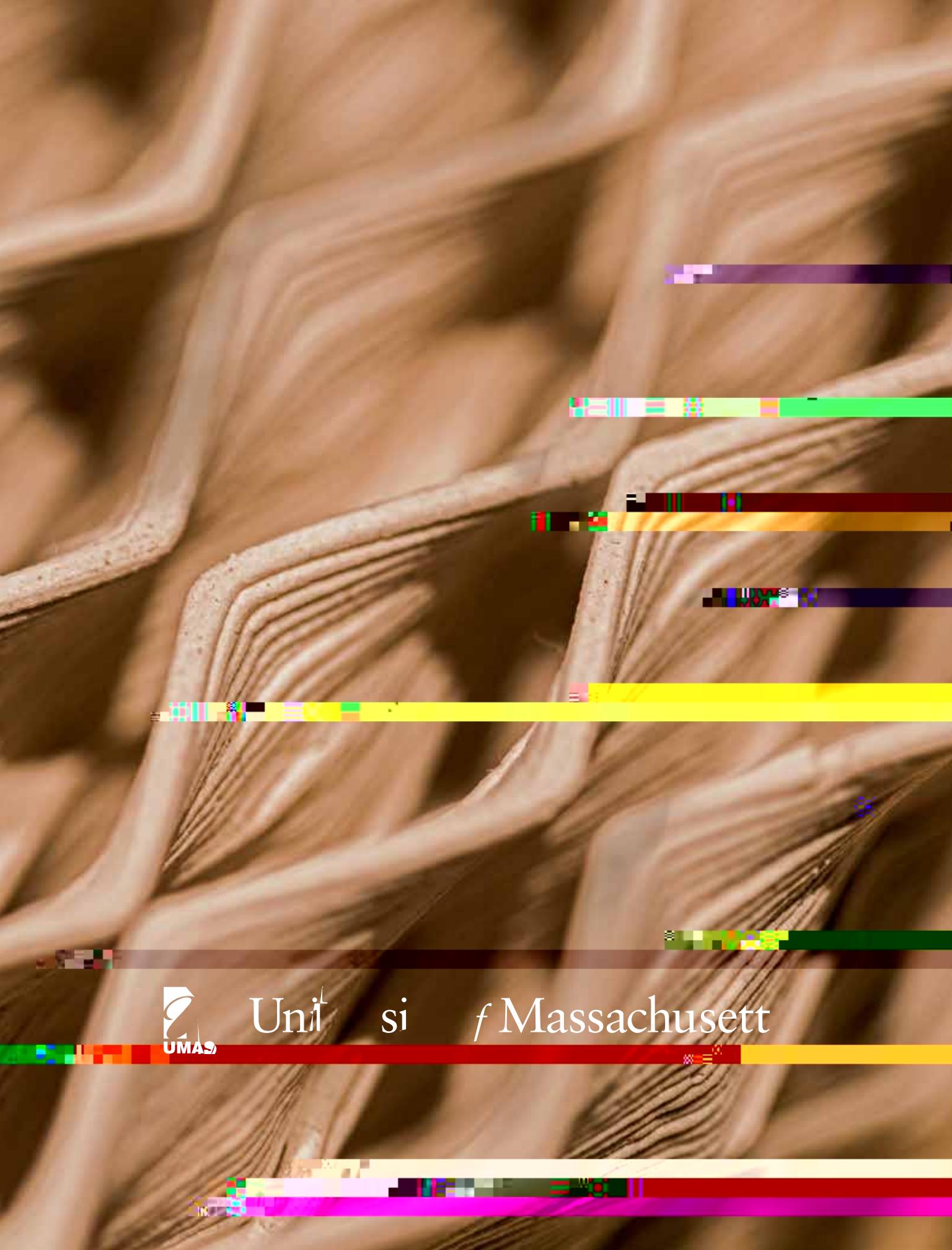

UMASS

Shaping 3D printing

One of several NSF-sponsored Industry/University Cooperative Research Centers across UMass, the Center for Science of Heterogeneous Additive Printing of 3D Materials (SHAP3D) at UMass Lowell works to advance additive manufacturing techniques like 3D printing. With an eye on the needs of industry, SHAP3D develops methods for additively printing varied products with a range of functions through the integration of advanced materials, complex structures, and cutting-edge processes. Partners include major manufacturing companies like Raytheon, Greene-Tweed, HP, and Stratasys; small businesses like Hutchinson, K&C, and Integrity; government entities, such as the U.S. Army Combat Capabilities Development Command; and researchers at the University of Connecticut and Georgia Tech.

