff Member, AI Technology Research.**

**Areas of interest:**

Integration across the stack including materials and devices, chip level integration, heterogenous package level integration, and novel architectures for emerging workloads such as foundation models. Architecture/device co-design for AI training and Inference. Agile SoC / SiP design methodologies. Chiplet-level microarchitectures and design automation. Programmable testbeds for evaluation of new chip and device architectures. Sustainability-driven design and manufacturing technologies.

## Why are you interested in this program?

The FuSe program offers a unique opportunity to think beyond silos of materials, devices, chip architectures, subsystem architectures, application requirements, etc., to exploit co-design opportunities across these boundaries. Industry collaboration is designed into the program, which helps prepare an industry-ready workforce.

## What do you expect the program to achieve?

In addition to specific research breakthroughs that cross the traditional boundaries described above, we expect the program to enable new ways for teams to work together through testbeds and shared demonstrations.

## What resources can you make available to the projects?

Project and student mentors, opportunities to experience an industrial research experience, share experience and insights from decades of bringing novel semiconductor materials/device/integration/architecture co-design to address emerging workloads.
If relevant and useful, we could potentially make available resources such as testbeds for co-design and demonstration.

# Partner Profile – Samsung

**SAMSUNG**

**Representative:**
Robert Ashcraft - Open Innovation Group

**Areas of interest:**
Next generation computing broadly, e.g., scalable/heterogeneous architectures, HPC, accelerators, AI for semiconductor industry, device hetero-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 the basic/applied research that 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.
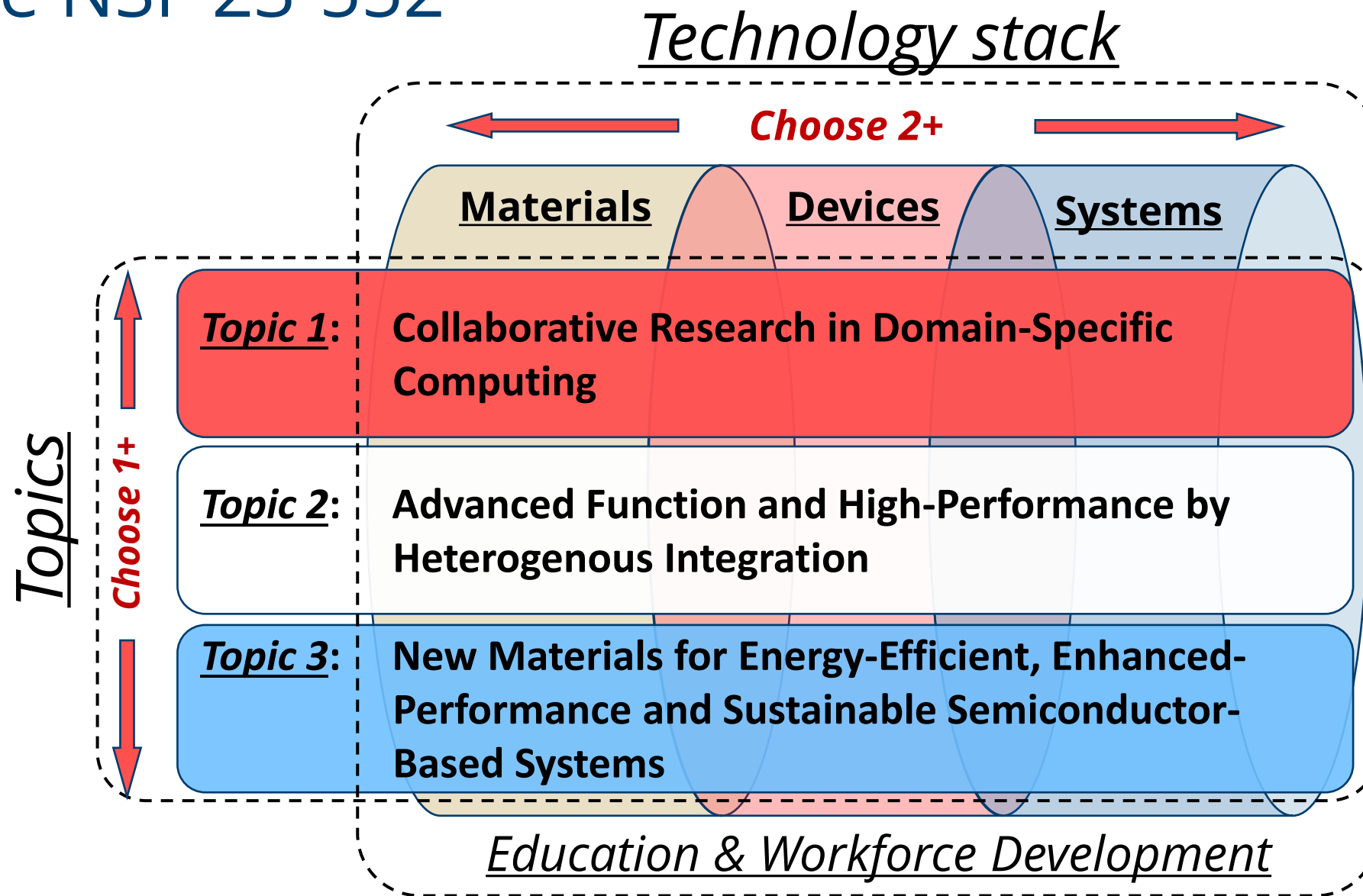
# Semiconductor Technology Stack
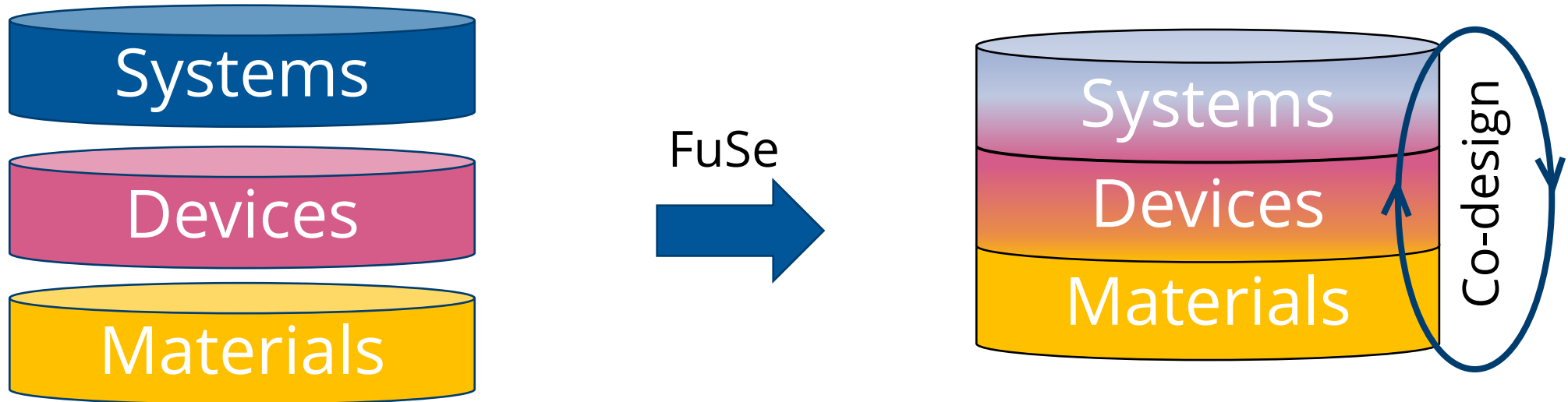


