

# RESEARCH at RIT

The Rochester Institute of Technology Research Report

Spring/Summer 2017

SPOTLIGHT ON

## MANUFACTURING

### Advancing the Industry

From remanufacturing to developing better batteries to multifunctional 3D printing, RIT is a leader in the transformation of American manufacturing

R·I·T

[www.rit.edu/research](http://www.rit.edu/research)

# Driving the United States Manufacturing Renaissance

RIT is proud to play a pivotal role in transforming advanced manufacturing in the region and the nation.

## RESEARCH at RIT

The Rochester Institute of Technology  
Research Report—Spring/Summer 2017

### Executive Editors

Ryne Raffaele,  
Vice President for Research  
and Associate Provost

John Trierweiler  
Vice President and Chief Marketing Officer

### Managing Editor

Bob Finnerty,  
Marketing and Communications

### Editor

Mindy Mozer,  
Marketing and Communications

### Design Director

Jeff Arbogast,  
Marketing and Communications

### Contributors

Marketing and Communications	Freelance Writers
Michelle Cometa	Kathy Lindsley
Laura Cummings	Suzette Norris
Susan Gawlowicz	Jane E. Sutter
Rich Kiley	

### Contributing Photographers

Marketing and Communications	Freelance Photographers
Elizabeth Lamark	David Lamb
A. Sue Weisler	John Myers
	Alex Tong

### Renderings

Beatriz Alvarez  
Sarah Chuah  
Behrad Ghodsi

### Office of Research Communications

74 Lomb Memorial Drive  
Rochester, NY 14623  
585-475-5094

### No. 19

13M-P2012-04/17-COH-JSA  
©2017 Rochester Institute of Technology  
All rights reserved

Rochester Institute of Technology publishes *Research at RIT*. RIT does not discriminate. RIT promotes and values diversity within its workforce and provides equal opportunity to all qualified individuals regardless of race, color, creed, age, marital status, sex, gender, religion, sexual orientation, gender identity, gender expression, national origin, veteran status, or disability.

No. 2, April 2017—RIT (USPS-676-870) is published 17 times annually by Rochester Institute of Technology, One Lomb Memorial Drive, Rochester, N.Y. 14623-5603, once in March, once in April, five times in June, three times in July, four times in August, once in September, once in October, and once in November. Periodicals postage paid at Rochester, N.Y. 14623-5603 and additional mailing offices. Postmaster: Send address changes to RIT, Rochester Institute of Technology, One Lomb Memorial Drive, Rochester, N.Y. 14623-5603.



In 2008, the financial crisis, the “Great Recession,” and the subsequent job losses caused many in the U.S. to start to re-examine the current state of manufacturing in the U.S. It was generally thought that if we did not act to reinvigorate our manufacturing sectors, more job losses would be inevitable.

In June 2011, U.S. President Barack Obama launched the Advanced Manufacturing Partnership on the recommendation of the President’s Council of Advisors on Science and Technology. The partnership was charged with identifying collaborative opportunities between industry, academia, and government to catalyze development and identify investment in emerging technologies to reinvigorate advanced manufacturing in the United States. Subsequently, the White House National Science and Technology Council issued “The National Network for Manufacturing Innovation (NNMI): A Preliminary Design” in January 2013.

On Dec. 16, 2014, the president signed the Revitalize American Manufacturing and Innovation Act into law, which gave congressional authorization to the interagency Advanced Manufacturing National Program Office and authorized the Department of Commerce to hold “open-topic” competitions for manufacturing innovation institutes, or NNMIs, where those topics of highest importance to industry could be proposed.

These new competitions afforded RIT an outstanding opportunity to enhance our growing research portfolio as their focus was so well aligned with where we have been as an institution for quite some time. One could say that furthering the techniques of advanced manufacturing

and the concomitant workforce development has been RIT’s mission from our very beginning.

RIT is a partner on seven of the winning NNMI teams and played a critical role in ensuring that two are headquartered in Rochester—AIM Photonics (American Institute for Manufacturing Integrated Photonics) and REMADE (Reducing Embodied-energy and Decreasing Emissions). The others include America Makes (additive manufacturing and 3D printing), ARM (Advanced Robotics Manufacturing), Digital Manufacturing and Design Innovation Institute, NextFlex (flexible hybrid electronics), and the Clean Energy Smart Manufacturing Innovation Institute.

In addition to the NNMIs (now called Manufacturing USA), over the past few years RIT has also been successful in securing the right to host a New York State Center for Advanced Technology in Additive Manufacturing and Multi-functional Printing (AMPrint Center), a New York State Center of Excellence in Advanced & Sustainable Manufacturing, the New York State Pollution Prevention Institute, and the RIT/New York Battery and Energy Storage Consortium Battery Prototyping Center.

Suffice it to say, we are very proud to be playing such a pivotal role in transforming advanced manufacturing in our region and the nation. I hope you will enjoy reading more about these initiatives and other ways in which RIT continues to live up to its legacy.

Best regards,

Ryne Raffaele, VP for Research

# Inside this Issue

## Features

2 - 41



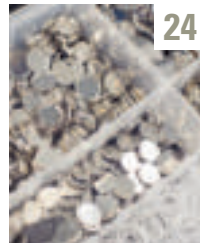
**2 Growing into a National University**  
RIT has a rich history of manufacturing dating back to the 19th century. Over the past three decades, RIT's connections to industry have expanded even more.



**10 Manufacturing USA**  
RIT is actively involved with seven of 14 national institutes that are bridging the gap between basic research and product development in areas critical to U.S. manufacturing.



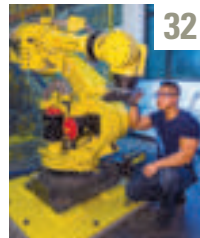
**20 Raising the Bar on 3D Printing**  
The new AMPrint Center on RIT's campus brings together university and corporate researcher-scientists in a way that impacts manufacturing in New York state and the nation.



**24 Next Generation of Batteries**  
RIT's \$1.5 million Battery Prototyping Center focuses on the development of emerging energy storage technologies and features equipment typically found in large corporate centers.



**28 Developing Sustainable Businesses**  
The New York State Pollution Prevention Institute directly assists businesses by providing on-site analysis and then offering options on how to improve processes.



**32 Training Manufacturing Engineers**  
Two industrial robots, donated to RIT by General Motors, are among a collection of manufacturing assembly and production systems that are used to instruct students on automation processes.



**36 Reducing Environmental Impact**  
The Center of Excellence in Advanced & Sustainable Manufacturing helps New York state manufacturing companies develop and commercialize new products and technologies.



**38 Improving Product Design**  
Industrial design students learn about sustainability and the manufacturing process early in their studies because it is an important part of the design process.

## On the Cover

cover



**On the Cover**  
The twin-wire electric arc spray process uses molten metal to apply a high-strength coating to the surface of damaged components. This additive manufacturing process can be used to repair damaged or worn components, allowing them to be returned to like-new condition.

## Research Awards and Honors

42 - 44



RIT's faculty, staff, and students have received significant national and international recognition for their research in a host of fields. A summary of awards and honors is provided.

# **ATHENÆUM** **AND MECHANICS' ASSOCIATION.**

---

The **SCIENTIFIC COURSE** will close with  
**THREE LECTURES BY**

# **JOHN PHIN**

---

**SUBJECT:**

The General **LAWS** and Practical **APPLICATIONS** of

# **Electricity**

---

These Lectures will be delivered in

# **CORINTHIAN HALL,**

ON THE FOLLOWING EVENINGS:

**THURSDAY, MARCH 7, 1861.**

**THURSDAY, MARCH 14, 1861.**

**THURSDAY, MARCH 28, 1861.**

AND WILL BE APPROPRIATELY ILLUSTRATED BY EXPERIMENTS.

---

**Admission, - Fifteen Cents.**

Doors open at 6

1-2 o'clock, P. M.

**Skilled Workers:** The forerunner of RIT, the Rochester Athenaeum and Mechanics Institute, was launched to provide technical instruction and training to workers in the area. The university has continued to create curricula that aligns with the needs of industry.

# Connections to Industry Helped RIT Grow into National University

by Kathy Lindsley

RIT has a rich history of manufacturing dating back to the 19th century.

## Technical Training for Workers

In 1885, John Bausch and Henry Lomb faced a serious problem.

The company they founded in 1853 had become the largest optical company in the world, but they were having difficulty finding the skilled workers needed. They knew that in Europe, technical institutes supplied a ready stream of qualified personnel. They determined that Rochester should have such a school.

Others concurred. Mechanics Institute—the forerunner of Rochester Institute of Technology—was launched when more than 50 industry leaders and prominent Rochesterians came together to establish “free evening schools for instruction in ... studies as are most important for industrial pursuits.”

Since then, RIT has grown into an internationally known university while preserving a focus on career-oriented academic programs and practical, applied research. The university has continued to create curricula that align with the needs of industry, including pioneering degree programs in imaging science, biotechnology, microelectronics, technical communication, information technology, diagnostic medical sonography (ultrasound), game design and development, packaging science, telecommunications engineering technology, photographic sciences, sustainability, and many other areas.



**25 years of CIMS:** The Center for Integrated Manufacturing Studies opened in 1992 to increase the competitiveness of manufacturers through technology development and training. The center moved into its current location inside Louise Slaughter Hall in 1996.

Today, RIT graduates find positions in companies all over the world and embark on entrepreneurial endeavors. Hundreds of businesses and government agencies come to the university to work on projects with students and faculty every year. The Princeton Review listed RIT in the 2017 edition of its book *Colleges That Pay You Back: The 200 Schools That Give You the Best Bang for Your Tuition Buck*, noting, “Employers trust the RIT brand implicitly, and the school stresses experiential learning and creativity as a part of every curriculum.”

## Industry Outreach Begins

Over the past three decades, RIT’s connections to industry have expanded tremendously with the launch of numerous research centers and initiatives. This explosion of growth can be traced to the late 1980s, when former President M. Richard Rose

championed the creation of the Center for Integrated Manufacturing Studies (CIMS).

“President Rose felt there were ways we could contribute to the regional economy and manufacturing by leveraging our expertise to help businesses,” recalled Deborah Stendardi, vice president for Government and Community Relations. At that time, New York state officials, concerned about the decline of manufacturing, were looking to educational institutions for ideas. RIT presented a detailed proposal for creating an applied research and training center to help small- and medium-size manufacturers titled “Technology Transfer and Education: The Keys to Restoring America’s Competitive Edge in Manufacturing.”

“Historically, RIT was not known as a research institution,” said Stendardi, “but we worked hard to introduce our elected officials to the kind of work that was being done at RIT and how it could support manufacturing. We received tremendous support from our state and federal legislators. They deserve kudos for having faith in RIT’s ability to deliver what we promised.”

The effort paid off. In 1992, then-

**Co-op Leader:** RIT’s cooperative education program kicked off in 1912. It has transformed from providing local companies with skilled workers to a global initiative.





**Remanufacturing:** Nabil Nasr, second from right, and members of his remanufacturing group met in 2000 to discuss the Navy ship project. Today, Nasr is director of the Golisano Institute for Sustainability.



**Hands-On Training:** CIMS co-op students worked on a Marine Corps Light Armored Vehicle in preparation for its use in a CIMS research program in 2006.

Gov. Mario Cuomo signed the Higher Education Advanced Technology Act, which made available about \$95 million to institutions including RIT, Rensselaer Polytechnic Institute, and Fordham, Cornell, Columbia, and Syracuse universities. “This was the first time that RIT was part of state funding that included major research universities,” said Stendardi. “It really did put RIT on the map as an institution that does research.”

RIT ultimately received \$10 million from the state, plus \$11.25 million from the federal government, to launch CIMS. In addition, Kodak, Gleason, Xerox, IBM, Bausch & Lomb, and many other companies contributed more than \$8 million. In 1996, CIMS moved into a new, 157,000-square-foot, state-of-the-art building.

CIMS differed from RIT’s colleges and academic units in that its primary mission was to provide technology development and transfer to businesses to help them grow and thrive. CIMS was to be self-sustaining, like a business: Its operating costs were and are covered by funding received from the organizations with which it works. The industrial bays and specialized labs at CIMS were quickly engaged in providing training, applied

research, and testing of manufacturing technologies of practical, immediate use to companies. Existing faculty, co-op students, and staff engineers with industry experience provided the manpower.

### Planting Seeds in a Green Field

Meanwhile, Nabil Nasr, then the Earl W. Brinkman Professor in the Kate Gleason College of Engineering, was developing a reputation for his pioneering work in sustainable design, lifecycle engineering, resource recovery, and remanufacturing—all aspects of sustainable manufacturing. He led the creation of the Center for Remanufacturing and Resource Recovery (C<sub>3</sub>R) and moved it into the new CIMS facility.

“Remanufacturing seemed to be a unique aspect RIT could bring to industry,” said Stendardi. “C<sub>3</sub>R became one of the real drivers in CIMS.”

“When I started, there was very little work being done in this area,” said Nasr, who was named director of CIMS in 2002. Many universities were working on recycling, but “remanufacturing”—the process of re-engineering components and equipment to extend their useful life—was an untapped area.

Nasr wanted RIT to become a very serious entity in all areas of sustainable manufacturing.

“We have focused on projects that reduce the use of hazardous materials in production, expand the quality and implementation of remanufacturing processes, and we have worked to design production systems that are completely closed-loop with no waste product and feature reuse of all materials,” Nasr said.

“Through our partnerships with industry, government, and non-governmental agencies, we seek to develop new technologies that will assist in implementing sustainable processes in industry while also disseminating knowledge, education, and training in the field.”

Nasr founded the Remanufacturing Industries Council (RIC), wrote articles and traveled around the U.S. and the world speaking to industry organizations and government forums. Bill Davies, president of the Albany-based Davies Office, was one of many who got the message. He met Nasr two decades ago at an industry conference and continues to keep in close contact.

“We commissioned Nabil to do a study,” said Davies, whose company—founded in



**Cutting-Edge Research:** For more than a decade, CIMS researchers worked on numerous projects aimed at extending the life of military vehicles. This retired A-6E Intruder jet served as a test subject for many years.

1948 by his grandfather—has grown to be the nation’s largest office-furniture remanufacturer. A team from C3R spent 18 months working with Davies, documenting the economic and environmental benefits of their processes and products. They determined that one year of office-panel remanufacturing conserved about 8.5 million pounds of raw materials and prevented the release of more than 6.9 million pounds of carbon dioxide.