Additive manufacturing

The rise of additive manufacturing processes like 3D printing represents a new paradigm for the manufacturing industry, one focused on customization and innovation. Additive processes build products in layers according to precise computer models, and offer appealing advantages to industry:

prototyping, and the ability to produce small lots cost-effectively. Additive manufacturing was an $11.8 billion

$53 billion by 2029.

Additive manufacturing research at UMass spans all aspects of the modern industrial process—including modeling, production technologies, quality-control automation, information systems architecture, and data-driven predictive analytics—and is highly collaborative with government and industry. The Raytheon-UMass Lowell Research Institute, for example, is an academic-corporate research partnership where

UMass Amherst's Institute for Applied Life Sciences houses state-of-the-art facilities for advanced manufacturing and materials discovery.

simulations, and engineering software, collaborated with Raytheon to produce a co-copyrighted software tool that helps product designers tell whether additive manufacturing is the right

UMass Amherst's Multiscale Materials and Manufacturing Laboratory are working with the Department of Energy to develop optimal 3D-printed structures for batteries and other

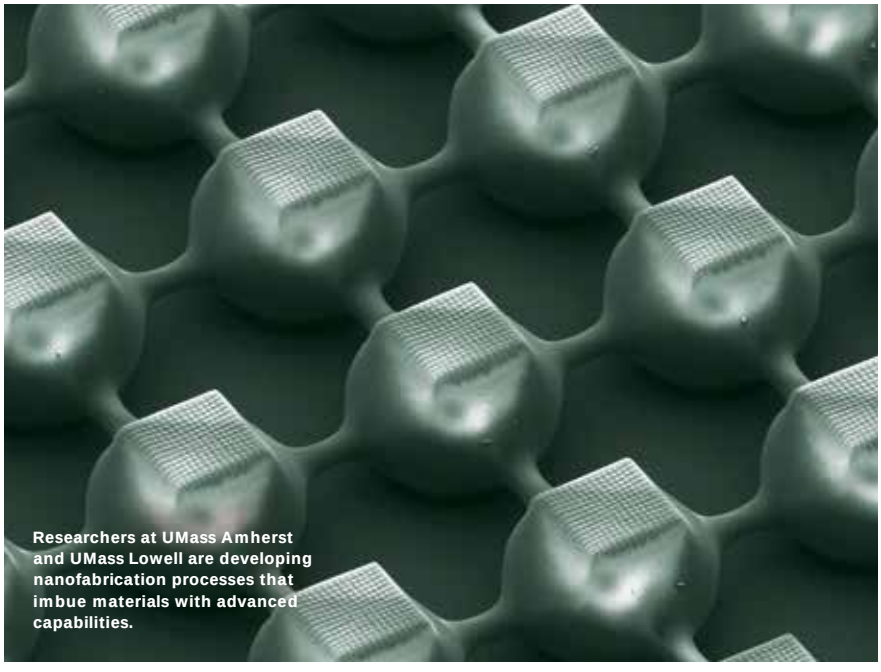
These researchers can draw on the Advanced Digital Design and Fabrication core facility, part of the $150 million Institute for Applied Life Sciences at UMass Amherst, which operates cutting-edge, industrial-grade, additive equipment. It is a

state, and a springboard for local industry development.

Materials in manufacturing

UMass has longstanding strength at the intersection of materials science and manufacturing, in both developing and producing new materials that resolve vexing problems and in analyzing how materials behave at scale. UMass Amherst's Center for UMass-Industry Research on Polymers, the longest-running NSF Industry/University Cooperative Research Center in the nation, has been working in this space since 1980. The system was an early leader in nanomaterials manufacturing. UMass Lowell and UMass Amherst hosted Science and Engineering Centers focused on nanomanufacturing: the $24.5 million Center for High-Rate Nanomanufacturing (and its

Nanomanufacturing Center of Excellence), and the $36 million Center for Hierarchical Manufacturing.



Researchers at UMass Amherst and UMass Lowell are developing nanofabrication processes that imbue materials with advanced capabilities.

The Lowell campus hosts the largest university-based collection of polymer processing equipment in the United States.

Research groups across the system are creating materials with a wealth of valuable properties. UMass Dartmouth faculty, for instance, hold a number

energy-absorbent materials (used, for example, to reduce rotational effects of impact in sports helmets).

UMass Lowell's Advanced Composites

from manufacturing, reducing or eliminating the use or creation of hazardous substances in the production of chemical products.

Biomedical manufacturing

Biomedical manufacturing, the manufacturing of drugs and medical devices, is a vital step in any medical

to the bedside. The UMass system has

One key focus is the use of genetically

create biopharmaceuticals. UMass

the inventions that were born in faculty labs.

