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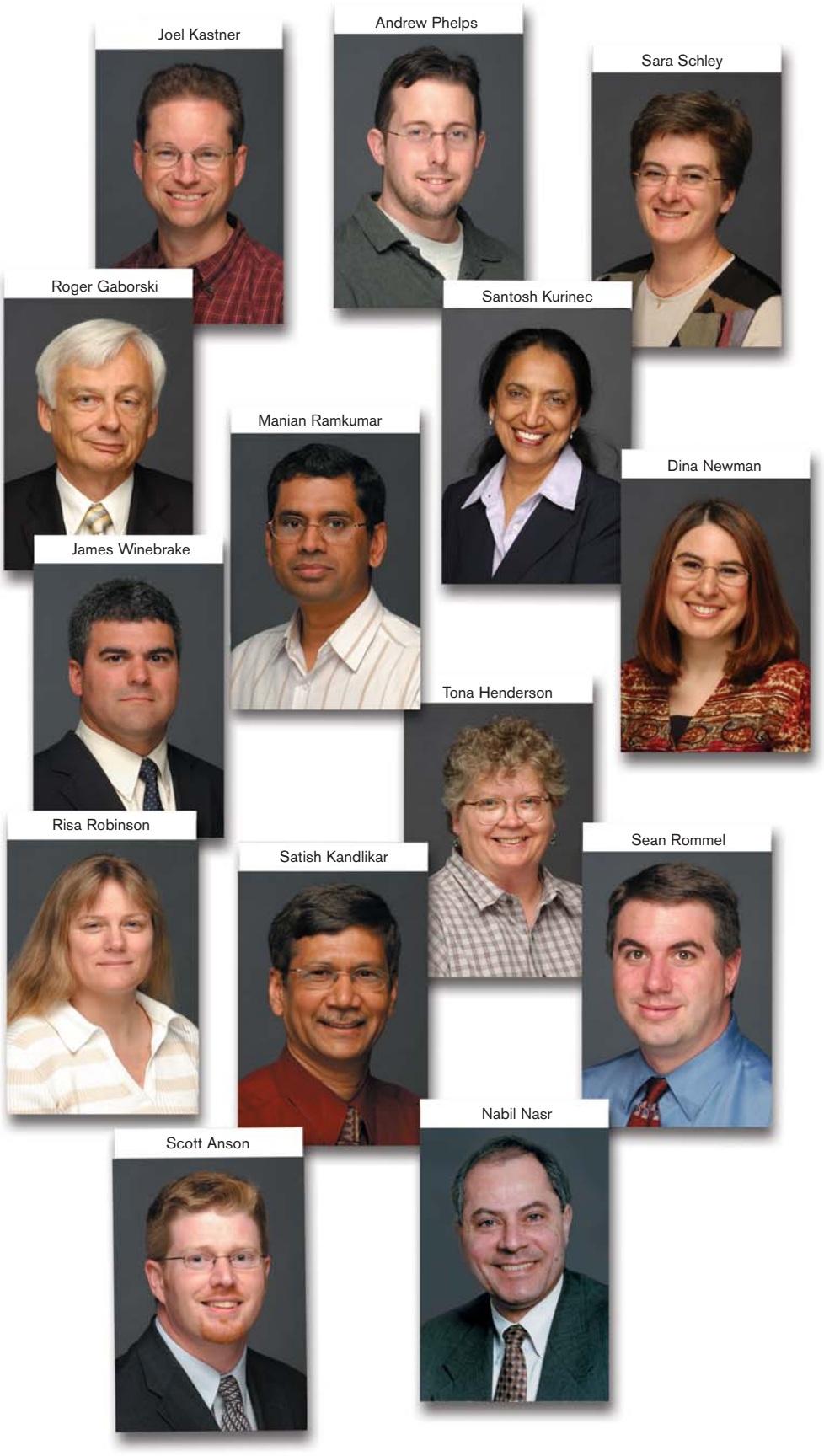
RIT RESEARCH PROGRAMS 2005 ANNUAL REPORT

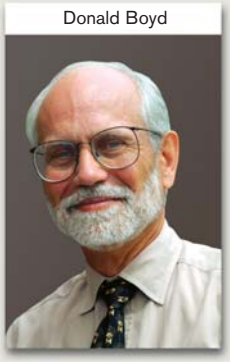
ROCHESTER INSTITUTE OF TECHNOLOGY



Front cover: Ryne Raffaelle in his laboratory

ASSOCIATE PROVOST'S REVIEW

GROWING RESEARCH at RIT



The next chapter in Rochester Institute of Technology's research agenda began this past year with the initiation of the university's new strategic plan, which focuses on student success through a strong integration of teaching and scholarship among all faculty, students, and research staff. The 13 projects featured in this year's report, along with others from the past 20 years of this journey, provide a glimpse into the future of RIT's research and scholarship.