“We always knew we were doing the right thing, but we needed third-party validation,” said Davies. Through the initial study and subsequent work

**A Man with a Vision:** Nabil Nasr, director of the Golisano Institute for Sustainability and associate provost, helped position RIT as a leader in sustainable design and product development.



with RIT, Davies became the first remanufacturer to earn sustainability certification from the Business and Institutional Furniture Manufacturer’s Association (BIFMA), which takes into account a company’s social actions, energy usage, material selection, and human and ecosystem health impacts.

“RIT has been instrumental in helping us achieve milestones,” said Davies.

**Providing a Roadmap to Success**

Since its inception, C3R has worked with thousands of companies and agencies of all sizes. Projects with the auto industry, copier and printer cartridge manufacturers, the U.S. Department of Energy, U.S. Department of Defense, and large companies including Eastman Kodak Co., Xerox Corp., Staples, and Caterpillar are on the long list of clients.

“CIMS really began to gain momentum when Nabil Nasr became director and started moving into the area of remanufacturing and sustainability,” said New York State Assembly Majority Leader Joseph Morelle. Early on, Stendardi and Nasr went to Albany and met with Morelle and other lawmakers. Morelle, then chair of the Assembly Committee on

**RIT Ties to Manufacturing**

**1829**

Col. Nathaniel Rochester and other Rochester community leaders found the Athenaeum, an association “for the purpose of cultivating and promoting literature, science, and the arts.”

**1885**



Mechanics Institute is founded. Henry Lomb, Max Lowenthal, Ezra Andrews, Frank Ritter, William Peck, and other Rochester businessmen and influential citizens established this school to provide technical training for workers needed by local industry. More than 400 students enroll in the first class, mechanical drawing.

**1891**

Rochester Athenaeum and Mechanics Institute merge, bringing under one roof cultural education and practical technical training. Enrollment reaches 1,000.

**1894**

The Manual Training Building is the first building erected by the institute. It houses machine shops, classrooms, and a lecture hall.

**1912**



The cooperative education program begins. Students find positions in industry and gain practical work experience. Early students work in stores, factories, restaurants, and hospital kitchens.

**1930**

The department of photography, which provides technical training for this growing local industry, is founded. About 2,210 students are enrolled in the institute.

## RIT Ties to Manufacturing

**1937**

Empire State School of Printing, now the School of Media Sciences, is acquired through the efforts of newspaper publisher Frank Gannett.

**1940**



Classes are offered all day and all night to train thousands of men and women for jobs in the defense industry.

**1944**

The institute adopts the name Rochester Institute of Technology.

**1950**

The Graphic Arts Research Center is established to “apply scientific and engineering principles to the printing and publishing industry.”

**1955**

The first Bachelor of Science degrees are awarded.

**1960**

The first master’s degrees are awarded. Enrollment reaches 8,546.

**1968**



RIT moves to its new campus in Henrietta. The first freshman class enters National Technical Institute for the Deaf.

**1980**

The RIT Research Corporation is formed to provide opportunities for collaborative projects with industry and government.

**1986**

The Center for Microelectronic and Computer Engineering, made possible by government and industry support, is dedicated.



**Living Lab:** Sustainability Institute Hall on the RIT campus is filled with cutting-edge technology. The building opened in 2013.

Small Business, looked for opportunities to fund CIMS’ work with manufacturers.

CIMS conducted a two-year analysis of upstate manufacturers funded with support from the New York State Assembly and the U.S. Department of Commerce resulting in the “Roadmap for the Revitalization of Upstate New York Manufacturing” Following this, the state included \$800,000 in the 2007-2008 state budget to support a pair of programs—the Innovation Testbed and the Knowledge Clearing House. Both aimed to assist companies in implementing new technologies.

“I think Nabil is one of the great assets of the state,” Morelle said. “What he’s done for businesses is quite extraordinary.”

### Keeping the Military on the Move

In an effort that spanned a decade, the Office of Naval Research worked with C3R to investigate ways in which old Navy ships, specifically the SES 200 B Surface Effect Ship, could be remanufactured and redesigned. The initial grant of \$5 million saved the Navy an estimated \$32.6 million.

That work led to other military projects. The Department of Defense came to CIMS for a system to monitor and assess the performance of light vehicles.

“The Marine Corps had many old

vehicles and the problem was keeping them going,” said Michael Thurston, technical director for the Golisano Institute for Sustainability. Thurston joined the engineering staff at CIMS in 2001 after working in industry and as a research associate at Penn State.

“We did an analysis of how the vehicles could be re-engineered to increase their lifespan,” Thurston explained. “In parallel with that, we had a project to develop tools for monitoring vehicles and predicting failure, so they can be serviced before they break down.”

In partnership with the U.S. Marine Corps Systems Command, the vehicle health management system was deployed on vehicles at Camp Pendleton, Calif. In 2007, RIT partnered with Lockheed Martin on a \$200 million competitive contract with the Marine Corps to equip 10,000 military vehicles with the technology.

Ultimately, Lockheed continued with the hardware portion of the project, and CIMS kept the software component to make it available to Lockheed and other potential customers. In 2008, a company called Liban (later renamed Vnomics), was formed at RIT’s Venture Creations business incubator to commercialize the product.

Vnomics, which “graduated” from the



incubator in 2011, provides a real-time analytics system that helps fleets and their drivers improve fuel efficiency.

The technology is now in use on 14,000 trucks, said Edward McCarthy, Vnomics' vice president of operations and customer success.

Customers include large and small companies in the Rochester region and around the U.S. and Canada. Using Vnomics' patented True Fuel technology, customers are able to realize an average 9 percent fuel savings. *Today's Trucking* magazine named True Fuel among the "Top 10 Products of 2016."

Vnomics has collected data on 434 million gallons of fuel used by customer truck fleets, showing a savings of 53 million gallons, or \$160 million.

"It's win-win," said McCarthy. "Our technology is good for the environment, and it's good for our customers' bottom line."

Still located in Rochester, Vnomics has about 40 employees, including several RIT graduates. The company continues to work with CIMS on product testing and other research, as well as with the University of Rochester.



**Commercializing Products:** Vnomics, a Rochester startup, has commercialized a system developed at CIMS that monitors the performance of vehicles.

The connections are important, said McCarthy, who joined the CIMS staff in 2004 after serving more than 20 years in heavy equipment combat units with the U.S. Marine Corps. "We're very excited about it. It's going very well."

It's one example of how technology developed at RIT can be transitioned to a private company, one of the original and ongoing missions of CIMS.

"Our core thing," said Thurston, "is problem solving. We're very serious about trying to help our sponsors be successful."

### Expanding the Green Horizon

The focus on sustainable manufacturing at CIMS led, in 2007, to the creation of the Golisano Institute for Sustainability,

propelled by a \$10 million commitment from B. Thomas Golisano, founder and chairman of Paychex Inc. and an RIT trustee. Nasr was named founding director. (He also holds the title of associate provost of RIT.)

The growth of GIS has continued at a dizzying pace.

In 2008, through a major, competitive award, RIT was named host of the New York State Pollution Prevention Institute, which works to make the state more sustainable for workers, the public, the environment, and the economy.

P2I, as it is called, is funded by the New York State Department of Environmental Conservation and is a partnership with Clarkson University, Rensselaer Polytechnic Institute, the State University of New York at Buffalo, and 10 Regional Technology Development Centers.

That same year, the first four students began studies in the new doctoral program in sustainability, supported by a \$465,000 grant from the Henry Luce Foundation and a \$500,000 gift from the Chester F. and Dorris Carlson Charitable Trust.

In 2010, the U.S. Department of Commerce's National Institute of Standards and Technology (NIST) granted \$13.1 million for the construction of a new building and New York state provided an additional \$15 million toward the construction and equipping of the facility. GIS moved into its new home in 2013.

In 2016, GIS was named a core academic partner in the federal Smart Manufacturing Leadership Coalition (SMLC), which will lead the new Clean Energy Smart Manufacturing Innovation Institute in partnership with the U.S. Department of Energy.

The goal is to connect information technology leaders and manufacturers in energy-intensive industries to develop ways of using less energy.

The initiative is part of the National Network for Manufacturing Innovation (NNMI, recently renamed Manufacturing USA) launched by President Barack Obama in 2012.

In 2014, RIT, through CIMS and GIS, was named a core partner in another Manufacturing USA initiative, the Digital Manufacturing and Design Innovation Institute.

## RIT Ties to Manufacturing

### 1986

The Chester F. Carlson Center for Imaging Science is dedicated. The building houses the new program in imaging science.

### 1992

The Center for Integrated Manufacturing Studies (CIMS), created with \$21.25 million in federal and state funding, is founded with a mission to increase the competitiveness of manufacturers through technology development and training.

### 1997

RIT establishes the Center for Remanufacturing and Resource Recovery (C3R) as a major component of CIMS. C3R focuses on sustainable manufacturing, remanufacturing, clean production, and sustainable product development.

### 2001

RIT is designated as a New York State Strategically Targeted Academic Research (STAR) Center as part of a state initiative to promote high-technology businesses. The IT Collaboratory, a joint project with the University at Buffalo and Alfred University, is founded.

RIT launches the High Technology Incubator, a not-for-profit subsidiary of the university aimed at fostering startup companies. In 2003, the incubator's name is changed to Venture Creations.

### 2006

The Henry Luce Foundation provides \$465,000 to create an interdisciplinary Ph.D. program in sustainability. The innovative program, one of the first in the world, is launched in 2008.

### 2007

The Golisano Institute for Sustainability is established with a founding commitment of \$10 million from RIT Trustee B. Thomas Golisano, founder and chairman of Paychex Inc. The institute conducts research in nanotechnology, alternative energy development, and sustainable design.

### 2008

The New York State Pollution Prevention Institute is established within the Golisano Institute for Sustainability. Its goal is to help businesses be more sustainable by applying cleaner production and product stewardship practices.



**Remanufacturing:** The additive manufacturing cell in GIS remanufactures components and prototype designs for future products. GIS uses this equipment when working with military and industrial partners.

In January of this year, GIS was selected by the U.S. Department of Energy to lead its new Reducing Embodied-energy and Decreasing Emissions (REMADE) Institute—a national coalition of universities and companies that will forge clean energy initiatives deemed critical in keeping U.S. manufacturing competitive. The project is part of the Manufacturing USA program.

Within a week of that announcement, GIS was named a core academic partner in another Manufacturing USA project, the Advanced Robotics Manufacturing Institute led by Carnegie Mellon University.

RIT is now involved in seven of 14 Manufacturing USA research institutes. (Read more on pages 10-19.)

### The Evolution Continues

CIMS, which served as the incubator for what has become GIS, is now one of that institute's components and remains devoted to working with companies on a variety of applied research projects. Also under the GIS umbrella are:

- Center for Remanufacturing and Resource Recovery;
- New York State Pollution Prevention Institute;
- Center of Excellence in Advanced

& Sustainable Manufacturing, established in 2012 as a New York State Center of Excellence supported by Empire State Development's Division of Science, Technology and Innovation;

- Center for Sustainable Mobility, begun in 2006 with a \$4 million grant from the U.S. Department of Transportation to assess the environmental and economic impact of alternative fuel and propulsion technologies on the public transportation system;
- NanoPower Research Labs, a consortium of faculty from GIS, the Kate Gleason College of Engineering, and the College of Science working on applications of nanomaterials in energy and photonics.

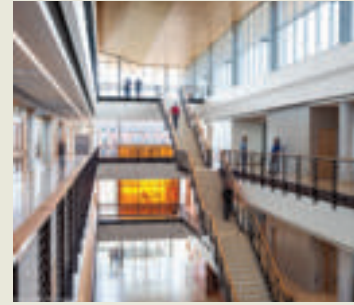
Combined, the components of GIS last year worked with 988 companies on a wide variety of projects.

Success has come the old-fashioned way—through hard work. “I’m blessed with the most wonderful and talented team,” said Nasr. “They’re passionate about what they do.

“We were always organized and focused. If we just meet the sponsors’ expectations, we feel we haven’t done our job. We want to always exceed expectations.”

## RIT Ties to Manufacturing

2013



The Golisano Institute for Sustainability moves into a newly constructed building. One of the greenest buildings in the world, it is powered by solar, wind, and fuel-cell technology and features a rooftop butterfly garden, a green wall of plants, and high-efficiency building materials.

2015

A New York-based consortium led by SUNY Polytechnic, RIT, and the University of Rochester is awarded a multimillion-dollar federal investment to create a national photonics center.

RIT unveils a state-of-the-art Battery Prototyping Center. The new center will work with companies and universities to develop the next generation of batteries.

2016

Golisano Institute for Sustainability is named an academic partner of the federal Smart Manufacturing Leadership Coalition, which will lead the new Smart Manufacturing Innovation Institute in partnership with the U.S. Department of Energy.

2017

The Golisano Institute for Sustainability is selected by the U.S. Department of Energy to lead its new Reducing Embodied-energy and Decreasing Emissions (REMADE) Institute. The goal of this national coalition of universities and industry is to forge clean energy initiatives deemed critical in keeping U.S. manufacturing competitive.

### On the Web

**Golisano Institute for Sustainability**  
[www.rit.edu/gis](http://www.rit.edu/gis)

**Center for Integrated Manufacturing Studies**  
[www.rit.edu/gis/research/centers/cims](http://www.rit.edu/gis/research/centers/cims)

## Expect the Unexpected

### Ignite. Astound. Repeat.

- ▲ **Students** who improve HIV medications in Africa, conduct remote sensing on volcanoes in Iceland, help select the Mars 2020 Rover landing site, and win national cyber defense competitions.
- ▲ **Faculty** who create wearable technologies that protect soldiers, work on the nation's top advanced manufacturing initiatives, and confirm Einstein's General Theory of Relativity.
- ▲ **Alumni** who win Academy Awards, claim 12 Pulitzer Prizes, and revolutionize the video gaming and sustainability industries.



### Distinctly RIT

- Among the nation's largest private universities with 19,000 students from more than 100 countries
- 11 colleges and institutes with campuses in China, Croatia, Dubai, and Kosovo
- A leading producer of STEM undergraduate degrees among U.S. private universities
- A world leader in experiential education with 4,300 students completing 5,700 co-op assignments annually
- Home to the National Technical Institute for the Deaf, the first and largest technological college in the world for deaf or hard-of-hearing students
- Internationally recognized programs in business, computing, engineering, fine arts, game design, imaging science, industrial design, photography, physician assistant, physics, sustainability



**National Leader in Manufacturing:**

RIT's Golisano Institute for Sustainability is leading REMADE—Reducing Embodied-energy and Decreasing Emissions—Institute to forge new clean energy initiatives. Researchers are using equipment such as this stereo microscope to identify the root cause of failure, wear rate, and surface roughness of components.

