MICROELECTRONICS AND SEMICONDUCTORS

Microelectronics and Semiconductors Funding[1]
(Dollars in Millions)

	FY 2023 Base Plan	FY 2024 (TBD)	FY 2025 Request
CISE	$40.00	-	$41.80
EDU	-	-	2.00
ENG	43.00	-	44.94
MPS	31.00	-	35.00
TIP	38.25	-	51.23
Total	**$152.25**	**-**	**$174.97**

[1] Funding displayed may have overlap with other topics and programs.

Overview

Without semiconductors, the world would be a very different place; we would not have cellphones, personal computers, electronically controlled cars, appliances, or many other technologies we rely upon every day. They are omnipresent in transportation, communications, healthcare, manufacturing, and information technology, among other industries. Yet, U.S.-led innovations in semiconductors and microelectronics have slowed in recent decades, and the Nation is now facing historically unprecedented global competition.

Transistors, the building blocks of today's microelectronics, are approaching fundamental down-scaling limits in both size and energy efficiency. Additionally, current transistor technologies require a significant investment of scarce natural resources to produce and are energy inefficient when used. Another important consideration is safety and security of microelectronics throughout the lifecycle. Microelectronics and semiconductors warrant strategic investment to ensure continued U.S. leadership in this foundational technology, which will also facilitate leadership in many other technology areas that underlie major sectors of the economy and critical aspects of national security. Investments in sustainable microelectronics—including holistic manufacturing processes that use environmentally-benign materials, encompass the entire manufacturing lifecycle, and account for energy efficiency, health and environmental impact, and cost effectiveness—are critical to the existential challenge of our generation: climate change.

The overarching objectives of NSF's investment in Microelectronics and Semiconductors are to develop new paradigms in semiconductor capabilities and to grow the corresponding, diverse workforce necessary to keep pace with industrial and research needs. Ongoing activities and new, complementary opportunities will leverage and create advances in materials, devices, circuits, architectures, and related software and applications. Advances in microelectronics and semiconductors in recent years continue to be made through longstanding NSF programs, including Electronics, Photonics and Magnetic Devices; Communications, Circuits, and Sensing-Systems; Energy, Power, Control, and Networks; Semiconductor Synthetic Biology; Foundations of Emerging Technologies; Software and Hardware Foundations; Principles and Practice of Scalable Systems; Secure and Trustworthy Cyberspace; Advanced Manufacturing; Materials Research programs, including the cross-cutting Designing Materials to Revolutionize and Engineer our Future program; as well as Science and Technology Centers; Engineering Research Centers; and Industry-University Cooperative Research Centers. The new Designing for Environmental Sustainability in Computing program addresses environmental sustainability of computing through its entire lifecycle: from design and manufacturing, through deployment into operation, and finally into reuse, recycling, and disposal. NSF programs for innovation and translation, including the NSF Innovation Corps (I-Corps™), and the Small Business Innovation Research and Small Business Technology Transfer programs, have enabled new knowledge and designs to make their way into the market and society.

The Future of Semiconductors (FuSe) program, begun in FY 2023, supports research and workforce education and training in partnership with industry to enable rapid progress in new semiconductor technologies. FuSe invests in new materials, materials processing and characterization, fabrication, devices and systems, and computing, sensing, and communication systems in response to both near-term supply chain concerns and longer-term Post-Moore's Law challenges. FuSe also considers research infrastructure needs in this domain, particularly improving semiconductor fabrication foundry access for NSF-funded researchers, and how potential partnerships with industry may facilitate such access.

There is an urgent need in the academic community for end-to-end semiconductor chip design support. The NSF Enabling Access to the Semiconductor Chip Ecosystem for Design, Fabrication, and Training (Chip Design Hub) program, begun in FY 2024, will establish and manage a community infrastructure that supports the entire integrated circuit (IC) chip design process. It will dramatically lower the barriers to accessing state-of-the-art electronic design automation tools, process design kits, and design intellectual property cores for students and academic researchers, and it will enable students at various levels to design IC chips. A key goal is to broaden participation in IC chip design beyond the small number of institutions currently engaged in these activities.

NSF's investments aim to demonstrate sustainable new semiconductors and microelectronic devices capable of overcoming the looming natural limits of current technologies and architectures. These investments will also enable the training of a critically needed U.S. workforce capable of adapting and advancing these technologies for a broad range of societal needs. This approach to NSF's investment in Microelectronics and Semiconductors will help overcome scientific barriers in essential technologies such as: advanced computing; artificial intelligence; distributed mobile processing platforms; internet of things; quantum communication, computing, and sensing; advanced communications; advanced manufacturing; and biological-semiconductor interfaces.

Goals

- *Support research and development of new, secure, high-performance devices and systems* made possible by novel and sustainable materials that offer improved security and energy-efficient functionality.
- *Investigate and implement methods and techniques to integrate new classes of devices into microelectronic circuits for diverse platforms.* Microelectronic devices are fabricated by integrating transistors with numerous other components that work with different physical principles. The need to bring various components—electrical, optical, magnetic, and quantum—into a microelectronic circuit necessitates the investigation of new co-design, packaging, and testing methodologies.

- *Create a semiconductor and microelectronics R&D ecosystem.* This ecosystem will enable researchers and trainees to fabricate novel transistors and devices and to integrate component technologies into systems using heterogeneous integration techniques. The ecosystem will connect user facilities to fabricate devices in the laboratory, advanced methods for semiconductor manufacturing, and partnerships with industry to translate laboratory-generated ideas into foundry-fabricated prototypes.
- *Grow a diverse workforce* across the U.S. and provide experiential learning and training opportunities in partnership with industry to support the ecosystem, from researchers to technicians, theorists to experimentalists, and entrepreneurs to practitioners.

FY 2025 Investments

Research in Foundational Principles
Ongoing and new opportunities in foundational research, from individual-investigator projects to efforts comprising large multidisciplinary teams, will create new classes of novel, secure, sustainable, high-performance semiconductors for microelectronic devices.

Methods for Integrating Devices into Diverse Platforms
NSF will invest in existing and new opportunities, including research infrastructure and use-inspired research, to investigate and implement new methods for device integration and novel architectures.

Microelectronics Ecosystem
NSF will continue to invest in advanced manufacturing research, lab-to-fab opportunities, and research infrastructure, such as the NSF Quantum Foundries and the National Nanotechnology Coordinated Infrastructure, to translate benchtop microelectronics and semiconductors research to fabrication and manufacturing.

Workforce Development
To prepare a diverse microelectronics and semiconductors workforce across the U.S., NSF invests in STEM education at all levels and across settings. Relevant NSF programs include Advanced Technological Education, Experiential Learning in Emerging and Novel Technologies, Improving Undergraduate STEM Education, Robert Noyce Teacher Scholarship Program, NSF Research Traineeship, Faculty Early Career Development, Research Experiences for Undergraduates (REU), Research Experiences for Teachers, as well as semiconductor and microelectronics education in research projects. NSF has partnered with industry to support REU sites on topics related to microelectronics and semiconductors. Support for NSF Non-Academic Research Internships for Graduate Students, Experiential Learning for Emerging and Novel Technologies, I-Corps™ and NSF Entrepreneurial Fellowships provides students with industrial and entrepreneurship experience.

As per the CHIPS and Science Act of 2022, NSF will be expanding and creating investments in programs that support microelectronics education and workforce development. These investments include curriculum development and faculty training, increasing infrastructure access and broadening participation in the microelectronics workforce through recruitment and retention efforts, and coordination and facilitation of partnerships.