- Ever growing need for materials, devices and system architectures
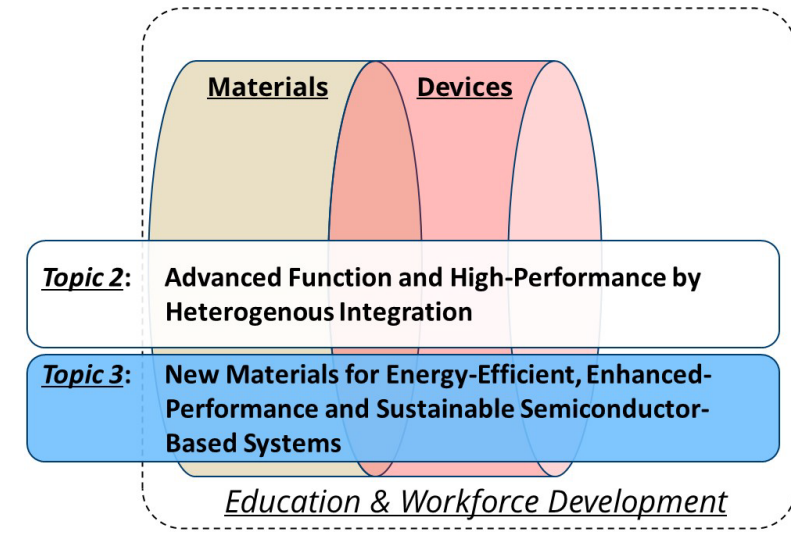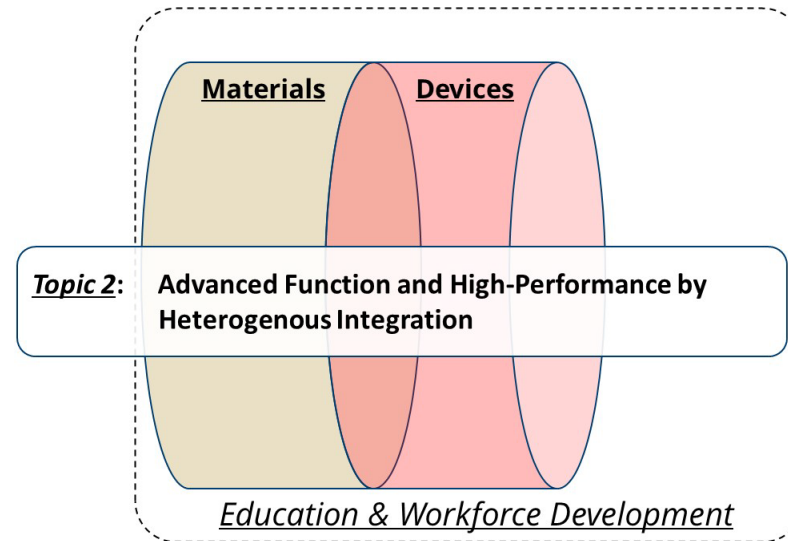- Research occurs mostly independent in these areas