# RIT is Becoming a Key Player in National Initiatives Critical to U.S. Manufacturing

by Rich Kiley

RIT is engaged in seven of 14 Manufacturing USA initiatives, a network of regional institutes tasked with bridging the gap between research and product development in key technology areas regarded as critical to U.S. manufacturing.

## Sustainability Leader

Among the framed family snapshots and pictures taken with dignitaries that adorn the walls of his office inside Rochester Institute of Technology's Golisano Institute for Sustainability (GIS), Nabil Nasr has prominently displayed over his desk a photograph of the late Apple co-founder and CEO Steve Jobs with the quote: "And we've all chosen to do this with our lives. So it better be damn good. It better be worth it."

Jobs' passionate words resonate strongly with Nasr, associate provost and GIS director.

"People always tell me that we must have a passion test to work at GIS," Nasr said. "You can't do what we do here every day and not feel strongly compelled to do this important work ... especially when the world demands it."

That fervency of spirit has combined with research know-how to catapult RIT to take on more and more significant roles in the quest to transform manufacturing—locally, regionally, nationally, and globally. It has positioned the university as a national leader in designing energy-efficient methods to achieve more advanced and clean energy manufacturing.

Today, this nearly 19,000-student university, which traces its earliest roots to providing professional development to the workforce at the Rochester-area region's major manufacturers, is steering



**Federal Initiative:** Manufacturing USA includes more than 1,300 companies, universities, and nonprofit organizations.

nationwide efforts to revitalize and revamp manufacturing methods across a wide range of industries.

One of the latest and most prominent efforts is as leader of the federal REMADE initiative, part of Manufacturing USA, a network of regional institutes tasked with bridging the gap between research and product development in key technology areas regarded as critical to U.S. manufacturing.

Manufacturing USA, formerly known as the National Network for Manufacturing Innovation, or NNMI, was launched by the Obama administration in 2012 as a nationwide network of regional institutes—each charged with a specialized technology focus. The initiative includes more than 1,300 companies, universities, and nonprofit organizations. The federal government has committed more than \$1 billion, matched by more than \$2 billion in additional investment across the network.

RIT is actively engaged in seven of the 14 Manufacturing USA institutes—among the top five universities in participation. REMADE, short for Reducing Embodied-energy and



**Finding Solutions:** Researcher Michael Haselkorn, back, works with student Cory Kreiss to determine the root cause of failure of a product and to identify subsequent solutions using a scanning electron microscope.



Decreasing Emissions, is a national coalition consisting of 26 leading universities, 44 companies, seven national labs, 26 industry trade associations and foundations, and three states working collaboratively to forge new clean energy initiatives.

REMADE, under the Sustainable Manufacturing Innovation Alliance (SMIA), is leveraging up to \$70 million in federal funding that will be matched by \$70 million in private cost-share commitments from industry and a \$20 million commitment from New York state. Its focus: driving down the cost of technologies essential to reuse, recycle, and remanufacture materials such as metals, fibers, polymers, and e-waste. The initiative aims to achieve aggressive measures that could save billions of dollars in energy costs and improve U.S. economic competitiveness through new manufacturing techniques, small-business opportunities, and new training and jobs for American workers.

“Almost a third of the energy in the United States goes into manufacturing,”



**Testing Prototypes:** A 3D printer is used to print and test product prototypes. Golisano Institute for Sustainability is housed in an 84,000-square-foot building with specialized labs and equipment.

said Mark Johnson, director of the Advanced Manufacturing Office, Energy Efficiency and Renewable Energy at the U.S. Department of Energy. “About half of that energy—what we call embodied energy—goes into the making of materials, and about half of those materials end up being thrown away within the first year of being manufactured.”

Johnson noted that initiatives such as REMADE are tasked with solving the biggest challenges facing the U.S. manufacturing industry.

“The resources within our universities

and national lab systems are the envy of the rest of the world,” Johnson said. “We need to open them up to work with our manufacturers. That’s what these institutes are all about when it comes to these 21st century challenges—mobilizing industry ranging from Fortune 500 companies to startups.”

Nasr, who credited his team at GIS for working tirelessly on the REMADE proposal for the better part of a year, said the initiative represents an unprecedented opportunity “to finally address issues of the entire lifecycle of manufacturing in a

◀ **New Technologies:** Additive manufacturing equipment is used to remanufacture components and create prototype designs in order to understand the benefits and limitations of new technologies.

comprehensive and integrated fashion.

“This is the first time in the U.S. that we’re bringing these areas and expertise under one program, one vision,” he said.

### Seven of 14 Initiatives

Within one week of the REMADE announcement, GIS was named a core academic partner in the Advanced Robotics Manufacturing (ARM) Institute, led by Carnegie Mellon University and awarded through the Department of Defense.

The other Manufacturing USA initiatives involving RIT include Digital Manufacturing and Design Innovation Institute (DMDII), Flexible Hybrid Electronics Manufacturing Institute (NextFlex), Clean Energy Smart Manufacturing Innovation Institute (CESMII), the National Additive Manufacturing Innovation Institute (America Makes), and American Institute for Manufacturing Integrated Photonics (AIM Photonics), which is also based in Rochester. (More on pages 16-19).

The Clean Energy Smart Manufacturing Innovation Institute—for which GIS was named a core academic partner last June—includes the development of smart sensors for use in advanced manufacturing. These sensors will help manufacturers better design, measure, predict, and control all aspects of the manufacturing process. As a result, traditional manufacturing processes will become more productive and efficient.

By modernizing the energy and water intensive manufacturing techniques that have been in place for decades and increasing energy efficiency, the United States can lower the cost of processing food, dramatically shrink the footprint of equipment needed on a crowded factory floor, and increase the efficiency of products that range from industrial motors to household appliances.

For the DMDII initiative, GIS is supporting the Department of Defense (DoD), including the integration of design data across product lifecycles,



**In the Lab:** Golisano Institute for Sustainability student Kirti Richa '16 (Ph.D., sustainability) is testing a new method for recycling lithium-ion batteries using a green chemistry approach.

reducing manufacturing costs and development time, and improving the “digital divide” across the DoD’s overall supply base.

“There is no comparison to the infrastructure that we can bring to bear on manufacturing challenges today,” said Ryne Raffaele, vice president for research and associate provost, who cited the rapid development of RIT’s facilities under retiring RIT President Bill Destler as a major catalyst to the university’s ascension as a national manufacturing powerhouse.

“We are infinitely prepared to work on these challenges,” he added. “We have unique tools that we’re among the first in the nation to have. People from the national labs see our prototyping facilities and—while they are bigger and receive more funding—they’re jealous of our remarkable facilities.”

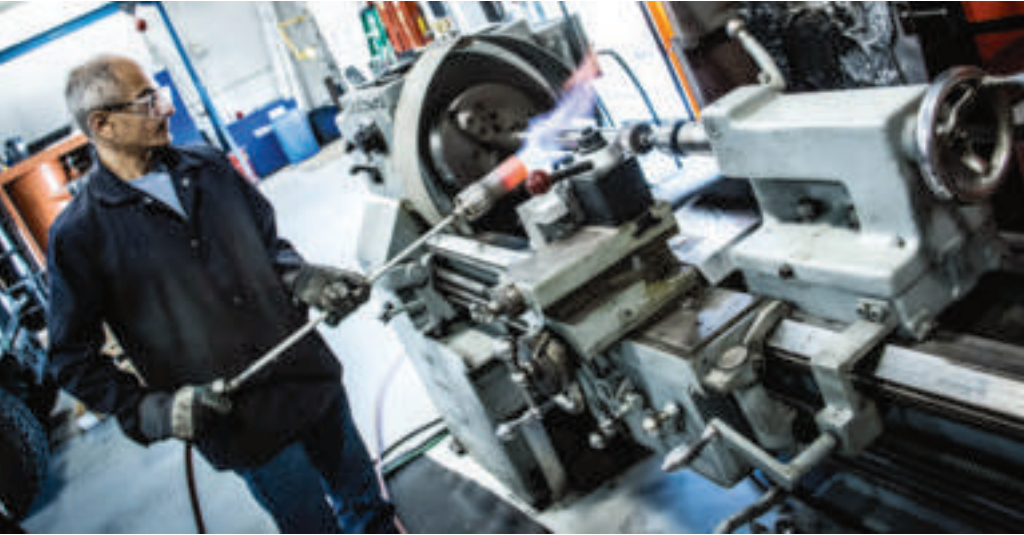
### Leading the Charge

Denis Cormier, director of the Center for Advanced Technology on Additive Manufacturing and Multifunctional

Printing—or AMPrint Center—is leading a team of multidisciplinary researchers in two Manufacturing USA institutes: NextFlex (flexible hybrid electronics) and America Makes (additive manufacturing). RIT has already been awarded funding on both project funding calls by the NextFlex institute.

Cormier, RIT’s Earl W. Brinkman Professor, came to RIT nearly eight years ago from North Carolina State University as a leading expert in rapid prototyping, the precursor to 3D printing. He is part of a growing number of researchers who have joined RIT over the last decade to further grow and enhance the university’s rapidly growing reputation in applied research and advanced manufacturing.

The NextFlex institute is being managed by the U.S. Air Force Research Laboratory. RIT is contributing expertise in high-performance print systems and functionality, engineering processes, and materials development, led by Cormier and Shu Chang, the Melbert B. Cary Jr. Distinguished Professor in RIT’s College



**Product Lifecycle:** Golisano Institute for Sustainability researchers use a thermal spray system to remanufacture a component to extend the product lifecycle cost-effectively.

of Imaging Arts and Sciences.

Flexible electronics involves assembling electronic devices by printing circuit patterns on flexible substrates and then placing the electronic components where needed. The technology has the potential to create an array of products varying from wearable devices to improved medical health monitoring technologies, according to Cormier. It also is expected to increase the variety and capability of sensors that already interconnect the globe, resulting in applications for both consumers and the military.

RIT was proud to be named a member of America Makes, the pilot Manufacturing USA initiative, back in 2012, Cormier said. Yet while he and his RIT colleagues are excited to work on future ways that printed electronics will be used in consumer goods such as smart watches and personal health monitoring devices, he credits the university's leadership for not losing sight of its important mission to students as RIT becomes a leading national manufacturing resource.

"RIT has a strong reputation as a world-class teaching university, and there has been a very careful and deliberate effort to grow the university's applied research expertise while not sacrificing the quality of an education here," Cormier said. "That's hard to do, frankly. I still teach classes. I don't think you deserve to call yourself a

professor if you don't teach students. I believe that RIT's longtime commitment to academics has helped further develop our already phenomenal reputation with the manufacturing industry."

### REMADE Calls on Longtime Heritage

The REMADE Institute will leverage the 84,000-square-foot GIS building's state-of-the-art facilities that house specialized research laboratories and graduate student work areas, powered by its distinctive green features such as a fuel cell, microgrid, and geothermal system.

Among the specialized labs that will help spur the REMADE initiative is the material science lab. Studies of material aging, wear, and failure analysis are conducted inside the lab, vital research to the development of longer lasting materials and more reliable and durable remanufactured parts. Improved materials, for example, can be studied and evaluated for greater strength and reduced weight to improve fuel economy.

REMADE partners have identified an ambitious set of five-year goals, including:

- Reducing primary feedstock consumption in manufacturing by 30 percent;
- Achieving 25-percent reduction in embodied energy of targeted materials;
- Attaining cost parity for secondary materials;
- Improving energy efficiency of secondary

material processing by 30 percent;

- Increasing the size of the remanufacturing industry by 100 percent.

REMADE will develop and implement an education and workforce development program that will fill workforce gaps identified by its industry, government, and academic partners and build the next generation of the recycling and remanufacturing workforce.

The workforce development strategy will involve leveraging the capabilities of partner organizations, including industry, community colleges, and the national manufacturing extension partnership programs; integrating education and training into pilot remanufacturing and recycling projects with industry; establishing standards-based education and certification programs for secondary-school students through the incumbent industry workforce; and outreach to under-represented populations, veterans, and dislocated workers.

In leading the recently established REMADE Institute, Nasr said the initiative will go a long way toward helping the university realize its goal of becoming the world's premier institute for sustainability, adding that GIS's singular passion will remain steadfastly focused on the industrial system and the built environment.

"I believe that universities have a big obligation to help society, to lead, and provide significant contributions to the advancement of society," he said. "You do that by educating the next generation of professionals and by conducting cutting-edge research for the betterment of all."

Raffaelle is confident that RIT is up to the task with REMADE, and the other Manufacturing USA initiatives.

"All of these manufacturing wins have afforded us the opportunity to do great things," he said. "Now it's all about delivering on the opportunity. These wins are a chance to do something great."