RIT's research journey began in the late '80s with a few pioneers conducting research in imaging science, manufacturing technology, and hearing loss. These pioneers established key programs in remote sensing, color science, print quality, image preservation, remanufacturing, and age-related deafness. Their research came together through new centers and labs such as the Center for Integrated Manufacturing Studies, the Chester F. Carlson Center for Imaging Science (which hosted RIT's first and only Ph.D. program at the time), and the National Technical Institute for the Deaf.

To expand those accomplishments, in 1999, President Albert Simone initiated the First in Class program, with a mission to form research partnerships with industry and government agencies. The program focused on research in six areas where RIT had or could establish technology leadership and create a

continued →

RESEARCH FINANCIAL SUMMARY

← *from inside cover*

positive return for our partners as well as the university. Return to the partner typically included new technical solutions to problems, innovations leading to new products or services, and graduates who were prepared to hit the road running as new employees in these fields. The benefits to RIT have included a major growth in research programs, new academic programs such as our second Ph.D. program in microsystems engineering, new equipment and laboratories, a growing population of research faculty and staff, new research centers, and a significant growth in externally sponsored research.

With the 2004-05 kickoff of the new RIT 10-year strategic plan, a stronger focus on student success and faculty scholarship was added that extends to all programs and faculty. RIT is experiencing a renewed focus on research partnerships, applied research, cross-disciplinary programs, innovation, and entrepreneurship involving both undergraduates and graduates. Our students are learning and gaining experience by applying the latest knowledge, participating in the discovery of new knowledge, developing new technologies, innovating products, creating companies, and finding solutions to problems faced by our industry and government partners.

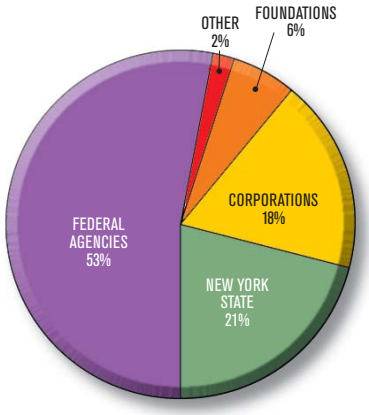
In this year's research report we are spotlighting RIT's Nanopower Research Lab, which is achieving all of the objectives established in the strategic plan. We also highlight cross-disciplinary projects from the newly formed Center for Advancing the Study of Cyberinfrastructure, as well as projects in the genetics of age-related hearing loss, greenhouse gas analysis, multicarcinogen dosimitry, fuel cell sustainability, and success factors for deaf students. An innovative new research program sponsored seven undergraduate student-teams addressing challenges identified by the intelligence community. Astrophysics research grew significantly in 2004-05, as highlighted by Professor Joel Kastner's project to investigate the birth and death of stars. Finally, the growth in micro-systems research is demonstrated in three projects: microfludic chip cooling, quantum and spin-device integration, and delamination phenomena in plastic packages.

These are just a few examples of RIT's growing research programs. The accompanying pie charts summarize the source, purpose, and disciplines of RIT's sponsored research. These charts depict a five-year total of more than $151 million in awards. They show that RIT's source of funds has been shifting to reflect a greater proportion of funding from federal agencies, our grant activity has been increasingly focused on research-oriented projects, and our discipline focus continues to grow in imaging and engineering when compared to recent years.

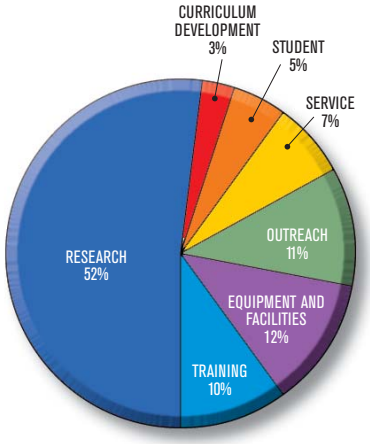
I am happy to say that, overall, RIT's research has seen amazing growth in the last few years, and will continue "to grow with a renewed vigor in "support of the 10-year strategic plan. I encourage you to read on and learn more about these exciting projects.