- Future manufacturing will be empowered by co-design
- Stronger coordination and research
  - A parallel process with constant feedback between the levels in the stack

# FuSe NSF 23-552



*Technology stack*

**Choose 2+**

| Materials | Devices | Systems |

*Topics* / *Choose 1+*

*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**

*Education & Workforce Development*

# FuSe NSF 23-552

## Examples of Permissible Submissions
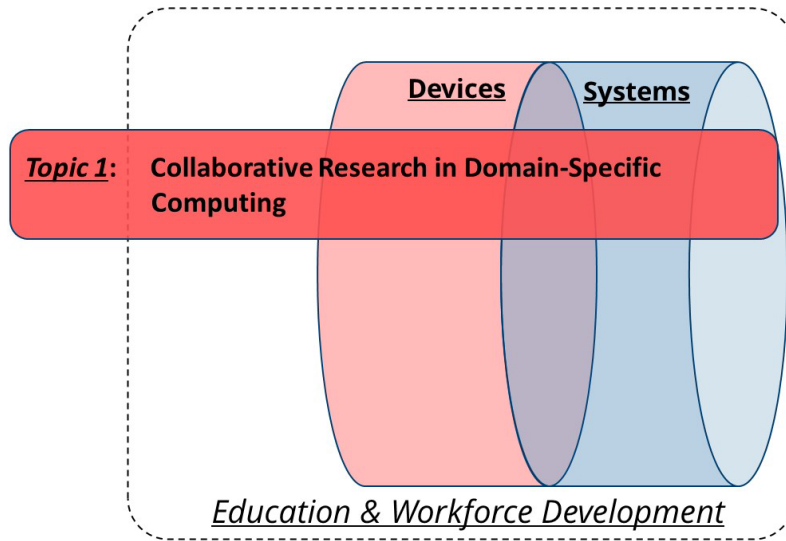
# FuSe NSF 23-552

- Each proposal should explicitly identify <u>at least one</u> of these research <u>topic areas</u>. Proposals which merge ideas from multiple topic areas are encouraged

- Every proposal should address co-design covering <u>at least two</u> of the areas in the <u>technology stack</u> (materials, devices, and systems) in the research approach

- Education for <u>workforce development </u>is important

- <u>Partnerships</u> between industry and academic institutions <u>are encouraged</u>

# FuSe NSF 23-552 Topic-1

Collaborative Research in Domain-Specific Computing

- Increase the performances, usability, sustainability or other aspects by exploiting the characteristics of a broad domain of interest.

- Examples:

  - Applications: AI/ML; wireless next-G; sparse-data computing; AR/VR

  - Architecture: Approximate/analog; X-inspired (X=brain, quantum, physics, bio); privacy-preserving

  - Technology: in-memory computing; 2.5/3D; CMOS+X; probabilistic bits; Novel Electronic Design Automation (EDA)

# FuSe NSF 23-552 Topic-2

Advanced Function and High-Performance by Heterogenous Integration

- This topic aims <u>to accelerate the adoption of advanced electronic, memory, photonic, energy, or sensing devices & components</u> in the semiconductor technology to enable cutting-edge functionality.