### On the Web

Manufacturing USA  
[www.manufacturingusa.com](http://www.manufacturingusa.com)



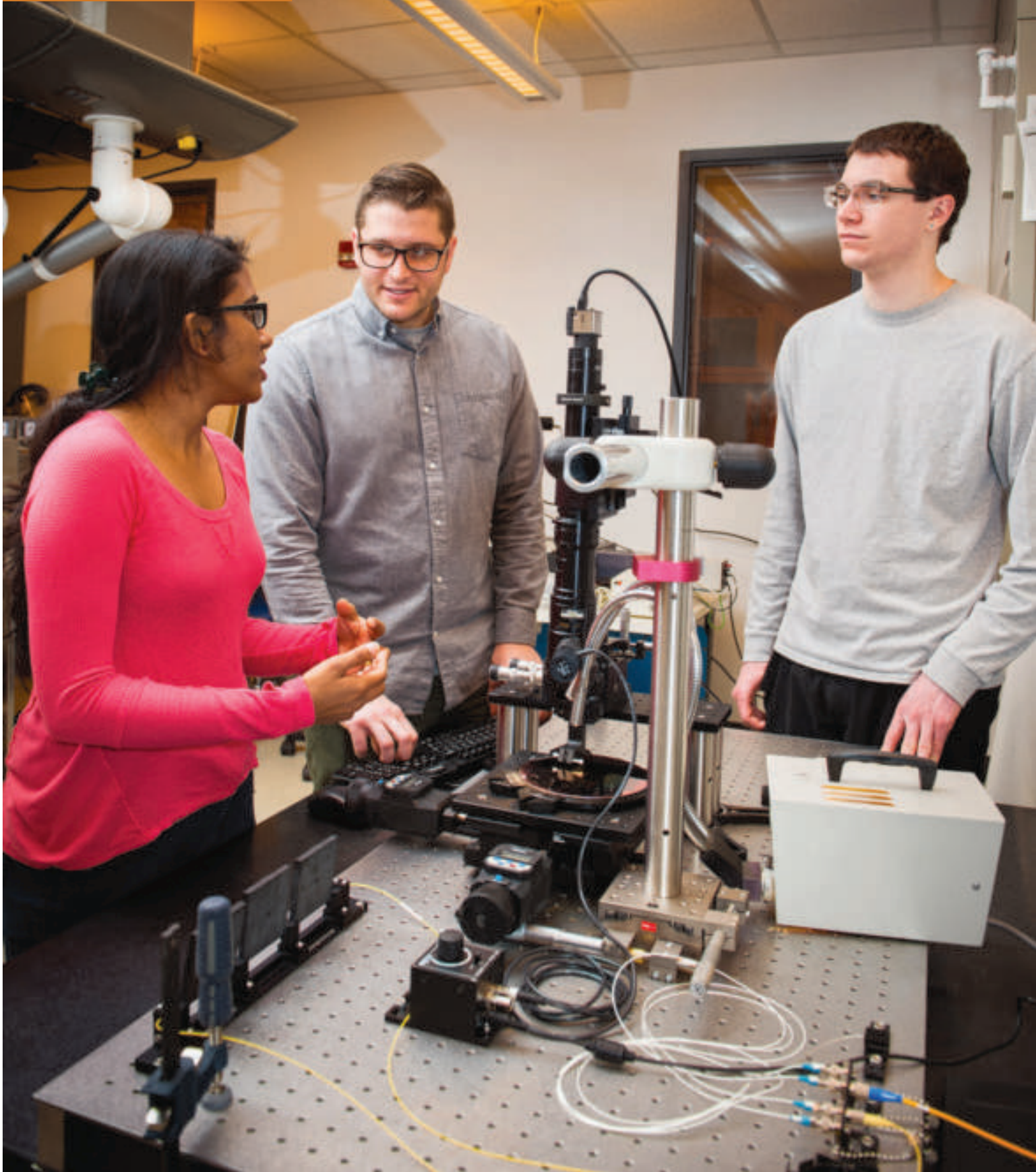


**Manufacturing USA:** RIT is involved in seven of 14 Manufacturing USA institutes. Two of the institutes are based in Rochester, with RIT leading the REMADE Institute. This places RIT among the top five most engaged universities in the network. Manufacturing USA advances manufacturing by connecting people, ideas, and technology. The network of institutes reaches across manufacturing, government, and academia. Orange indicates RIT is a contributing member. (Source: Manufacturing USA)

## The Manufacturing USA institutes to which RIT has been named as a contributing member:

- Reducing Embodied-energy and Decreasing Emissions (REMADE) Institute**  
 The first RIT-led initiative, this institute selected by the U.S. Department of Energy in January will be headquartered in the Rochester region and focused on clean energy manufacturing.
- American Institute for Manufacturing Integrated Photonics (AIM Photonics)**  
 Also based in Rochester, this institute is tasked with leading the Department of Defense's (DoD) national photonics center.
- Advanced Robotics Manufacturing (ARM) Institute**  
 RIT was named a core academic partner of the DoD's new federal robotics institute, led by Carnegie Mellon University.
- Digital Manufacturing and Design Innovation Institute (DMDII)**  
 RIT is playing a key role in the nation's first "digital manufacturing" initiative, selected by the DoD and headquartered in Chicago.
- Flexible Hybrid Electronics Manufacturing Institute (NextFlex)**  
 RIT has been funded on the first two project calls of this San Jose-based consortium awarded a Manufacturing USA grant by the DoD for flexible electronics development.
- Clean Energy Smart Manufacturing Innovation Institute (CESMII)**  
 GIS is part of a federal smart manufacturing initiative, based in Los Angeles, designed to bolster advanced manufacturing across the United States.
- National Additive Manufacturing Innovation Institute (America Makes)**  
 The pilot Manufacturing USA initiative, the Youngstown, Ohio-based America Makes is a national accelerator and the nation's leading collaborative partner for technology research, discovery, creation, and innovation in additive manufacturing and 3D printing.

**Education:** RIT is educating students in integrated photonics. Sanjna Lakshminarayanamurthy, left, Tayler Swanson, and Thomas Kilmer discuss building prototype photonic chips in a new course about the photonics manufacturing and electronics packaging process.



# AIM Photonics Educational and Workforce Development Initiatives are Underway

by Michelle Cometa

RIT is contributing to AIM Photonics' roadmap to expand the photonics industry, providing introductory and advanced educational modules for workforce development. The university will also continue research into breakthrough photonics packaging solutions.

## AIM Photonics

Harnessing light through photonics to power today's electronic devices is an industry in the making. Rochester became the focal point of that emerging industry when it was awarded a multi-million dollar federal investment in July 2015 to create a national photonics center, AIM—the American Institute for Manufacturing Integrated Photonics—part of the federal government's Manufacturing USA institutes.

The New York-based consortium includes RIT, SUNY Polytechnic, the University of Rochester, MIT, Columbia University, and the University of Arizona along with more than 90 other universities, government agencies, and corporations. The federal government allocated \$110 million for the new national institute, and New York state contributed \$250 million, with another \$250 million expected from public and private companies. It is part of a major investment in the state that will have an impact for the country, as photonics, an emerging technology with wide-ranging potential, is essential to the nation's manufacturing capabilities in areas such as high-speed data and telecommunications.

As part of the roadmap to bring photonics technology to the forefront, RIT will provide workforce development that will include degree programs for students as well as continuing education and training courses for regional and national companies. The university's laboratories; its experience



**In the Classroom:** Microsystems engineering Associate Professor Stefan Preble, center, helped develop the new, special topics course Photonic Integrated Circuits, one of the first to be rolled out for RIT and eventually the AIM Photonics Academy.

in microelectronics and microsystems engineering; and its expertise in manufacturing and mechanical systems integration, telecommunications engineering technology, and imaging position RIT to be a major contributor to the industry.


Integrated photonics as an industry is in its earliest stages. Contributions by consortium members such as RIT will influence how this industry is built.

## Educational Programs

RIT faculty designed an integrated photonics course, one of the first that

will be rolled out for AIM Photonics Academy, the educational arm of the consortium. Established in 2015 and overseen by MIT, AIM Academy intends to provide educational programs for differing levels of personnel currently in the photonics field or those seeking to enter the field. Work retraining and certification programs are planned as well as degree programs from undergraduate to doctoral levels.

“AIM Academy is looking to be the worldwide go-to organization for integrated photonics education,” said Stefan Preble, associate professor of



**Providing Expertise:** The new courses being developed at RIT will be used at the university as well as corporate training and education options through the AIM Academy.

microsystems engineering in RIT's Kate Gleason College of Engineering.

Photonic Integrated Circuits, an upper-level course, is a combination lecture and lab class being co-taught by Preble and Dale Ewbank, senior lecturer in the electrical/microelectronic engineering program in the Kate Gleason College. They are joined by Martin Anselm, assistant professor in the manufacturing and mechanical engineering technology department, and Drew Maywar, associate professor in the electrical, computer, and telecommunications engineering technology program, both part of RIT's College of Applied Science and Technology.

This first introductory class has more than 20 students enrolled to learn about the overall photonics manufacturing process and to produce a prototype chip. It will be the basis for degree program concentrations and an eventual master's degree concentration specific to photonics integration and manufacturing, including the complex packaging assembly process.

"We have so many talented, technical people that are looking to move into this technology," said Preble, part of the team at RIT developing the new photonics curriculum. "What are the things we need to be teaching our students? That's really the starting point for us in developing education programs in this field because we need to know what industry is actually looking for."

RIT is working closely with industry to determine skills and training that will best foster job growth in integrated photonics. A team led by Ben Zwickl, assistant professor of physics in the College of Science, and Kelly Martin, assistant professor of communication in the College of Liberal Arts, founded the Photonics and Optics Workforce Education Research group in 2014 to study education and careers in the Rochester-region photonics industry.

They are also collaborating with researchers from two other AIM partner institutions, MIT and the University of California Santa Barbara, on a comprehensive workforce needs assessment study to determine how AIM can best support career paths into integrated photonics. RIT is leading data collection with

companies located in New York, while the other groups are focusing on Massachusetts and California.

Early results from the interim report indicate there are critical skills necessary in the key phases of photonics: circuit design, testing, packaging, assembly, and system integration.

### Integrated Photonics Packaging Challenges

A comprehensive photonics ecosystem is a goal for AIM and the AIM Academy. The organization's approach includes developing technological tools for the design of photonics devices as well as establishing high-tech packaging assembly and testing processes and facilities.

This technological work is being combined with multi-layered workforce development objectives. With this structure in place, the ability for companies to integrate the new technology to improve current products or develop newer ones expands the marketplace.

One area where RIT excels is in electronics packaging. Its Center for Electronics Manufacturing and Assembly (CEMA) supports local companies in building test beds for prototype electronics devices that are exposed to different types of electrical, optical, or thermo-mechanical stresses to test reliability and functionality.

"The AIM Photonics organization has plans to do those same types of tests for new integrated photonic circuits, but that is further downstream, and they have more immediate needs right now," said Anselm, a faculty-researcher who also serves as director of CEMA.

Attaching fiber optics to a circuit is a complex and time-consuming part of the process, even before the chips can be mass-produced for devices. Researchers such as Preble and Anselm are working on both fiber attachment solutions and related manufacturing processes.

Fiber must align on the silicon, but it is much smaller than components for an electronic circuit, needing precision and different materials to anchor the fiber to the base chip.

Anselm described the overall process challenges: With an electronic circuit,



**Introductory Course:** Undergraduate and graduate students in the Photonic Integrated Circuits class interact with faculty from the Kate Gleason College of Engineering and College of Applied Science and Technology during the semester, each with expertise in photonic circuit design and electronics packaging.

electrons pass through a conductor such as copper or the soldering material; heated to its melting point, that material coalesces into separate, tiny droplets that align with features on the circuit board to close the electrical circuit.

For photonics, light in an optical fiber needs to be perfectly aligned to a feature on a piece of silicon. Light is sent through the fiber and a reading of its peak intensity is measured.

"Now the challenge becomes how am I going to hold that fiber in place? Researchers are trying to apply electronic circuit attachment concepts to photonics but there is no solution—yet," said Anselm, who added that fibers must be affixed with materials that do not degrade due to heat or humidity inherent in the close proximity of the circuit's structures and interfaces. Further manipulation of the circuit is needed to protect the fiber before testing.

AIM Photonics was created to build streamlined, high-volume manufacturing capabilities. That infrastructure doesn't exist today because the technology to build photonic devices is so sophisticated

that only the most elite companies can do it, and usually for only specialized applications such as military heads-up displays, Anselm explained.

Utilizing the model of the electronics industry infrastructure, fine tuning it, and making it more precise is a goal, but comes with a downside. The current outcome is a slower process with higher costs, impacting volume.

"If you do things one or two at a time, and it takes an army of Ph.D. engineers to put something together, then the price is astronomical," said Anselm, who is working with Preble and Maywar in developing photonic packaging education materials to be used for all levels of training needs. "But part of the long-term, broader impacts to all this type of research and work that AIM Photonics is doing—that RIT is doing—is to try to develop the technology that will make it more mass producible."

#### On the Web

AIM Photonics  
[www.aimphotonics.com](http://www.aimphotonics.com)

**3D Technology:** The AMPrint Center, which opened on the RIT campus last fall, brings together university and corporate researchers to advance printing and imaging. Denis Cormier, left, explains to doctoral students Pritam Poddar and Chaitanya Mahajan how different items were 3D printed.



# AMPrint Center Raises the Bar on 3D Printing

by Michelle Cometa

RIT's new AMPrint Center brings together university and corporate researcher-scientists in a way that will impact manufacturing in New York state and the nation.

## A New Dimension in Printing

In 1980, it took 25 jobs to generate \$1 million in manufacturing output in the United States, according to the Brookings Institution. Today, it takes five.

That's why manufacturing today requires highly skilled workers using next-generation equipment. RIT's AMPrint Center is positioned to make an impact in that new reality—investing in and conducting innovative additive manufacturing research and leading new equipment, materials, and product development.

The AMPrint Center, which opened last fall, brings together university and corporate researcher-scientists to advance two industries that the region is noted for—printing and imaging—in a way that will significantly impact manufacturing in New York state and the nation.

“The vision for this center is to be at the forefront of creating the next generation of 3D-printing technologies, materials, and applications,” said Denis Cormier, the Brinkman Professor in RIT's Kate Gleason College of Engineering and director of the center. “That can take the form of new technologies invented here or through partnerships with really innovative companies.”

The AMPrint Center is one of 15 Centers for Advanced Technology supported through NYSTAR, a division of New York state's Empire State Development. The RIT center was awarded a 10-year designation in 2015 and includes \$921,000 per year in funding from the state to support research operations. Additional funding of \$500,000 was awarded through the state's Higher Education Capital Facilities Program and was matched by the university and



**State of the Art:** The AMPrint Center is one of 15 Centers for Advanced Technology supported through NYSTAR, a division of Empire State Development.

corporate partners to support construction of the lab.

State-of-the-art equipment in the center includes an Optomec Aerosol Jet printer, Stratasys additive manufacturing equipment, and a Novacentrix photonic curing system. Usually found in industry, the Novacentrix is rare in a university setting and will be a resource for both faculty-researchers and regional companies creating new devices using metals and ceramics.

For RIT, the center offers the opportunity to conduct groundbreaking research, while also training students as the next-generation workforce.

“The AMPrint Center is one of the first centers in the country to focus on multi-functional printing,” Cormier said. “We are at the forefront of this technology.”

## Embedded Electronics

Defined as the process of developing single products using a variety of materials with different conductive properties, multifunctional 3D printing opens the door for a wide variety of products to be made faster, stronger, and less expensively.

“There are a lot of different materials that serve functions other than a mechanical function, and they can be printed,” Cormier said. “That is what we are focused on, multi-material 3D printing using functional materials that we are developing to embed electronics—heaters, sensors, you name it—within a 3D-printed part.”

Embedded electronics have powerful sensors directly “written” onto materials and equipment.