Best Regards,

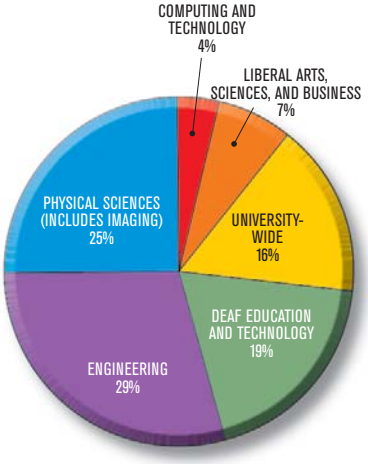
Donald L. Boyd, Ph.D.
Associate Provost for Outreach Programs



SOURCE OF FUNDS



GRANT ACTIVITY BY PURPOSE



GRANT ACTIVITY BY DISCIPLINE

All figures represent a five-year total of awards (2001–05).

RIT RESEARCH PROGRAMS

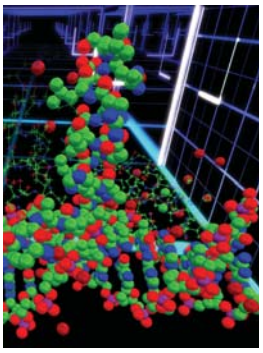
FACULTY RESEARCH AND SCHOLARSHIP

Ryne Raffaelle in the NanoPower Research Laboratories

IN THE SPOTLIGHT: NanoPower Research Laboratories

Ryne Raffaelle, professor of physics and microsystems engineering and director of the Nanopower Research Laboratories (NPRL), has identified nanopower technology as a key enabler of future microsystems applications for space, consumer, health, military, and intelligence. These high specific-power density (power per mass) supplies are a critical component for everything from autonomous homeland security sensors to next-generation biomedical implants.

Graphical Visualization of Complex Systems



The MUPPETS system for molecular visualization

Assistant Professor Andrew Phelps, director of the Laboratory for Graphical Simulation, Visualization, and Virtual Worlds in the B. Thomas Golisano College of Computing and Information Sciences, leads a project titled The Multiuser Programming Pedagogy for Enhancing Traditional Study (MUPPETS). While the project continues to produce a world-renowned virtual-worlds platform for education, the technology also is being adapted for use in several domains, including molecular visualization (in collaboration with RIT's College of Science), game-engine design, and virtual theatre (in collaboration with RIT's College of Imaging Arts and Sciences). MUPPETS provides a graphical visualization of complex systems and their interactions, facilitating development and understanding of these complex systems. This work is partially sponsored by Microsoft Corp. Find out more about the MUPPETS project and our work at http://muppets.rit.edu.

Lifecycle Strategies for Fuel Cells

Developing reverse logistics methods for commercial fuel cells

Led by Dr. Nabil Nasr, director, the Center for Integrated Manufacturing Studies (CIMS) is conducting research on advancing fuel cell life cycle engineering. Using integrated reverse logistics models, the CIMS group aims to make fuel cells that are more inclusive of sustainable attributes, including sustainable design, remanufacturing, resource recovery, and recycling. This research is funded by the United States Environmental Protection Agency to help minimize the potential solid waste and environmental impacts of direct methanol fuel cells (DMFC) in portable electronic product applications. This multistakeholder research effort, titled "Lifecycle Strategies for Direct Methanol Fuel Cells," is helping the industry evaluate life-cycle impacts as well as end-of-life options for DMFC technology, reducing operating costs, improving product performance, and preparing product platforms to be more sustainable in the growing commercial fuel-cell market.

Greenhouse Gas Analysis

Marine transportation is a major source of marine greenhouse gas emissions.

Dr. James Winebrake, chair of the public policy department in the College of Liberal Arts, is leading an effort to study greenhouse gas emissions from ferries and other forms of marine transportation. This work, funded by the U.S. Department of Transportation's Center for Climate Change Research, is the first attempt at quantifying the impact of greenhouse gases and other pollutants from ferries, barges, and ocean-going vessels. One of the key outcomes of this year-long project is the development of a software modeling tool that will calculate emissions from marine vessels, including emissions from the entire fuel pathway (from fuel extraction, production, delivery, and ultimate use in a marine vessel). Results of this study will help officials untangle tricky questions of responsibility for greenhouse gas emissions by attributing emissions to countries on the basis of vessel or fuel use.

