MASH Mission & Scope

MISSION & SCOPE

MASH will support the CHIPS and Science Act to enhance America's strength in semiconductors and microelectronics and promote economic development.

The goal of MASH is to create the world's largest nanofabrication, packaging, and characterization facility by linking and enhancing the facilities in the region. The MASH "distributed" network of facilities will support technology transition to manufacturing and offer redundancy of resources and immediate access to a huge amount of technical expertise in semiconductors.

MASH will focus on helping the semiconductor industry to transition materials into systems, which is a critical industrial need of many emerging applications such as advanced communications, non-volatile memory, More than Moore devices, Industrial Internet of Things, artificial intelligence, edge computing, wireless communications, quantum devices, environmental sustainability, and materials and substrates.

MASH activities will center around three cross-cutting areas: Si-adjacent technologies, advanced packaging, and virtualization of semiconductor processes.

MASH will develop skills-based educational and workforce development plans to provide companies with an agile system to meet staffing requirements, and at the same time, enhance racial and socioeconomic diversity.

MASH will be a hub for regional and national activities to promote professional education and training, educate the public on semiconductors and microelectronics, share and coordinate materials standards, identify funding opportunities, and build networks and technology road maps.

MASH Mid-Atlantic SEMICONDUCTOR HUB

PennState

The success of Penn State as a leader in the researching and engineering of materials and devices has enabled the establishment of a robust research infrastructure through shared facilities. Most of these facilities are centrally housed in the 275,600 square-foot Millennium Science Complex at University Park where an entire wing of the building is dedicated to materials research.

2DCC: synthesis

NSF 2D CRYSTAL CONSORTIUM MATERIALS INNOVATION PLATFORM

The 2DCC operates as a national resource providing access and expertise in 2D chalcogenide layered materials in the form of bulk crystal, multilayers, and one-atom thick films. It enables cutting-edge research into next-generation 2D electronics and collaborates with microelectronics manufacturing companies.

CONTACT: Joan Redwing, jmr31@psu.edu

The 2DCC-MIP is funded by NSF cooperative agreement DMR-2039351.

NANOFAB: fabrication

NANOFABRICATION LABORATORY

The Materials Research Institute Nanofab provides access to state-of-the-art nanofabrication capabilities and expertise to researchers from academia, industry, and federal research labs. The Nanofab is a 15,000 sq.ft. cleanroom (Class 1000/100) and high-quality support space and is unique in its ability to handle small parts up to 200mm wafers on most tools. The Nanofab staff, in addition to its nanofabrication expertise, has broad experience in condensed-matter physics, chemistry, X-ray physics, optics, and magnetism, offering a broad knowledge base to support the user community. The Nanofab has decades of experience in developing piezoelectric and ferroelectric materials, MEMS devices, heterogeneous integration, and glass packaging. The facility has a long tradition of teaching semiconductor processes to undergraduate and graduate students, and it works closely with industry in developing processes compatible with technology transfer. We are currently working with many semiconductor companies and start-ups that take advantage of our expertise in materials synthesis, integration, and nanofabrication.

CONTACT: Daniel Lopez, dlopez@psu.edu

MCL: characterization

MATERIALS CHARACTERIZATION LABORATORY

The MCL is a core facility of the Materials Research Institute and is a fully staffed, open access facility providing access to characterization equipment for materials and devices to enable advanced research while educating the next generation of highly qualified scientists and researchers. The MCL laboratories occupy more than 15,000 square feet within the Millennium Science Complex (MSC) at Penn State and are staffed by interdisciplinary scientists and engineers. Current MCL state of the art capabilities include transmission electron microscopy, scanning electron and ion microscopy, surface characterization, X-ray scattering, molecular spectroscopy, thermal analysis, particle characterization, electrical characterization, and mechanical testing.

CONTACT: Josh Stapleton, jjs36@psu.edu

AIMI: AI, machine learning

CENTER FOR APPLICATIONS OF ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING TO INDUSTRY

Penn State's Center for Applications of Artificial Intelligence and Machine Learning to Industry (AIMI) connects industry members with Penn State's vast research community of artificial intelligence (AI) and machine learning (ML) researchers and their students to solve real-world problems and seize market opportunities.

AIMI can help your business or organization partner with world experts to explore innovative ways to leveraging AI that addresses your organizational needs, engage directly with faculty and students on short-term, low-risk, high-reward, shared intellectual property development. We develop a comprehensive and diverse workforce pipeline through substantive involvement in shared projects and deliverables.

CONTACT: Soundar Kumara, u1o@psu.edu

FACILITIES

STRONG #1 REPUTATION
NSF Expenditures rankings by U.S. Universities – **#1 in Material Science** & **#2 in Materials Engineering**
#2

DIGITAL TWINS:
materials growth & immersive interaction

MATERIALS GROWTH SIMULATIONS

Penn State has extensive expertise in simulating materials growth and calculating material properties – covering size ranges all the way from atomistic-scale to the continuum. This involves computational methods including quantum mechanics – in particular: density functional theory, physics-based and machine learning-based, reactive and non-reactive empirical force fields, phase field- and phase diagram-based methods, and computational fluid dynamics methods. In each of these methods, Penn State provides world-leading method development and application expertise – which established connectivity to experimental efforts in 2DCC and Nanofab.

CONTACT: Adri van Duin, acv13@psu.edu

IMMERSIVE INTERACTION WITH DIGITAL TWINS

By creating a high-fidelity digital twin of physical processes, Penn State can provide a state-of-the-art immersive networking and computing platform to support interactive training, real-time immersive monitoring, and precise control through virtual/mixed reality (VR/MR) headsets. Customizable to suit a diverse range of digital twin applications, we can offer comprehensive guarantees on human performance, ensuring seamless integration and operational excellence from start to finish.