Working with sponsors Quest Integrated



**Next Generation:** The AMPrint Center brings together university and corporate researcher-scientists to advance printing and imaging in a way that will significantly impact manufacturing in New York state and the nation. For RIT, the center offers the opportunity to conduct groundbreaking research, while also training students as the next-generation workforce.

and the U.S. Air Force Research Laboratory scientists, RIT microsystems engineering Professor David Borkholder is part of the team helping to develop a new sensor system called Smart Skins. These are ultrathin, printed electronic devices of 50 microns—the equivalent of a human hair—but strong enough to detect information about the effect of airflow across an aircraft's wing and how this pressure might change material properties and structural reliability.

They were 3D printed using the AMPrint Center's high-tech ink-jet deposition and photonic systems without damage from the sintering procedure, even using the high heat of the photonic equipment.

Another of Borkholder's projects using the direct-write application is for an inner ear drug delivery system, consisting of a micropump, canulae, and micro-electrical-mechanical system (MEMS) technologies. Designed to deliver bio-therapies to address noise-induced hearing loss and

other hearing disorders, precision-detailed nano-scale sensors for the micropump are being 3D printed as part of the overall inner ear MEMS system.

College of Science faculty researchers Scott Williams and Zoran Nikov are working with ThermoFisher to produce a low-cost imaging sensor to take photos of ultraviolet wavelengths. Cameras can detect visible light, but ultraviolet light has a shorter wavelength that cannot be seen with the naked eye.

The researchers are using the 3D-printing processes to put a coating of quantum dots—nanoscale semiconductor particles—onto a low-cost imaging sensor to better fluoresce visible light. Capturing an image with ultraviolet light can be used for space applications specific to differentiating gas temperatures, magnetic fields, or other atmospheric data.

### **New Materials**

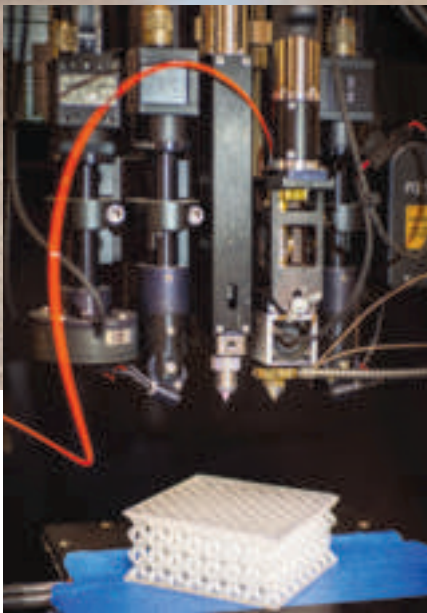
While AMPrint's core focus is to develop

a better scientific understanding of how materials in a multifunctional device interact with one another and affect the overall composite material's performance, researchers are also investigating equipment improvements.

3D printing is enabled onto various substrates because of high-tech print equipment and nontraditional materials such as metals and ceramics being used similar to the way traditional inks had been deposited through xerography. Even traditional manufacturing equipment is being enhanced with additive manufacturing functionality to continually improve operational processes.

One hybrid manufacturing system project in development blends 3D printing/additive manufacturing with traditional machining to make metal parts. RIT and Hardinge Corp., an Elmira-based equipment manufacturing company; Hybrid Manufacturing Technologies in Texas; and the laser





**Equipment:** The design, analysis, fabrication, and characterization of 3D-printed lattice structures is a focus of Denis Cormier's research.



**Making Models:** Denis Cormier, director of the center, holds a 3D-printed model of an arm that could be used as a guide to assist orthopedic surgeons during reconstruction surgeries.

company IPG Photonics are building prototype systems to allow fabrication of metallic parts through a combination of laser material deposition and milling or turning. Vader Systems, a Buffalo startup, is developing an ink-jet printing system using metal wire. After meeting Cormier at a symposium last year, the company sought advice on how to further develop its liquid metal 3D-printing process—an ink-jet printing system using metal wire fed into the print head.

Existing commercial technologies for

making metal parts use powdered metal and a laser that scans the powder, melts it, then repeats the process. It is cost prohibitive as metal powder typically costs five to 10 times more than the exact same material in bar or wire form.

Vader's new process would make both a financial and a process impact. Some of their development toward these ends are taking place with AMPrint researchers.

"We are just starting to see systems that are able to print conductive materials for electronics within a 3D-printed part," said

Cormier. "I think that is what differentiates our emphasis because the region has such a strong history in printing technology. New York state is very well-positioned to capitalize on '3D printing 2.0.' Multifunctional printing will be 3D printing 2.0."

#### **On the Web**

**AMPrint Center**  
[www.rit.edu/amprint](http://www.rit.edu/amprint)

**Battery Prototyping Center:**  
RIT's \$1.5 million Battery Prototyping Center is one of a kind in a university setting. In the center, stainless steel coin cell cases are used to assemble lithium-ion batteries 20 mm in diameter and 3.2 mm in thickness.



# Center Prototypes Next Generation of Batteries

by Suzette Norris

RIT's \$1.5 million Battery Prototyping Center focuses on the development of emerging energy storage technologies and features equipment typically found in large corporate- or government-operated centers. The center was made possible by support from New York State Energy and Research Development Authority, Empire State Development, and the New York Battery and Energy Storage Technology Consortium.

## Expertise

RIT's 2-year-old Battery Prototyping Center just got a nod from NASA.

The National Aeronautics and Space Administration is looking to develop new approaches to power generation and energy storage for the development of affordable, small spacecraft, which could one day be for science, exploration, and space operations. NASA recently announced it will collaborate with RIT and seven other universities on the project.

RIT's expertise in battery solar cell and testing played a role in NASA's decision, said Christopher Schauerman, RIT research scientist and co-director of the prototyping center. Building viable prototypes is complex and time consuming, yet a critical step in the quest to improve methods of energy storage. Lithium-ion cell batteries, for example, must be built in a water-free environment with humidity measuring at less than 0.5 percent (humidity levels in a desert hover around 20 percent).

RIT's \$1.5 million Battery Prototyping Center is one of a kind in a university setting, according to Schauerman. It features a 1,000-square-foot dry room supported by a dehumidifier that's the size of a tractor trailer truck. The state-of-the-art assembly equipment and environmental

test chambers are on par with equipment typically found in large corporate or government-operated centers.

Currently, the center can prototype pouch-cell-size batteries that resemble those found in cell phones. NASA is interested in RIT's research related to nanotechnology for satellite power systems.

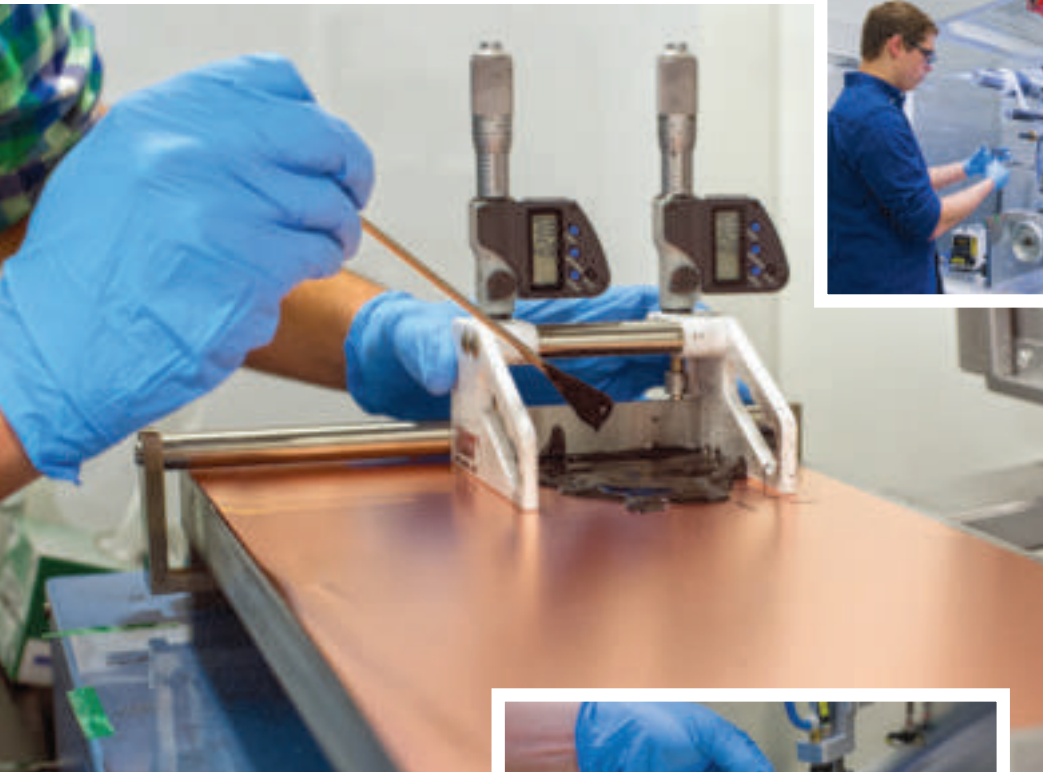
The work includes efforts to improve lithium-ion batteries, electrical conductors, and solar cells by enhancing conventional materials with the addition of nanomaterials, Schauerman said.

## A One-of-a-Kind Facility

The center is an open-user facility, giving companies and researchers access to a dry room and laboratory space for a fee. Companies also have the option of providing their materials and assembly formula to center personnel who would build the battery based on the company's specifications.

Prototypes can be put through the paces, continually charged and discharged within environmentally controlled chambers that mimic extreme temperatures between 300 and minus 30 degrees Fahrenheit. This testing environment, coupled with semi-automated battery assembly equipment, is impressive, but what makes the center unique is





**Making Batteries:** Several steps take place on varied equipment in the center, from coating battery electrodes to stacking cells and, upon completion, loading the battery components.



**Top:** Martin Dann, a master's degree student in material science, works with battery prototyping equipment.

**Above:** Andrew Kailil, an undergraduate chemical engineering student, works in the center.

that it is not focused on one industry or chemistry. The center works with companies and government agencies from around the world.

The ultimate mission, he added, is to serve as another resource in New York state's growing energy storage hub.

The center was made possible by support from New York State Energy and Research Development Authority (NYSERDA), Empire State Development (ESD), and the New York Battery and Energy Storage Technology Consortium (NY-BEST).

"Before we opened two years ago, it would be very unusual for a startup or university researcher to have access to this sort of facility," said Matthew Ganter, center

co-director and RIT research scientist. "This type of capability is typically found in a national lab like Argonne."

### Building Viable Prototypes

Finding a safe "super battery" today is a big dream with lots of economic implications. But the path from prototype to industrial fulfillment is steep and fraught with barriers—especially for smaller companies and organizations.

Without access to a dry room, lithium-ion cell battery prototypes must be built manually using an oxygen- and water-free box, known as a glove box. The manual process is time-consuming and requires precision difficult to achieve in a small space. In one stage,

for example, electrode-coated foil must be cut into squares the size of a credit card. Twenty to 30 pieces then must be stacked one by one with an insulating layer in between each sheet—all done via rubber gloves inserted into the glove box.

During the past two years the center has helped about two dozen companies, including Lionano Inc., a Cornell University spinoff company commercializing a new battery material that aims to increase the capacity, extend battery lifetime, and reduce charging time required for lithium-ion batteries.

### Expansion and Opportunity

In the coming months, the center plans to install about \$700,000 worth of additional



**In Charge:** Matthew Ganter, left, and Christopher Schauerman are co-directors of the Battery Prototyping Center and research scientists at RIT.

equipment, making it possible to expand operations and add cylindrical cell capabilities. Cylindrical cell batteries are of high interest to electronic manufacturers because they are a commonly used shape and have been used for decades. Instead of stacking repeating layers of electrodes, cylindrical cells are rolled up like a newspaper.

Expansion plans also include workforce development training for RIT undergraduate and graduate students. The center plans to offer special topic classes on energy storage technology, which will include instruction on battery design for portable electronics, best practices, and performance testing. Classes could be offered as early as this fall with 20 to 30

students expected to take the course.

“We get inquiries constantly from companies and national labs that are looking for students to co-op who are already trained in energy storage, and we never have enough to send,” said Ganter. “The course will have a lab component that allows students to build a commercial-quality cell and then test performance. These students will have the type of experience that will let them get to work on day one and contribute to companies.”

Cooperative education is full-time, paid work experience directly related to a student’s course of study and career interests. Andrew Kalil, a third-year chemical engineering student, is working

at the prototyping center full time as part of his co-op. “I see a huge need for this (research), and I wanted to get into the business while it is still young,” he said.

Martin Dann is pursuing a master’s degree in material science and will be working on the NASA project as part of his thesis. “Renewable energy, solar cells—that’s the publicized side—but how are you going to store the energy? That’s the challenge,” he said.

**On the Web**

**Battery Prototyping Center**  
<http://bit.ly/batteryprototypingcenter>

**Leading the Team:** Charles Ruffing is the director of the New York State Pollution Prevention Institute. Before beginning as director in January 2016, he was vice president of Health, Safety, Environment and Sustainability at Eastman Kodak Co. He leads a team of engineers, technical staff, outreach specialists, and students.



# Pollution Prevention Institute Fosters Development of Sustainable Businesses

by Jane E. Sutter

The New York State Pollution Prevention Institute (P2I) directly assists businesses by providing on-site analysis and then offering options of how to improve processes based on research and technological opportunities.

## Third-Party Assessment

When the founders of Keen Home needed independent testing of the heating, ventilation, and air conditioning enhancement that they were developing, they contacted the New York State Pollution Prevention Institute (P2I). Keen Home was incubated at the NYU-Poly ACRE Incubator based at the Urban Future Lab in Brooklyn, which referred Keen Home to P2I.

Keen Home, now based in Manhattan, manufactures the Smart Vent System, which is designed to enhance user comfort and energy efficiency within a building or house. As a startup with its product still under development, Keen Home wanted to get third-party validation of its system to share with potential clients such as utility companies and home builders, said Nayeem Hussain, co-founder and CEO.

P2I conducted its own testing and shared the results with Keen Home.

“I would encourage any entrepreneurs or companies looking to provide a clean tech product to leverage this resource because they ended up coming in very cost efficiently as well as providing some really timely services to us,” Hussain said.

P2I works solely with New York state-based companies. “Our mandate is both environmental improvement and economic development, and that’s why the state is interested in our help to businesses,” said Charles Ruffing, director of P2I, which is located in Louise Slaughter Hall at RIT. With help from P2I’s staff of 15 and the opportunity to tap into other experts at RIT, companies can reduce their environmental impact, save money, or grow their customer base by touting proven environmental performance or improvements.