The work of biomedical manufacturing researchers has been critical in the

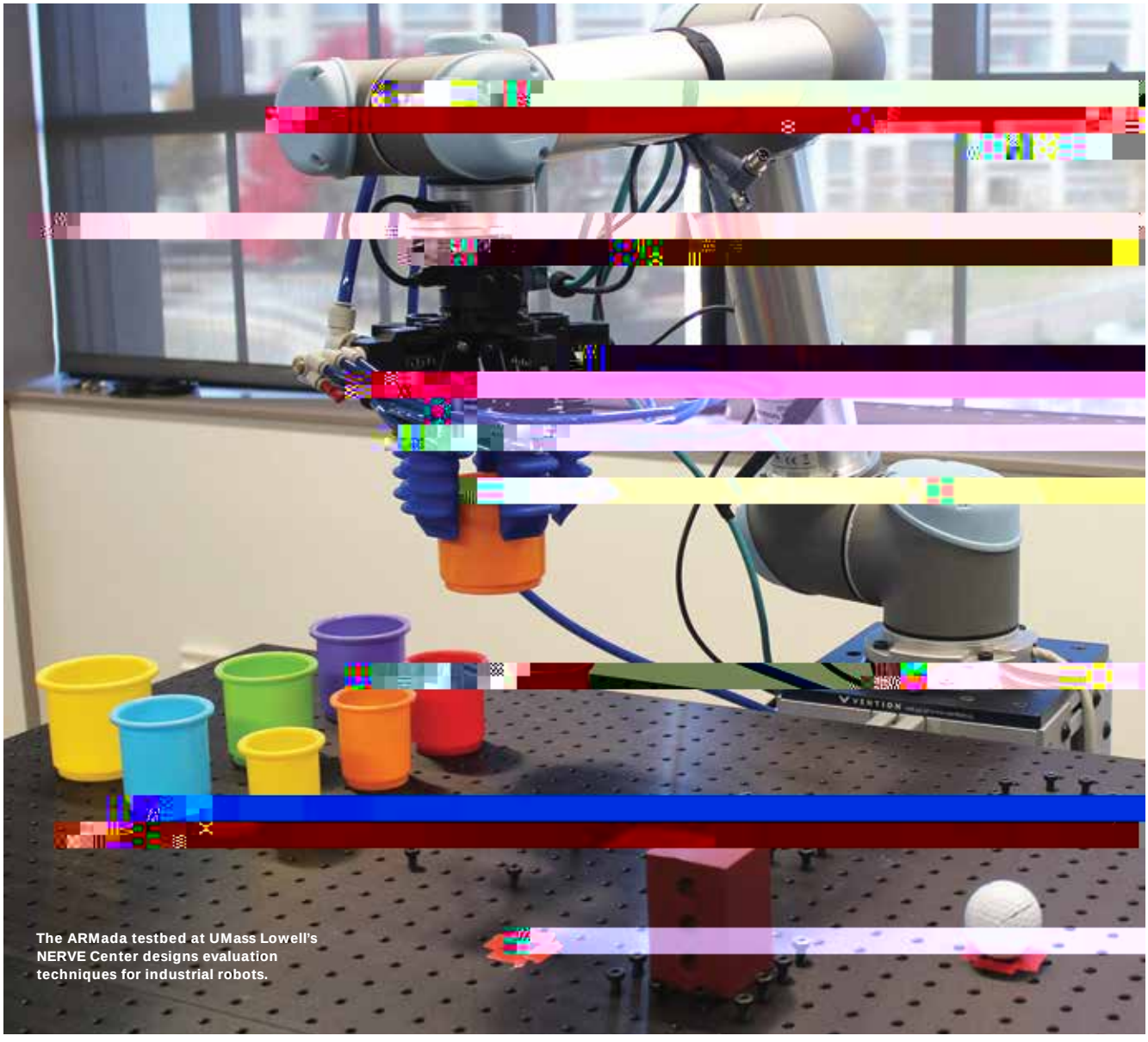
research into antiviral coatings and

personal protective equipment, testing swabs made with UMass Dartmouth's

low-cost, fast-track face shields designed in collaboration with nursing faculty.

Roll-to-roll manufacturing

Advanced roll-to-roll manufacturing—a process that coats, prints, embeds,



The ARMada testbed at UMass Lowell's NERVE Center designs evaluation techniques for industrial robots.

University Cooperative Research Center for e-Design, develops manufacturing design paradigms and processes. The Dynamic Facilities Layout and Simulation Modeling Lab, the Human Robots Systems Lab, the Process Automation Lab, the Supply Chain Management Lab, and a number of other research groups whose work is relevant to manufacturing and automation collaborate to address virtually all aspects of automation.