These digital twin activities are supported by the Materials Research Institute (MRI), the Institute of Computational and Data Science (ICDS), and the Center for Immersive Experiences (CIE). In support of semiconductor research, ICDS has a number of strategic efforts under its artificial intelligence (AI) Hub. The high performance computing infrastructure maintained by ICDS and its highly qualified staff also enable the handling of large data sets arising from detailed synthesis monitoring, and complex device designs that increasingly need hierarchical spatial and time analytics in their simulations. CIE is driven to catalyze fundamental scientific research efforts through immersive technologies. Using high fidelity and hyper realistic virtual, augmented, and mixed reality experiences, paired with a deep expertise in human factors, advanced simulations, and computer visualizations, our work is easily integrated into research, education, and outreach efforts. Projects in the center range from fully interactive digital twins of complex manufacturing systems to hands-on training to upskill the current and future workforce. Because the scope and potential reach of xR is not limited to any one discipline, CIE's work is rooted in empirical research and a pedagogical approach to its implementation.

CONTACTS:

Bin Li, binli@psu.edu *(immersive interaction with digital twinning)*

Jessica Menold, jdm5407@psu.edu *(CIE)*

250 WIDE-RANGE OUTREACH
Since 2017, MRI has worked with **100+** companies in Pennsylvania alone and **250** independent organizations

KEY MASH CONTACTS

	NAME	TITLE	DETAILS
PennState	**Daniel Lopez**	Liang Professor of Electrical Engineering Director, Nanofabrication Lab, Materials Research Institute	dlopez@psu.edu (814) 867-1575
	Osama Awadelkarim	UNESCO Chair Professor Director, Center for Nanotechnology Education and Utilization	ooa1@psu.edu (814) 863-1773
	Shannon Munro	Vice President for Workforce Development Pennsylvania College of Technology	smm20@pct.edu (570) 320-2400
	Mark Threeton	Professor of Education, Associate Director of PPDC	mdt177@psu.edu (814) 863-5361
	Priya Baboo	Senior Director of Corporate and Industry Engagement, College of Engineering	pzb104@psu.edu (814) 863-9142
Penn	**Mark Allen**	Scientific Director, Singh Center for Nanotechnology	mallen@seas.upenn.edu (215) 898-5901
	Gerald Lopez	Director, Business Development Singh Center for Nanotechnology	lopezg@seas.upenn.edu (215) 573-4041
NYU	**Nina Gray**	Assistant Vice Provost for Research	graya01@nyu.edu (212) 998-2304
	Kurt Becker	Vice Dean for Research, Innovation and Entrepreneurship	kurt.becker@nyu.edu (646) 997-3608
University of Delaware	**Jamie Philips**	Chair, Department of Electrical and Computer Engineering	jphilli@udel.edu (302) 831-2128

KEY MASH CONTACTS

MASH Mid-Atlantic SEMICONDUCTOR HUB

	NAME	TITLE	DETAILS
PRINCETON UNIVERSITY	**Alex Norman**	Executive Director Princeton Materials Institute	an8759@princeton.edu (609) 258-6855
	Barry Rand	Associate Professor of Electrical and Computer Engineering	brand@princeton.edu (609) 258-7692
	Richard Register	Director, Materials Institute	register@princeton.edu (609) 258-4692
BOSTON UNIVERSITY	**David Bishop**	Head of the Division of Materials Science & Engineering	djb1@bu.edu (617) 353-8899
	Alice White	Professor and Chair, Mechanical Engineering	aew1@bu.edu (617) 353-2814
COLUMBIA UNIVERSITY	**James Hone**	Chair, Department of Mechanical Engineering	jh2228@columbia.edu (212) 854-3304
	Samar Kaukab	Director of Strategic Research Development	sk4578@columbia.edu (212) 854-2996
UNIVERSITY OF MARYLAND	**Pamela Abshire**	Professor, Electrical and Computer Engineering	pabshire@umd.edu (301) 405-6629
	Ankur Srivastava	Professor & Director Institute for Systems Research	ankurs@umd.edu (301) 405-0434
UNIVERSITY OF THE DISTRICT OF COLUMBIA 1851	**Pawan Tyagi**	Professor of Mechanical Engineering & Director of ME Graduate Program	ptyagi@udc.edu (202) 274-6601

MARKETING COMMUNICATIONS

	NAME	TITLE	DETAILS
PennState	**Jennifer McCann**	Marketing Director, Materials Research Institute MASH Communications Manager	jmm96@psu.edu (814) 867-4173
	Kimberly Brue	Assistant Vice President Research Communications	kimberly.brue@psu.edu (814) 865-6042
Penn	**Lee Ozier**	Program Coordinator Singh Center for Nanotechnology	ozierd@seas.upenn.edu
NYU	**Joseph Tirella**	Senior Director of Executive Communications	jvt8915@nyu.edu (212) 998-6796
University of Delaware	**Tracey Bryant**	Senior Director for Research Communications	tbryant@udel.edu (302) 831-8185
Princeton University	**Steven Schultz**	Director of Engineering Communications	sschultz@princeton.edu (609) 258-3617
Boston University	**Rachel Lapal Cavallario**	Associate VP, Public Relations	rlapal@bu.edu (617) 353-7628
Columbia University	**Michele Hoos**	Executive Director of Communications, Engineering	mfh2107@columbia.edu (212) 305-0820
University of Maryland	**Institute for Systems Research**	Resources for the Media	mediainfo@umd.edu (301) 405-6602
University of the District of Columbia 1851	**Leeaan Hall**	Vice President for Marketing & Communications	leeann.hall@udc.edu (202) 934-5047
	Andrea Williams	Assistant Vice President for Marketing & Communications	andrea.williams@udc.edu (202) 274-5177

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