As more large companies, like Walmart,



**Keen Home:** Manhattan-based Keen Home manufactures the Smart Vent System, which is designed to increase comfort and reduce energy costs by regulating a home’s temperature room by room. P2I did an assessment that evaluated the energy savings from the system.

become environmentally conscious, smaller companies that want to be suppliers “find it’s in their best interest to be able to tell a good environmental story both about themselves and the products they are selling to these suppliers,” Ruffing noted. More consumers, too, are seeking products from companies that utilize sustainable practices.

P2I’s work with companies has traditionally fallen within three defined areas: Direct Assistance, Green Technology Accelerator Center, and Sustainable Supply Chain. Direct Assistance focuses on finding cost-effective solutions for areas such as reducing toxicity and waste, and conserving and recycling water.

Experts in the Green Technology Accelerator Center may be called upon to provide independent third-party product testing and evaluation, environmental and energy impact evaluations, assessments of market viability and life cycle, and competitive product benchmarking.

With regard to the Sustainable Supply Chain, P2I experts help identify ways a company can be more competitively positioned. Projects can include supply chain assessments and development of frameworks for management systems; sustainable sourcing and procurement policies; and supplier tracking, documentation, and sustainability metrics.

## Variety of Market Segments

Now in its ninth year, P2I has developed a track record in various segments of the market, such as metal finishers, where it has helped several companies reduce water usage, Ruffing said.

One area occupying a lot of P2I’s current “mindshare,” as Ruffing put it, is helping entities deal with food waste. That’s because New York state Gov. Andrew Cuomo is pushing for legislation that would prohibit large generators of food waste (about two tons per week) from depositing it in landfills. But there’s



**Locust Hill:** Rick Slattery, right, Locust Hill golf course superintendent, and Casey Grann, senior assistant, worked with P2I to find a way to recycle wastewater when washing mowers. Right: P2I engineers identified flow restrictors and nozzles that reduced water flow without affecting quality.

limited infrastructure in place for dealing with that amount of food waste, Ruffing said. So P2I's staff is working to improve and expand the options such as composting and anaerobic digestion through business assistance and research. Staff also are visiting food waste generators, such as universities and supermarkets, to audit their practices.

P2I also is working with small businesses, such as auto body shops, in the New York City area, where the effects of climate change could be devastating to bodies of water nearby.

Thanks to New York state's funding, businesses pay only a modest amount of the project's total cost, Ruffing said. Typical project costs range from \$20,000 to \$40,000 and are completed in three to six months.

P2I, which is funded by the New York State Department of Environmental Conservation, is a consortium of four higher education institutions: RIT (lead entity), University at Buffalo, Clarkson University, and Rensselaer Polytechnic Institute. While most of the funds that P2I receives from the state go to its work with businesses, some monies go toward research and development projects at those four institutions. An independent panel of judges evaluates proposals and picks the grantees.

Another portion of the state funding goes toward community grants, issued to groups and nonprofits with environmental missions. Proposals must resonate with the mission of P2I, have measurable outcomes, and be scalable across the state. About 12 to 15 grants are awarded annually; the highest awards are about \$20,000, Ruffing said.

Here's a look at three businesses that P2I has assisted in recent years:

### Keen Home

Prior to approaching P2I for evaluating its Smart Vent System, Keen Home had already conducted testing in multiple homes across the country. For a test site/home in New Jersey, P2I experts designed and executed an independent assessment that evaluated the energy savings and occupant comfort of using a pre-production version of the Smart Vent System versus a baseline forced air system.

P2I engineers installed sensors to measure the inside temperature and energy usage during the summer months of 2015. After analyzing and extrapolating the data, P2I found that the Smart Vent did not require more energy usage to deliver a higher level of comfort. "Comfort increased while energy usage stayed the same," Hussain said. Keen Home's product

development at the time of the evaluation was "about 70 percent of the way there." Hussain added, "I'm very confident had we run that study now, we'd be able to show not only increased comfort but also decreased energy usage, rather than increased comfort with flat energy usage."

Keen Home shipped more than 30,000 Smart Vent units in 2016. The third-party valuation from P2I has helped Keen Home executives get their foot in the door with potential partners, such as large utility companies, Hussain said. Another invaluable aspect of working with P2I was the "generous subsidization" from New York state for the testing, Hussain said. Other third-party quotes were 10 to 20 times more than what P2I charged.

### Locust Hill Country Club

Rick Slattery, veteran golf course superintendent at Locust Hill Country Club in suburban Rochester, N.Y., is proud that the course's environmental efforts have resulted in it being named a Certified Audubon Sanctuary by Audubon International.

That led to Locust Hill being named to the group New York Environmental Leaders (NYEL), by which the state recognizes businesses and organizations that not only are in compliance with environmental regulations and laws but





**Ecovative:** The biological materials company that produces packing materials that are alternatives to plastics and foam worked with P2I to do a lifecycle assessment. P2I also looked at the environmental impact of transporting materials used by the company.

also are committed to future environmental performance improvements.

But Slattery wasn't ready to rest on those laurels. In its evaluation, Audubon had identified a gap with regard to the washing of the mowers. Although the current practice was in compliance, wastewater from the washing was being sent through an underground tank and discharged into a wooded area.

Slattery wanted to find ways to develop a closed-loop system to recycle the wastewater, he said. Such a system costs "six figures easily" and was unaffordable. NYEL connected Slattery to P2I.

Engineers determined that one way to keep the cost down was to reduce the amount of water being used, so first engineers measured the volume of water being used and then looked for ways to decrease it. "We started using air to blow the (grass) clippings off first, so that reduced the amount of rinsing water by half," Slattery said.

The next step was to test various nozzles to find one that could cut the volume in half but still be effective, Slattery said. Ultimately, P2I engineers identified certain flow restrictors and nozzles that reduced water flow by 50 percent without significantly affecting cleaning time and quality. Engineers

also determined that recycling the water did not need to result in pure water for effective cleaning, so not needing complete purifying would reduce the cost of a closed-loop system.

Since the testing in the summer of 2015, Slattery's crew now uses a flow restrictor and nozzle identified by P2I, thus resulting in Locust Hill using 25 percent less water. Slattery hopes to get a prototype built to recycle the water, and he's in discussion with Cornell University and the New York State Turfgrass Association to achieve that.

### Ecovative

Ecovative is a biological materials company that produces packaging materials that are alternatives to plastics and foam.

To do this, Ecovative uses domestic and locally sourced agricultural byproducts, feedstocks, and mycelium (mushroom roots). Gavin McIntyre, co-founder and chief scientist, said his company, which grows its own materials, wanted to know its environmental impact such as energy consumption, environmental health, water usage, and greenhouse gases.

P2I worked with Ecovative to do a lifecycle assessment—for example, measuring energy usage of its pasteurization and drying processes. One key

finding was that Ecovative's convection drying process was its biggest energy hog, McIntyre said. The company has explored the use of microwave technology, which is far more energy efficient.

P2I also looked at the environmental impact of transporting some of Ecovative's materials, which were coming from Texas to its facility in Green Island, north of Albany, N.Y. Today the company sources these materials from within 50 miles of its facility.

The P2I assessment helps support Ecovative's marketing claims that it uses less energy and has a smaller environmental footprint than manufacturing of traditional plastics, McIntyre said. That's important to its customers, which include Dell computers and manufacturers of items that vary from tabletops to industrial goods to lightbulbs.

The process went so well that Ecovative asked P2I to work with them on testing Mushroom Packaging parts to achieve certification for a home compost ability of their materials, another feature that customers wanted, McIntyre said.

### On the Web

New York State Pollution Prevention Institute:  
[www.rit.edu/affiliate/nysp2i](http://www.rit.edu/affiliate/nysp2i)



**Robotics:** A donation from General Motors adds an important piece to the larger manufacturing system at RIT, giving the university a complete, in-house manufacturing production and assembly system. SunWoo Ji is completing his master's degree in manufacturing and mechanical systems integration. He is looking for an engineering position that revolves heavily around automation and robotics.

# General Motors Robots are One Piece of In-House Manufacturing System

by Laura Cummings

RIT is preparing students for careers as manufacturing engineers, process engineers, or quality engineers with a complete, in-house manufacturing production and assembly system.



**Robots Donated by GM:** The robots are used for laboratory exercises in robotics, automation, and CNC courses, as well as for capstone projects by undergraduate and graduate students.

## GM Donation

Automation, which includes the use of robots and other high-tech means, has had a significant impact on the nation's manufacturing industry. With its ability to improve quality and speed and decrease costs industrywide, automation is the present and future of manufacturing. And while it has displaced working class production jobs, automation has simultaneously created a shortage of qualified manufacturing engineers. According to the U.S. Bureau of Labor Statistics, the annual deficit is between 50,000 and 100,000, and growing. This shortage is creating a ripe opportunity for students enrolled in RIT's mechanical and manufacturing engineering technology programs.

Two yellow, heavy-duty industrial robots, donated to RIT by General Motors in 2015, loom large in one of several

manufacturing labs filled with a variety of robotic equipment. The two Fanuc R-2000iA/210F robots are among a collection of manufacturing assembly and production systems that are used to instruct students on an assortment of manufacturing and automation processes.

The GM donation adds an important piece to the larger manufacturing system at RIT. With the addition of the GM robots, the university has a complete, in-house manufacturing production and assembly system.

"There's nobody in the world that has the robotics system, the surface-mount assembly system, the metrology lab system, and the CNC manufacturing system that our department does," said Robert D. Garrick, professor and acting chair of the manufacturing and mechanical engineering technology department.

The value of this comprehensive, hands-on system is twofold. First, it is preparing students to embark on in-demand careers as manufacturing engineers, process engineers, or quality engineers in an industry that is rapidly changing. Second, the all-encompassing system is providing research opportunities, including those that explore intelligent systems, which extract data from manufacturing robots that is used to inform productivity, quality improvements, and more.

The impact of having an entire manufacturing system available to students is powerful. It gives them the rare chance to engage in all phases of manufacturing, automation, and production, said Garrick.

The manufacturing process entails a number of steps between product concept and the fabrication of a final product. Ideas often begin as a solution to a problem. Research on the current needs of the market confirm whether a concept could be in demand by consumers and whether an idea has the legs to endure product design and development.

Once an idea is fleshed out and a final design takes shape, students use CAD (computer-aided design) software to visualize a 3D model of their product, which also enables them to break down the individual components into smaller parts. Once theoretical problems are identified and analyzed, and the design is altered to accommodate these potential roadblocks, a product design moves into computer-aided manufacturing, or CAM. This is where a product leaps from a computer-visualized design to a three-dimensional, physical prototype with



**Manufacturing Process:** SunWoo Ji uses the Fanuc R-2000iA/210F robots as part of a welding process where the robots interface with programmable logic controllers and vision systems to enable a fully automated welding operation.

individual working parts.

Using metrology machines, the object's parts are measured to verify the quality of the parts down to the level of microns. This type of measurement is essential to assess the quality of precision parts, such as those used to build automobiles, airplanes, and electronic devices.

Prototype testing follows, with improvements made as needed. If a product passes tests for functionality and performance, it moves to fabrication, where it may be produced in small quantities first before being manufactured on a larger scale.

### Comprehensive Approach

Most higher education institutions specialize in one or two phases of the manufacturing process. RIT's manufacturing and mechanical engineering technology department houses this entire manufacturing system.

"Students see the production process of designing a product, making it, producing

it, controlling it, and then measuring it," said Garrick. "Then they make parts that actually interface. Students get a feeling for how complex manufacturing is, rather than talking in the abstract."

This comprehensive approach is creating graduates who are in high demand. With a year of work experience from required cooperative education placements and an education that's supported by extensive lab experiences at each phase of the manufacturing process, students are entertaining job offers from companies such as GM, General Electric, Tesla, Toyota, Apple, Fisher-Price, General Dynamics, Harris Corporation, and Honda before they graduate.

Because the department specializes in advanced manufacturing, automation and robotics, and electronics assembly and packaging, research into these areas is expanding. According to S. Manian Ramkumar, interim dean of the College of Applied Science and Technology, research focuses on the industrial implementation

of robots and controls, and the research associated with electronics and photonics manufacturing and packaging. The college is also wading into Industry 4.0, the current trend of extracting data from robots and other manufacturing technologies. It's the introduction of the "smart factory," where computers and automation come together. The result is data collected at every level of the manufacturing process.

How companies handle this data and how they utilize it to quickly take action with these advanced systems is what will improve manufacturing processes, said Ramkumar. "The future is going to become the implementation of robotics to make life easier. And to improve productivity and to provide quality and timeliness," said Ramkumar.

### On the Web

GM robots  
<http://bit.ly/GMrobots>

## Expect the Unexpected

### ▲ International Campuses

in China, Croatia, Dubai, and Kosovo featuring academic programs in entrepreneurship and innovative ventures, information technology, management information systems, micro-electronic engineering, and service leadership and innovation.

### ▲ Faculty

who harness GIS mapping to upgrade infrastructure in Syrian refugee camps, apply imaging science to improve biodiversity in Rwanda, and partner with Swedish colleagues on emerging art forms.

### ▲ Students

who establish sustainability standards for Peru, design sanitation and cooking systems in Haiti, and ensure quality support services for the deaf and hard of hearing in the Dominican Republic.



### Distinctly RIT

- Among the nation's largest private universities with 19,000 students from more than 100 countries
- 11 colleges and institutes offering more than 200 career-oriented and professional programs
- A leading producer of STEM undergraduate degrees among U.S. private universities
- 4,000+ international students from 103 countries studying at RIT campuses
- 43 RIT students (U.S. and international) currently studying and researching under Fulbright awards
- Internationally recognized programs in business, computing, engineering, fine arts, game design, imaging science, industrial design, photography, physician assistant, physics, and sustainability



**Results:** The Gunlocke Co., a furniture manufacturer, connected with the Center of Excellence in Advanced & Sustainable Manufacturing to reduce production costs and build upon its green philosophy while remaining competitive in the market.

# State-Funded Center Helps Reduce Environmental Impact

by Suzette Norris

The Center of Excellence in Advanced & Sustainable Manufacturing helps New York state manufacturing companies develop and commercialize new sustainable products and technologies.

## Center of Excellence

There's an eco-minded place at RIT that's become a wellspring of bright ideas for manufacturers in New York state. Instead of focusing on innovation by specific industry, the Center of Excellence in Advanced & Sustainable Manufacturing (COE-ASM) at RIT's Golisano Institute for Sustainability takes a more holistic approach to improving the way manufacturers use energy and manage processes.