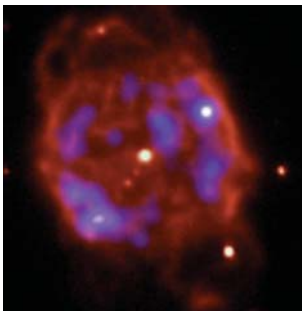
"The NanoPower Research Lab is dedicated to the development of new nanomaterials and nano-enabled devices for power generation and storage at the micro scale." —Ryne Raffaelle

The NPRL was established in 2001 as part of RIT's First In Class initiative to pursue these Nanopower applications. The RIT First in Class strategy is to provide seed funding in those areas in which RIT has built or can build applied research competence for nationally recognized programs sustainable through federal, state, and industry research funding. By enhancing the performance of energy conversion and storage devices through the development of nanomaterials, the NPRL has demonstrated that it is indeed one of these areas. Since its inception, the NPRL has received more than $5 million in support from the National Science Foundation, the Department of Energy, the Defense Advanced Research Projects Agency, and the National Aeronautics and Space Administration. In addition, the NPRL has worked with a number of corporate sponsors including Eastman Kodak Co., BP Solar, Wilson Greatbatch, Ohmcraft, and Alpha V.

The NRPL works on a wide variety of power devices, including solar cells, lithium ion batteries, radioistope batteries, and hydrogen fuel cells. A particular focus of the labs has been the synthesis, characterization, and utilization of new nanomaterials for these devices. Examples of projects under way include higher efficiency fuel cells and higher capacity lithium ion batteries utilizing high-purity, single-wall carbon nanotubes, more efficient photovoltaic solar cells utilizing semi-conducting quantum dots, and longer-life microelectronic radioisotope power sources using intermediate quantum-dot absorbers.

The NPRL prides itself on supporting a large, interdisciplinary group of undergraduate and graduate research students, faculty, and post-doctoral researchers representing more than 16 different academic disciplines. The current team includes

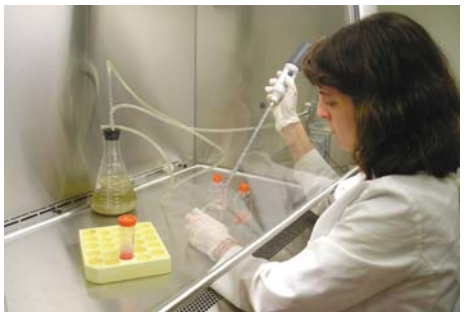
Stellar Life Cycle



Composite X-ray-image of a dying sun-like star

Professor Joel Kastner of the imaging science department in the College of Science studies the very earliest and very last stages in the lives of stars like our sun. To see stars in the process of forming and dying requires imaging capability beyond the realm of visible light, requiring Dr. Kastner and his students to make extensive use of NASA's Chandra X-ray Observatory and Spitzer Space (infrared) Telescope. The revolutionary imaging capabilities of these two observatories make it possible to "peer into the cradle" and study newborn stars and proto-solar systems that remain enshrouded in the gas and dust out of which they formed. On the other end of the stellar life cycle, Dr. Kastner's observations have produced new insight into the surprisingly violent deaths of sun-like stars. This research is funded by NASA, the Smithsonian Astrophysical Observatory, and the National Science Foundation.

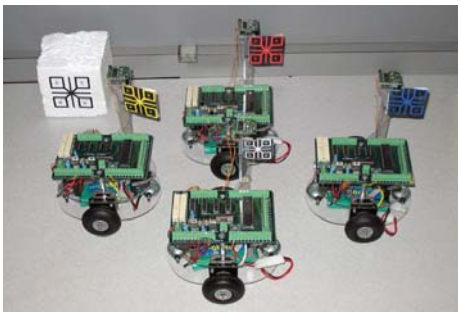
Age-Related Hearing Loss



Researchers extract and sequence mitochondrial DNA

Dr. Dina Newman and her research team in RIT's College of Science are studying the genetics of age-related hearing loss (presbycusis). Most people lose their hearing as they age, but the timing and rate of auditory degeneration is not uniform and tends to run in families. Based on evidence that suggests presbycusis is correlated more with mothers than fathers, the human genetics laboratory at RIT is studying mitochondrial DNA, which is maternally inherited. Volunteer subjects have their hearing extensively tested at RIT's International Center for Hearing and Speech Research, then donate a blood sample for genetic studies. Researchers sequence a portion of each subject's mitochondrial genome in order to construct a genealogical tree and find a branch that contains variations associated with presbycusis.