- <u>Examples</u>:
  - Technology: *3D-based heterogenous integration; bio-inspired sensing; wireless communications; wide bandgap semiconductors, etc.*
  - Systems integration: *advanced packaging; novel thermal management; improved interconnects and power delivery; etc.*
  - Designs/Tools: *Process improvements; reliability enhancement; new design and validation tools; etc.*

# FuSe NSF 23-552 Topic-3

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

- *Materials and device co-design is critical*

- Examples:

  - Materials enabling novel, energy-efficient logic and/or memory functions

  - Materials and interfaces of relevance to novel hetero-integration architectures and packaging

  - Sustainable and energy-efficient fabrication processes that enable novel device architectures, especially those that use earth-abundant elements and nontoxic chemicals

  - Development of new transport (thermal, electrical, …) measurement and high-resolution imaging technologies for the characterization of these materials at the atomic/molecular level and for the mapping of defects

# Education and Workforce Development

- All proposals must address how the *work will contribute to education and workforce development.*
- The proposal must include *within the Broader Impact Description* a section titled "**Education and Workforce Development Plan**" that clearly articulates:
  - Education and Workforce Development goals,
  - A plan for recruitment, retention, and graduation of students from underrepresented minority groups, and
  - A plan for assessing the effectiveness of the education and workforce development plan,
  - A plan to integrate research and education & workforce development components.
- Engage experts in education, curriculum development or academic assessment, as appropriate.

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# Timelines for FuSe NSF 23-552

Letter of Intent – Not Required

Preproposal – Not Required

Full Proposals – 15 pages Project Description
- **Due April 24, 2023**, 5PM local time
  - Submit through Research.gov or Grants.gov

# FUSE NSF 23-552 Award Information

**Anticipated Type of ward:** Standard Grant or Continuing Grant

**Estimated Number of Awards:** ~ 20

Approximately 20 Awards under this program solicitation. Each award provides up to three-year project support.

**Anticipated Funding Amount:** $40,000,000

Up to $2,000,000 per grant

$ The number of awards and average award size/duration will depend on proposal responsiveness to this solicitation and is subject to the availability of funds.

# Full Proposal Preparation Instructions - 1

- 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, senior personnel on only two proposals.

- There is no limit to the number of  proposals per organization

- This solicitation allows both a single proposal submission with underline subawards administered by the lead organization or submissions using the format of a underline collaborative proposal

# Full Proposal Preparation Instructions - 2

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

FuSe proposals should demonstrate:

- The need for sustained support of a multidisciplinary team using a convergence research approach

- Proposals must describe why the project team is appropriate to realize the project's goals and how the team will assure effective collaboration in the co-design process

- A compelling rationale must be presented for a multi-organization structure of the project