"What makes us different from other Centers of Excellence around the state is that we work with manufacturers in a variety of industry segments," said Mark Krystofik, the center's senior program manager. "We've worked with high-tech companies, startups, a food company—many different types of manufacturers."

The approach uncovers common threads across industries, making it possible to replicate success in reducing manufacturing's environmental impact and conserving resources. The ultimate goal, Krystofik said, is to strengthen the bottom line for businesses in New York state.

The center's efforts are gaining traction as seen in a three-year snapshot of COE-ASM's work:

- 42 New York state companies engaged in projects with the center, resulting in a \$10 million impact in cost savings, increased revenue, capital investment, and funding (seed or federal);
- 68 new and retained jobs.

The COE-ASM is one of 11 centers funded by the Empire State Development's Division of Science, Technology and Innovation (NYSTAR). The Centers of Excellence program, established by New York state, fosters collaboration between universities and the business sector to promote the development and

commercialization of new products and technologies. The center at RIT opened in 2012.

## Bringing Eco-Innovation to Smaller Companies

Many small- to medium-size companies in the Rochester area manufacture parts that go to original equipment manufacturers. They know reducing energy spend is an advantage, but they need guidance on where to begin, explained Krystofik. For example, while there are energy monitoring systems on the market that target opportunities for energy savings, often they are prohibitively expensive for smaller manufacturers.

One of the center's current projects uses off-the-shelf components for testing and for the development of low-cost power monitors. The monitors being developed collect data, which can be used to uncover opportunities to improve operations and reduce energy use.

Using this type of monitor, one local company discovered it could shave 20 percent of peak energy demand charges, saving tens of thousands of dollars. The company also discovered ways to reduce electricity consumption costs by 7 percent by shutting off idle equipment, Krystofik said.

"You can imagine the ripple effect if hundreds of small companies start reducing energy use in this way," he said.

## Furniture Manufacturer

The Gunlocke Co. has manufactured furniture for companies, government agencies, and even U.S. presidents over the past 114 years. Environmentally conscious, the company connected with COE-ASM to reduce production

costs and build upon its "lean is green" philosophy while remaining competitive in the market.

"In manufacturing, we have a responsibility to use resources and employees' time as effectively as possible," said Roy Green, director of stewardship and sustainability at Gunlocke. "So if there is automation equipment or process improvements that allow us to be more efficient, we must consider it."

COE-ASM conducted a comprehensive assessment that reviewed every phase of production processing for the 750,000-square-foot Wayland, N.Y., facility, including process technology, facility layout, production throughput, supply chain management, energy use, health and safety, and material handling. The analysis identified strengths, weaknesses, and opportunities for existing operations and provided economic and environmental justification for each detailed recommendation.

In total, it identified more than \$2 million in annual savings from efficiency gains, energy savings, waste minimization, and implementation of alternative technologies.

Gunlocke installed semi-automated equipment that could perform more functions and required one operator instead of multiple employees. The decision increased production and capabilities and saved 900 square feet of factory space.

And, surprisingly, it helped Gunlocke retain jobs in an industry where highly skilled employees are needed to compete.

"Gunlocke's skilled workers are critical to the quality and beauty of our products," Green said. "Installing the new equipment allowed us to re-allocate 10 operators to more value-added functions."



**Industrial Design:** Students learn about sustainability and the manufacturing process in their first year. Alex Lobos focuses on teaching sustainability, emotional attachment, and user-centered design as means to elevate quality of life.



**Collaboration:** A collaboration between the industrial design program and General Electric focused on developing new refrigeration systems.



**User-Centered Design:** The project strived to enhance sustainable user behavior and an improved user experience for the GE Profile brand. The end result was a series of concept designs for appliances that integrate strategies for engaging design, improved sustainability, and positive user behavior.

# Encouraging Sustainable Behaviors Through Product Design

by Laura Cummings

Sustainable manufacturing gets a boost from more efficient user behaviors.

## Sustainability in Product Design

It's a common scenario: When prepping for a holiday gathering, refrigerator shelves become prime real estate. People juggle bottles and jars, readjust dishes by stacking some on top of others, and inevitably toss a few items to make way for casserole dishes and appetizer trays.

General Electric recognized that its customers perform this ritual regularly and sought out concepts to help alleviate the static nature of the refrigerator, a largely unchanged household appliance since it first gained widespread use in the 1920s. GE brought this challenge to a Senior Design Studio class with a missive: Propose a conceptual design that

addresses this consumer issue while encouraging sustainable behavior.

Sustainable behavior, or the actions of consumers that enhance the environmental, economic, and social impact of a product, is an area GE wanted to explore in greater depth. Sustainability in product design and manufacturing is twofold. A product can be designed and fabricated to maximize sustainability through energy efficiency, materials, and performance. But these elements can only carry sustainability so far.

"You can have a very efficient product, but if it's used in an inefficient way, then many of the benefits are gone," said Alex Lobos, associate professor and graduate

director of RIT's industrial design program. "That's where sustainable behavior comes into play. For industrial designers, that's a way of looking at making better emotional connections between users and their products."

Emotional connections encourage sustainable behaviors in consumers, who are now more likely to repair a product that breaks down, which extends its life cycle and offsets the energy used to manufacture the product. "If you have a good experience with a product, you are less likely to dispose of it, or to replace it often," said Lobos. Ultimately, consumers extend a product's life cycle by using an item for a longer period of time.



### Conceptual Refrigerator

The Senior Design Studio project sponsored by GE resulted in several student projects. One of them is a conceptual refrigerator system designed by three industrial design students—Beatriz Alvarez, Sarah Chuah, and Behrad Ghodsi—that featured four customizable compartments with individual climate controls. The innovative design enables a sustainable solution that also influences the way users engage with the appliance.

On a daily basis, a consumer may need to utilize only two of the compartments. Because each compartment has its own temperature settings, on any given day one compartment can serve as a refrigerator and a second as a freezer. On the occasions when more space is needed, compartments three and four can become added refrigerator or freezer space. When not in use, extra compartments can be turned off, which saves energy, and these spaces become dry cabinet shelving for bakeware, cookware, or kitchen gadgets.

For industrial design students, sustainability and the manufacturing process are addressed beginning in the first year. And the importance of these concepts in the design process cannot be undervalued. It's paramount that students understand the manufacturing process in order to achieve their design concepts, said Lobos.

“As industrial designers, we look at manufacturing as a way to make sure that our ideas can be produced and that they can be fabricated,” he said. “It doesn't matter if you have great dreams of how a product might change someone's life; if you are not able to make that product, and make it at a reasonable price or quality, then that idea is not good.”

Lobos, who worked for GE and Whirlpool as an industrial designer before joining RIT, has seen the industry change and move toward one that now demands more skills and knowledge from its industrial designers. The curriculum in the program has evolved to include the broader concepts of manufacturing, sustainability, circular

economy, materials, and interaction design. These concepts, along with an exceptional level of design skill, have produced graduates who are able to understand both the context and the implications of whatever they are designing.

“Our students are able to look at a bigger picture and understand the actual value of their designs,” Lobos said.

### Real-World Preparation

The broader curriculum, which many students enhance with minors in disciplines such as mechanical engineering, packaging science, and business, is helping to prepare students for the realities of the workplace.

“Understanding manufacturing processes and elements that go beyond design empowers students and makes them more effective at communicating and defending their ideas when they are in a business setting,” Lobos said. “They can understand some of the limitations or some of the perspectives of other disciplines such as manufacturing, engineering, business, marketing.”

Industrial design students spend time in the various manufacturing labs at RIT and visit local companies and factories to see a full range of manufacturing processes at work. This perspective illustrates the scope of the design and manufacturing process, from the initial conception of an idea all the way to its execution in a manufacturing setting for mass production.

“The way we look at manufacturing is not as a challenge that needs to be overcome, but rather as a way of improving the design of products,” said Lobos.

He notes that many successful products in the marketplace seamlessly blend design with the manufacturing process, making it difficult to distinguish between elements that a designer wanted as part of the project versus something that, for manufacturing reasons, had to be part of the project. “If you use manufacturing, new materials, and processes in a good way, then those become important features of the design.”

### Studio 930: Where Ideas Flourish

Tucked in a corner on the fourth floor of James E. Booth Hall on the RIT campus is Studio 930. With its concrete floors, bare walls, and good lighting, the space is practical. And so are the problems students are addressing in the studio.

Otto, Lily Pad, Help Dress, and EZTP are just a few of the projects evolving at Studio 930. All of them emerged as solutions to challenges faced by children and adults with disabilities and special needs.

Students from RIT-sponsored ideation workshops, such as Idea Lab, needed a place to further explore the viability of the ideas and services they designed in response to problems presented to them by health care organizations.

“After students met with local agencies and presented possible solutions to their problems, the question became ‘what do we do with these potential solutions?’” said Stan Rickel, associate professor of industrial design and faculty coordinator for Studio 930. “The answer was Studio 930, which allows students to take their ideas to the next level where they can maybe be produced.”

Studio 930 is a summer co-op where students can continue to develop their projects from concept to prototype to viable product. It's part of the Simone Center for Student Innovation and Entrepreneurship, which helps to advance student ideas and projects through business development programs, funding opportunities, student competitions, and mentoring.

Some projects have evolved into startup companies. The team behind ThermApparel, a garment with cooling technology that helps regulate body temperature for multiple sclerosis patients, participated in Studio 930.

“That's been the real magic about Studio 930. It brings a real human component to design,” said Rickel. “Students see there's an impact to what they are doing, a real reason to make a product.”



# Helping Businesses Improve Performance

by Jane E. Sutter

The John D. Hromi Center for Quality & Applied Statistics uses proven methodologies to work with employee teams to solve thorny problems or develop processes that will lead to continuous improvement within an organization.



Mark Smith

## Variety of Clients and Goals

RIT established the Center for Quality & Applied Statistics (CQAS) in 1983, naming it for its first leader, John D. Hromi, a Frederick H. Minnett Distinguished Professor.

The goal was to meet the needs of local manufacturers for applied statisticians and quality professionals. Since then, the mission of CQAS has evolved to keep up with dramatic changes in the economy. Although CQAS staff still work with manufacturers, the diversity of clients now varies from health care to call centers to the service industry to local government entities and community colleges, according to Mark Smith, the center's director.

"Our mission overall is to help organizations improve their performance by leveraging all the expertise that we have here at RIT in statistical methods, decision sciences, process engineering."

About 80 to 85 percent of the training offered by CQAS is the Lean Six Sigma methodology, which focuses on a structured problem-solving process to achieve better productivity and efficiency. It's a team-oriented approach, with participants achieving various levels of expertise, starting with Yellow Belt, then progressing to Green Belt, and finally Black Belt.

Teams of employees hone in on an immediate problem a business faces,

Smith said. "We're not there to teach at them. ... We're trying to get them to incorporate tools and a structured methodology to address real challenges and problems they have."

CQAS staff meets with interested businesses to tailor programs to their needs, too. Even after the formal training ends, CQAS staff will keep in touch with participants and company sponsors until a project is completed or in the "control phase" of the process.

"We're not successful until they're successful," Smith said.

Smith cited examples of success from companies that have worked with CQAS:

- Reducing inventory cost by 5 to 10 percent for a total annual savings of \$200,000 to \$300,000;
- Reducing the amount of material that goes to landfills by 50 percent;
- Reducing scrap by 90 percent;
- Reducing the cost of project planning, tracking, and management by 50 percent;
- A hospital's emergency department reduced by 80 percent the amount of time patients spent on a long spine board, which is very uncomfortable.

## Training Programs

CQAS also has a strong commitment to the RIT community, Smith noted. For example, Yellow Belt training is offered for students prior to the beginning of each semester and during spring break. An academic course is also taught that leads to a Yellow Belt and offers the students the opportunity to earn a Green Belt by executing an individual project under the guidance of a sponsor and CQAS. Lean Six Sigma training can help



**Mission:** The Center for Quality & Applied Statistics helps organizations improve performance.

students be more marketable to potential employers, Smith noted.

CQAS works with faculty who need assistance with research, and the center also may connect faculty to companies that need consultation after training.

A variety of other courses are offered by CQAS focusing on improving performance. While most classes are offered at RIT or on-site at an organization, CQAS offers "blended" programs (on-site and online) and will be offering both Green Belt and Black Belt training online later this year, Smith said.

Cost for training ranges from \$90 to \$350 per person per day, depending on the program. The center usually offers a fixed price to businesses and organizations for training up to 20 people per day, Smith said, with a range of \$2,000 to \$3,500 per day. While the center consists of a half dozen staff, it is closely affiliated with the Department of Industrial and Systems Engineering in the Kate Gleason College of Engineering, and it taps into expertise from engineering and statistics and elsewhere around RIT as needed.

# Analytics New Tool in Optimizing Manufacturing

by Susan Gawlowicz

RIT's new Data and Predictive Analytics Center hopes to play a significant role in advancing how data analytics is used to optimize manufacturing decisions, reduce down time, monitor the health of equipment, and predict maintenance and repairs.



Mihail Barbosu

## Power of Data

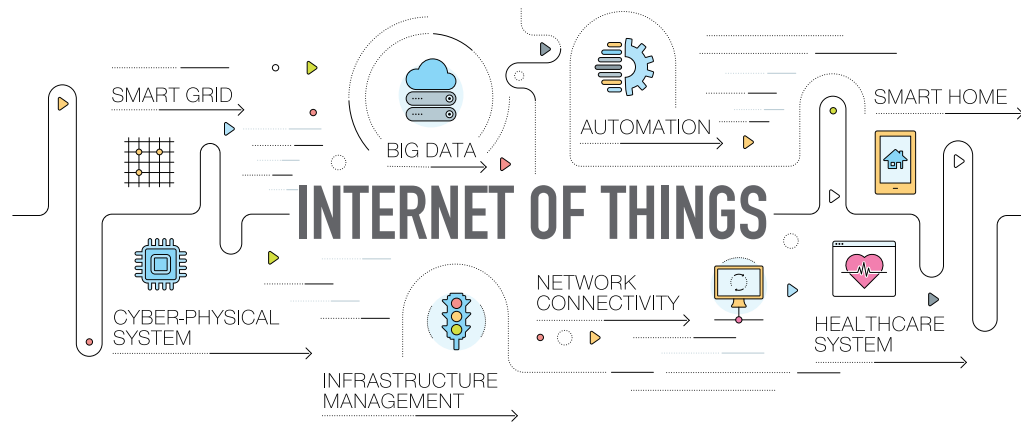
The Data and Predictive Analytics Center in RIT's College of Science is helping industry partners harness information from their smart, interconnected devices and streamline manufacturing processes.