Modeling and data fusion are particular areas of strength. Professor Ana Muriel, for example, works with aerospace manufacturer Pratt & Whitney to develop a detailed computer simulation, or “digital twin,” of the company's supply chain

Sundar Krishnamurty works with the National Institute of Standards and Technology on compiling and coordinating actionable data from sensors on additive manufacturing equipment; and Professor Leo Liu studies integration of electronics, rubber components, and liquid metal technology in smart medical devices and micro-robots.

UMass Lowell's New England Robotics Validation and Experimentation (NERVE) Center, an interdisciplinary robotics testing, research, and training facility, evaluates robotic capabilities, human performance, and human-robot interaction across many domains, including manufacturing. The ARMada testbed
variety of robotic arms, end effectors, mobile bases, and sensor systems to develop methods for evaluating grasping, human-robot collaboration, and assembly capabilities for industrial automation tasks.

Tomorrow’s frontiers

Demand for custom products is growing. COVID-19-related shortages revealed the worrisome limitations of existing supply chains. Responsible resource management is

pharmaceuticals, reducing fossil fuel use and emissions.

Next frontier 3:
3D printing on an industrial scale

3D printing, with its computer-powered nimbleness, is an essential element of an agile manufacturing industry. But today, additive manufacturing is not ready to grow to industrial scale. The materials toolset is limited, for one, and throughput is too slow. One of the largest roadblocks is the lack of a uniform code of operation.

Additive manufacturing is the Wild West today, but UMass researchers are changing that. One important step: Sundar Krishnamurty, site director of UMass Amherst's Center for e-Design, is working with the National Institute for Standards and Technology to develop standards and protocols for additive manufacturing that will yield consistent materials, processes, and results.

Next frontier 4:
Integration of biological and non-biological manufacturing

Today, biomanufacturing is largely distinct from other aspects of manufacturing. But integrating the processes to create products that combine organic and inorganic materials is a frontier with health care applications that beg to be explored. UMass's strengths in biopharmaceuticals, medical devices, wearable electronics, and advanced manufacturing puts us at a sweet spot for leading this integration.

Some of the manufacturing groundwork has already been laid. Nanomanufacturing is already highly bio-inspired; at UMass Lowell, for example, Joey Mead and Carol Barry have manufactured nano-patterned polymer surfaces that control interaction with biological materials and that could be used to create antibody-based sensors.

Next frontier 5:
Collaborative robots in manufacturing

potential in manufacturing. Unlike today's industrial robots, which are often cordoned off from workers for safety reasons, co-robots are designed to work alongside humans, safely and productively. The New England Robotics Validation and Experimentation Center at UMass Lowell is already evaluating 0 -1.4 Td[an)9 (ti)-1(y

Bridging the advanced manufacturing workforce gap

Commonwealth's GDP ($53.26 billion) was produced by the manufacturing sector, which employs more than 6 percent of the state's workers.

Approximately 718,000 of those manufacturing professionals comprise the highly skilled workforce of the state's advanced manufacturers, the organizations responsible for producing the fruits of Massachusetts' famed innovation economy. In 2015, advanced manufacturing was one of the Commonwealth's three largest economic and employment sectors, according to the Massachusetts Department of Higher Education,

remain an important part of the Massachusetts economy for the foreseeable future.

At that time, however, the department's data showed that demand for skilled advanced manufacturing professionals outstripped the state's supply by

manufacturing will grow by more than

and that advanced manufacturing

needed to bridge the advanced manufacturing workforce gap come

from the University of Massachusetts. In 2019, UMass awarded almost 20 percent of all related degrees conferred in the state, making the system the top producer of degree-holders in our region.

Self-cleaning surfaces

At the UMass Lowell Center for High-rate Nanomanufacturing, professors Joey Mead and

superomniphobic and superhydrophobic surfaces,

organic solvents due to micro- and nano-scale structures imparted during the manufacturing process. The potential applications are numerous:

The University of Massachusetts' faculty and students are passionate about the future they see for advanced manufacturing—an industry enabled by

Additive manufacturing
ADDFab: Advanced Design and Fabrication core facility (Amherst)
www.umass.edu/ials/addfab

Printed Electronics Research Collaborative (Lowell)
www.uml.edu/Research/PERC

Raytheon-UMass Lowell Research Institute (Lowell)
www.uml.edu/research/perc/ruri

Center for e-Design NSF IUCRC (Amherst)
edesign.ecs.umass.edu

SHAP3D: Science of Heterogeneous Additive Printing of 3D Materials NSF IUCRC (Lowell)
www.uml.edu/research/shap3d

Flexible Hybrid Electronics: UMass Lowell NextFlex initiative (Lowell)
www.uml.edu/research/nano/research/

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