- Inclusion of minority serving institutions is encouraged
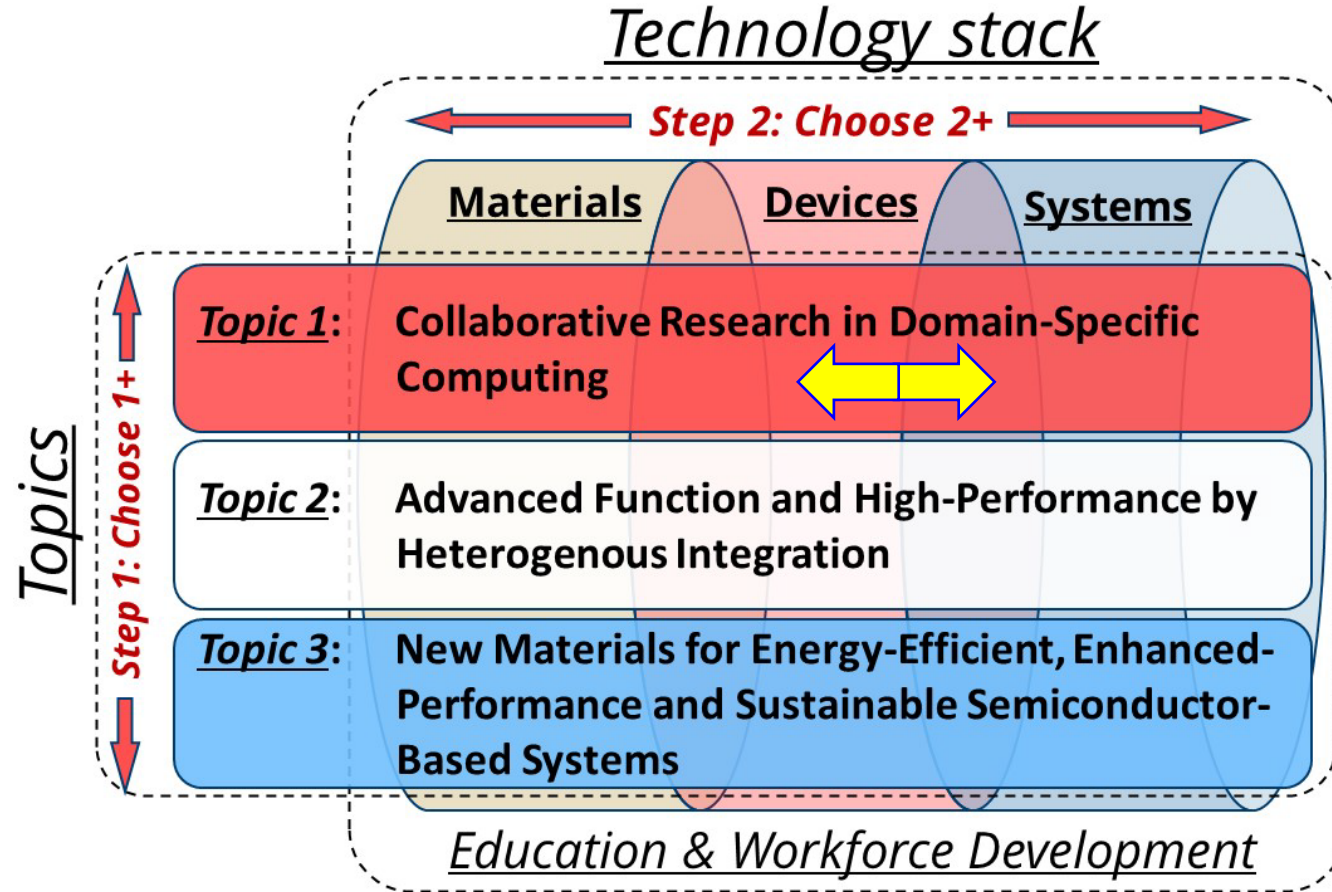
- In the project summary page, the first sentence, please mention the topic(s) and the technology stack that your proposal plans to tackle

  - Example: This proposal is on Topic-1 and devices/systems technology stack.

# Proposals may leverage other activities/resources and broaden opportunities for participations

**Collaboration:**
- Industrial collaborations*
- National Laboratories Collaborations

*These organizations are all qualified to participate but whether they can receive funding, see the FuSe solicitation and Proposal and Award Policies and Procedures Guide*

**Encourage Participation:**

Institutions of EPSCoR States

Minority-Serving Institutions, HBCUs, HSI

* Industrial Collaborations -  Grant Opportunities for Academic Liaison with Industry (GOALI) mechanism can 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; and

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

**FuSe Specific Review Criteria:**

- **Project Scope**

- **Commitment of the Investigators**

- **Composition of the Team**

- **Justification for Support**

# FuSe Specific Review Criteria:

- What does the project identify an overarching foundational problem which requires a co-design approach to accelerate the eventual manufacture?

- Are energy-efficient, sustainable device manufacturing processes using earth-abundant and nontoxic materials, minimizing water usage, and is striving for zero waste emphasized?

- Identify the integrated multi-disciplinary research agenda or plan presented that defines the roles of all participants. Is the composition of the multidisciplinary team appropriate for the scope of the proposed activities and engage PIs from along the technology stack?

- How are the research tasks synthetically 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?

# FuSe Industry Partners (Ericsson, IBM, Intel, Samsung)

- Proposals may <u>not list</u> or describe any kind of agreed or assumed arrangement to use the contributions or any other collaborative arrangement with <u>this solicitation's industry partners</u>

- Proposers are <u>not restricted</u> from making use of the widely accessible products or <u>services of FuSe industry partners</u>

- Proposers <u>should not directly contact FuSe industry partners</u> with questions pertaining to their company's participation in this solicitation. All questions should be directed to NSF

- Read eligibility section of this solicitation

# FuSe Industry Partners – Prior to Awards

- FuSe 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

  - Reviews and panel summaries will also be shared

- NSF will take into consideration the input of all FuSe industry partners prior to making final funding decision.