Director Mihail Barbosu is positioning the center as a resource for companies investing in the Industrial Internet of Things, in which connected digital networks

combine big data and machine learning for increased operational efficiency.

Insights collected through large-scale data analytics can optimize manufacturing decisions, reduce down time, monitor the health of equipment, and predict timely maintenance and repairs, Barbosu said.

The interdisciplinary Data and Predictive Analytics Center, formed in September, is an affiliation of faculty and students who manipulate large-scale data, drawing upon a mix of mathematics and statistics, computer science, engineering, and other areas. The center will involve undergraduate researchers and support graduate students from the new mathematical modeling Ph.D. program, starting this fall, specializing in data analytics and



simulation of complex systems.

An early partnership with ITT Gould Pumps has led to ongoing internships through the center. Undergraduate students already have gained hands-on experience developing monitoring systems that measure vibration and temperature and detect equipment failure.

“ITT wanted to know when some devices would stop working and what kind of parts and services they would need to plan for,” Barbosu said. “The larger context is the same: You get sensors, collect information, analyze data, and identify where the problem might occur and under what circumstances.”

Barbosu anticipates a growing interest in this area at RIT, especially with an international conference related to the Internet of Things planned for the fall. Nathan Cahill, associate dean for industrial partnerships and associate professor in the School of Mathematical Sciences, is organizing the event aimed at academics and industry members.

“RIT could be a leader in the Industrial Internet of Things,” Barbosu said. “We have everything here that we need: data science, mechanical engineering, computer science—and students.”

College of Science Dean Sophia Maggelakis pointed to potential collaboration with RIT's Golisano Institute for Sustainability in its Manufacturing USA federal initiative. Earlier this year, the U.S. Department of Energy selected the institute to lead its new Reducing Embodied-energy and Decreasing Emissions (REMADE) Institute—a national coalition of universities and companies that will explore clean energy initiatives that keep U.S. manufacturing competitive.

“The ability to mine large amounts of data to discover patterns and make actionable predictions is revolutionizing manufacturing, among many other concerns,” Maggelakis said. “RIT can play a significant role in advancing how our industry partners use data analytics to inform their business decisions.”

# Faculty, Staff, and Student Achievements

RIT values the research contributions of its faculty, staff, and students. Below are some members of the RIT community who have received recent international, national, and university recognition.



**Mehran Mozaffari Kermani** recently received a grant to design security measures for computing systems that will protect wearable and implanted

medical devices such as pacemakers from cyberattacks. It is work that could improve both patient safety and data integrity of deeply embedded systems.

Mozaffari Kermani, an assistant professor of electrical engineering in RIT's Kate Gleason College of Engineering, received \$343,406 in funding from the National Institute of Standards and Technology—Measurement Science & Engineering Research Grant Program. He will develop cryptographic systems and technology that will further secure deeply embedded computing systems—organizational networks connected to the internet.



**Brian Tomaszewski**, associate professor in the B. Thomas Golisano College of Computing and Information Sciences, and **Robert Parody**, associate professor

in the College of Science, received a \$250,000 grant from the National Science Foundation to conduct an international research experience for RIT students to study the relationship between

geographic information capacities and disaster risk reduction.

The three-year project will allow five students each year to participate in a 10-week summer research experience with collaborators at the United Nations University Institute for Environment and Human Security and the University of Bonn—both located in Bonn, Germany. The experience will look at how geographic information capacities—such as GPS and predictive models—can be used to mitigate the risk of disasters, including floods, earthquakes, and droughts.

The project is part of the NSF's International Research Experiences for Students program, which supports the development of globally engaged U.S. science and engineering students.



Research is underway at RIT that will give scientists a better understanding of the vitreous humor, or gel, that fills the eye and could lead to advances

in the treatment of vision disorders, drug delivery, and eye surgery.

**Moumita Das**, an assistant professor in RIT's School of Physics and Astronomy, is leading a National Science Foundation-funded study to explore properties critical to the function of the vitreous and the eye. Her team is investigating changes in the vitreous gel on structural and mechanical levels that result in vision impairment.



RIT faculty member **Nathan Cahill** was named a Rising Researcher by SPIE, the international society for optics and photonics, for his contributions

to defense and security research.

Cahill is one of 10 early career professionals selected to receive the new award. The first cohort of SPIE Rising Researchers was chosen for their work in defense, commercial, and scientific sensing, imaging, and optics, or in product development.

Cahill is the associate dean for industrial partnerships in the College of Science and an associate professor in RIT's School of Mathematical Sciences.



Researchers at RIT are using fluid dynamics and mechano-biology strategies to better understand blood flow and how cells moving through blood vessels are affected by shear

stress—pressure and friction on objects.

**Jiandi Wan**, an assistant professor of microsystems engineering in RIT's Kate Gleason College of Engineering, received a \$476,505 award from the Gordon and Betty Moore Foundation for this work.

Wan's research focuses on how biological cells "know" and respond to externally applied mechanical forces.

It is part of a growing field of research, and his research team has developed state-of-the-art experimental models and devices to explore the mechano-sensing dynamics of red blood cells, circulating cancer cells, and primary erythroid cells—red blood cells, or their developmental precursors. The work could advance the understanding of biological mechanics and enhance the ability to treat diseases with effective therapeutic strategies.



**It's Time: ExOut Extremism**, a student project, has won yet another prestigious prize. The online initiative, which started out as a classroom assignment, has been awarded \$149,000 from the Department of Homeland Security to continue its campaign to counter violent extremism.

The latest comes just months after winning a UNESCO global award at a star-studded gala and winning the State Department's Peer to Peer (P2P) Challenging Extremism competition.



A team of interdisciplinary researchers, designers, and developers led by **Owen Gottlieb**, an assistant professor of interactive games and media at

RIT, has created a digital prototype for *Lost & Found*, a strategy game that aims to promote and enhance the public understanding of religion.

The project, funded by a \$100,000 grant from the National Endowment for the Humanities, marks the first time an NEH award has been given to a professor in

RIT's B. Thomas Golisano College of Computing and Information Sciences. The prototype was even featured at the 50th Anniversary of the NEH, held last September at the University of Virginia.

The "Lost and Found: Promoting Religious Literacies through Gaming" project focused on developing a digital game set in 12th century Egypt that teaches students about medieval religious legal codes. The purpose is to enhance people's understanding of religion, improve discussion surrounding religious legal systems, and increase awareness of their prosocial aspects, including collaboration and cooperation.



**Joel Kastner** is broadening and deepening his research program on the origins of our solar system and planetary systems orbiting other stars while on consecutive

fellowships and visiting positions during his sabbatical this academic year.

Kastner, professor in RIT's Chester F. Carlson Center for Imaging Science and the School of Physics and Astronomy, was the Study Abroad International Faculty Fellow for the month of November at the Arcetri Observatory in Florence, Italy. He collaborated with former RIT post-doctoral fellow Germano Sacco and other Arcetri scientists to identify and study young stars within a few hundred light years of the sun using newly available data from the European Space Agency's Gaia space telescope.

He was also awarded two additional fellowships for 2017—the prestigious Merle A. Tuve Fellowship from the Carnegie Institution for Science Department of Terrestrial Magnetism in Washington, D.C., for his six-week residency there, in January 2017; and a Smithsonian Institution Short Term Visitor fellowship for his residency at the Smithsonian Astrophysical Observatory in Cambridge, Mass., in March and April 2017.



**Dimension Technologies Inc.**, an RIT

Venture Creations business incubator company, was featured in one of NASA's technical publi-

cations in an article titled "SBIR Advanced Technologies in Aviation and Air Transportation System 2016." NASA cited the LCD display technology developed by the company that enables viewers to see full-resolution 3D images without the need for special glasses or headsets.

NASA's interest in the technology is based on extensive studies at the NASA Langley Research Center and the U.S. Air Force Research Laboratory that showed that 3D displays can improve pilot situational awareness by 18 percent. Three-dimensional visualizations also help in identifying and classifying objects and manipulating objects in real or virtual space. According to the NASA report, applications for the technology include flight-deck instrumentation displays, air traffic monitoring and control, luggage screening, unmanned vehicle operation, and training and simulation.



**The Image Permanence Institute (IPI)**

at RIT has received a \$182,730 grant from the National Endowment for the Humanities (NEH) Preservation and Access Education and Training program in support of "Teaching a Methodology for Photographic Process Identification."

During the two-year project, IPI will attempt to reach the broadest audience possible using a variety of outreach tools, including seven regional workshops, six 60-minute webinars, and three short video tutorials on photographic process identification and care. These educational programs will focus on how to use Graphics Atlas, an online reference resource developed by IPI. Alice Carver-Kubik, a photographic research scientist at IPI and content developer for Graphics Atlas, will lead the project.



RIT Distinguished Professor **Vicki Hanson** was elected to the ACM CHI Academy, an honorary group of individuals who have made substantial contributions to the field

of human-computer interaction, or HCI. With this honor, Hanson joins principal leaders of the field whose efforts have shaped the disciplines and industry of HCI.

The academy is a part of the ACM Special Interest Group on Computer-Human Interaction—more commonly known as SIGCHI. ACM (Association for Computing Machinery) is the world's largest educational and scientific computing society.



Imaging technology advanced by researchers at RIT and Florida Institute of Technology is being tested on the International Space Station and could someday

be used on future space telescopes.

A new twist on the charge injection device camera, originally developed in 1972 by General Electric Co., fine tunes the array of pixels for improved exposure control in low light conditions. The enhanced technology could give scientists a new method for imaging planets around other stars and improve the search for habitable Earth-like planets.

**Zoran Ninkov**, professor in RIT's Chester F. Carlson Center for Imaging Science, and Daniel Batcheldor, head of physics and Space Sciences at FIT, designed the charge injection device camera to capture contrasts between light emitted by astronomical objects. "In addition to improving presently available devices, the development of next-generation imaging arrays promises considerable flexibility in read-out and on-chip processing for the future," Ninkov said.

## In the News

### Science Exploration Program Studies Habitable Zone of Alien Planets



**Jared Luce**, from Coventry, Conn., studies alien oceans and atmospheres that might exist on distant planets.

**First-year students in RIT's Science Exploration Program** are reproducing a slice of life in their lab that might exist on the seven Earth-like planets recently discovered in another solar system.

NASA announced the record-setting discovery of planets orbiting another star on Feb. 21. The red dwarf star, called TRAPPIST-1, is located 40 light years away. Astronomers studied fluctuations in the star's brightness when the planets crossed in front of the star and blocked its light.

Excitement surrounds the potential of liquid water on the seven planets and habitable conditions on the first three.

RIT undergraduates are simulating the right atmospheric conditions within the habitable zone suitable for supporting life beyond our solar system. The students' experiments have created 10 amino acids—the fundamental building blocks of life—in different solutions. Their laboratory apparatus contains tiny oceans and atmospheres that could mimic conditions on an exoplanet. They

are studying if amino acids can be produced in these harsh environments. Chains of amino acids can form proteins and, eventually, more complex organic material like RNA and DNA.

"The team has reproduced a wide range of conditions that might exist on distant planets and has been simulating the environmental and photochemical processes to determine whether or not amino acids are created," said Roger Dube, director of the Science Exploration Program and professor in RIT's Chester F. Carlson Center for Imaging Science.

The students have found a range of parameters that produce amino acids, which is the prerequisite for predicting what type of life might appear on exoplanets, Dube said.

RIT's Science Exploration Program challenges first-year undeclared students with an interdisciplinary year-long project. Students will present their findings at the 10th Imagine RIT: Innovation and Creativity Festival on May 6.

# R·I·T

Experience  
the

# FUTURE

SATURDAY, MAY 6



**10**  
YEARS  
**IMAGINE RIT**  
INNOVATION + CREATIVITY FESTIVAL

## A Free Festival For Everyone

**What:** Imagine RIT: Innovation and Creativity Festival is the university's signature event, a showcase that displays the ingenuity of students, faculty and staff.

**When:** 10 a.m. to 5 p.m. Saturday, May 6.

**Admission:** Free and open to the public, rain or shine. Parking available on RIT's campus and at Monroe Community College with a free shuttle service to RIT.

**What you'll see:** Nearly 400 interactive presentations, exhibits, research projects, hands-on demonstrations, and live performances.

**Plan your day:** Build an itinerary of your favorite exhibits and live performances. Check out the entire festival program at [www.rit.edu/imagine](http://www.rit.edu/imagine).

**Save the date:** Can't make it this year? Next year's festival is April 28, 2018.

# R·I·T

**Rochester Institute of Technology**

125 Lomb Memorial Drive  
Rochester, NY 14623-5608  
[www.rit.edu/research](http://www.rit.edu/research)

Nonprofit Org.  
U.S. Postage  
**PAID**  
Rochester, N.Y.  
Permit 626



**Connect**—to RIT’s key corporate partnership groups  
**Research**—opportunities for your products and systems  
**Recruit**—talented RIT students and alumni to work for you

RIT is fueling creativity and innovation for a changing world. And, we enjoy highly collaborative and mutually rewarding partnerships with industry leaders—both big and small—who are doing the same. Whether you want connections to world class faculty to further your business objectives, the opportunity to leverage RIT’s unique skills through joint research projects or the chance to recruit top talent among RIT’s best and brightest students and alumni, let RIT be your partner of choice.

To get started, visit RIT’s Corporate Gateway at [\*\*rit.edu/corporate\*\*](http://rit.edu/corporate)

R·I·T

Rochester Institute of Technology is home to leading creators, entrepreneurs, innovators, and researchers. Founded in 1829, RIT enrolls about 19,000 students in more than 200 career-oriented and professional programs, making it among the largest private universities in the U.S.

The university is internationally recognized and ranked for academic leadership in business, computing, engineering, imaging science, liberal arts, sustainability, and fine and applied arts. RIT also offers unparalleled support services for deaf and hard-of-hearing students. The cooperative education program is one of the oldest and largest in the nation. Global partnerships include campuses in China, Croatia, Dubai, and Kosovo.

### Contact Information

To learn more about research opportunities on campus, contact us directly or through the RIT research website at [\*\*www.rit.edu/research\*\*](http://www.rit.edu/research).

#### Ryne Raffaele

Vice President for Research  
and Associate Provost  
585-475-2055  
[\*\*ryne.raffaele@rit.edu\*\*](mailto:ryne.raffaele@rit.edu)