- Proprietary or privileged information provided by the PI in the separate "Single Copy Documents" section of the proposal will not be shared with reviewers or industry partner representatives.

- NSF will retain final authority for making all award decisions.

# FuSe Industry Partners – Post Award

- NSF will administer awards under the Program in accordance with standard NSF policies and procedures.

- FuSe Industry partners will not oversee the activities or use of funds by grantees under this Program.

- FuSe Industry partners may make available direct contributions of resources

  - Example: software (prototypes or products), data sets, and/or other computing infrastructure.

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

- A FuSe industry partner may also 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 FuSe industry partners after those reports have been reviewed and accepted by the cognizant NSF Program Officer.

# FuSe Industry Collaboration – Intellectual Property

- The 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 and Samsung will be named as sponsoring parties for all awards.
            - Ericsson and IBM will be named as sponsoring parties in a partial set.
- No rights or licenses are granted by the FuSe industry partners.
- Awardees may delay the publishing of data and software describing inventions to first permit the filing of patent applications.
    - *NSF terms and conditions will require that awardees promptly publish all results, data, and software generated in performance of the research.*
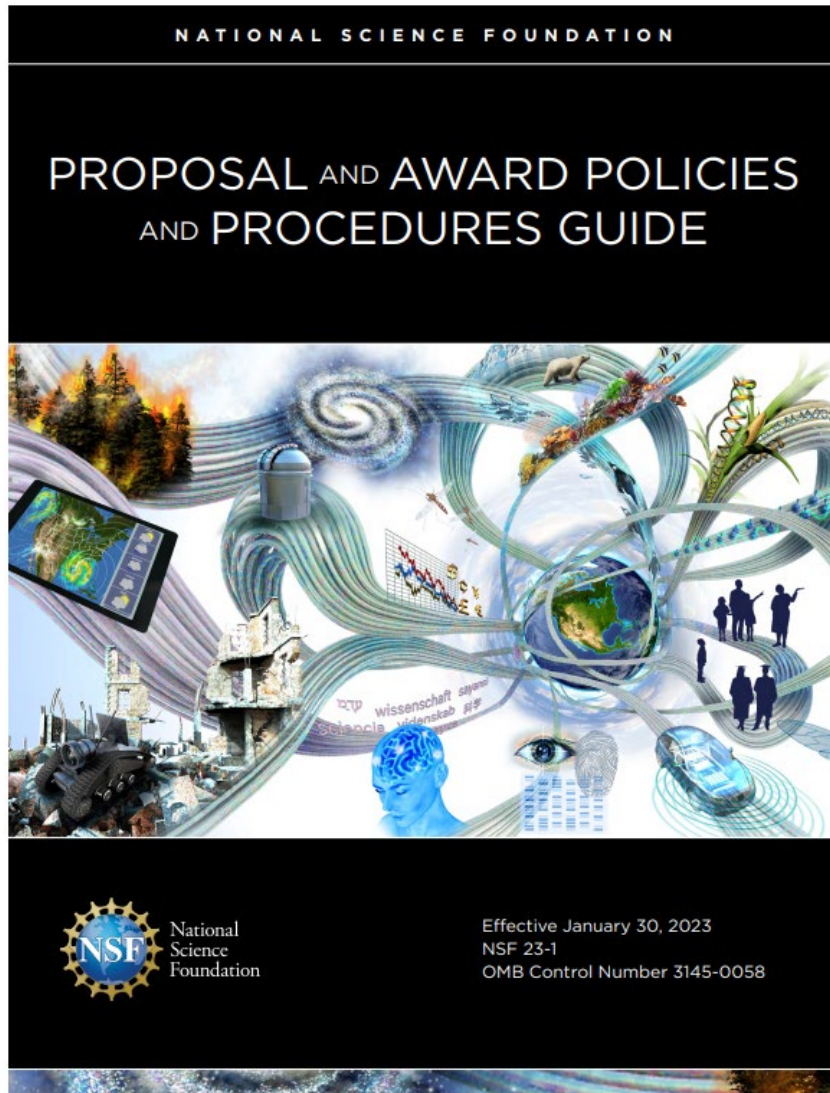
# Resources and Program Officers are Available to Help

- Be sure to fully read the solicitation NSF 23-552
- 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

# Q&A

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

- After the webinar, email your questions to <u>fuse1@nsf.gov</u>

- Check Webinar Materials and updated FuSe FAQ online
https://beta.nsf.gov/funding/opportunities/national-science-foundation-future-semiconductors

# THANK YOU