Intelligence Community Challenges



Autonomous wireless sensing robots

Under a program funded by the Intelligence Technology Innovation Center, Professor Roger S. Gaborski led a group of nine faculty and 17 students from the Colleges of Science, Engineering, and Computing in undergraduate and master's research projects addressing intelligence community supplied challenges. The seven projects selected were carried out as students' master's theses or senior projects, and addressed technology challenges in sensors, robotics, imaging, and secure communications. Results achieved included the development of a robot cluster that can work in a cooperative manner and video algorithms focused on detecting and analyzing novel scenes in video surveillance. The research activities exposed students to current research challenges in the intelligence community and prepared them for future graduate studies or careers in these dynamic technical fields.

undergraduate students in physics, chemistry, mechanical engineering, electrical engineering, and industrial and systems engineering; master's candidates in materials science and imaging science; and doctoral candidates in microsystems engineering and imaging science.

As the NPRL continues to develop new nanomaterials, the opportunity to produce higher-efficiency micropower supplies with additional functionality will correspondingly increase. Researchers in the NPRL believe that the use of nano-materials for power will not only be en-abling to microsystems, but will be the key to large scale future power systems as well.

Laborato

RIT performs applied research in partnership with i

Chester F. Carlson Center for Imaging Science

- Laboratory for Advanced Spectral Sensing
- Laboratory for Image Algorithms and Systems
- Laboratory for Astrophysics and Photonics
- Munsell Color Science Laboratory

Center for Bioscience Education and Technology

- Laboratory for Computational Biology
- Laboratory for Genetics of Human Sensory Loss

Center for Integrated Manufacturing Studies

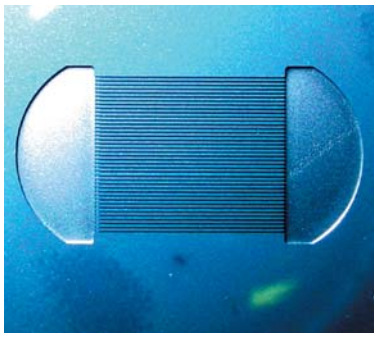
- National Center for Remanufacturing and Resource Recovery
- Systems Modernization and Sustainment Center
- Sustainable Systems Research Center
- Center for Excellence in Lean Enterprise
- Manufacturing Technologies Program
- Imaging Products Laboratory
- Occupational Safety and Ergonomics Excellence Program

Retention of Women in Information Technology

Sara Berg, MSIT graduate student, researches women in IT programs.

Nationwide, participation of women in science and technology has declined precipitously, representing a major problem for future technology growth in the United States. Helping to address this problem are Professors Elizabeth Lawley and Tona Henderson of the Golisano College of Computing and Information Sciences, who have been assessing the retention of women in information technology (IT) programs under a grant from the National Science Foundation. In the first year of the program students at RIT had been interviewed about their experiences in the IT program. In the second year, a national survey of female IT students will be conducted at schools across the country. The outcome of this research will provide a basis for understanding and improving the retention of women in IT programs at RIT and nationally.

Microfluidic Chip Cooling



Microscopic image of microfluidic cooling channels integrated on a computer chip

Dr. Satish G. Kandlikar, Gleason Professor of Mechanical Engineering at RIT, received an IBM Faculty Award for the second consecutive year to conduct research on liquid cooling of next-generation computer chips. To achieve this, microchannels are etched directly on the back side of the computer chip and water is circulated to carry the heat away. This fundamental research is aimed at increasing the cooling rate from around 50 Watts/cm^2 to well over 500 W/cm^2. The chips are fabricated by IBM at their T. J. Watson research center. This work has been conducted at the Thermal Analysis and Microfluidics Laboratory at RIT by Mark Steinke, who successfully defended his doctoral thesis in microsystems engineering this past academic year. Future work in this area will focus on utilizing boiling in these chips.

Quantum and Spin Device Integration Research

Dr. Kurinec, graduate student Stephen Sudirgo, and Dr. Rommel celebrate the successful testing of their RITD-CMOS integrated circuit.

Professor Santosh Kurinec, chair of the microelectronic engineering department at RIT, and Dr. Sean Rommel, who pioneered the development of resonant interband tunnel diodes (RITD) before joining RIT, are researching the integration of silicon-based resonant quantum devices with conventional CMOS. Conducted over the last five years, in collaboration with Ohio State University and the Naval Research Laboratory, the research has resulted in the first integration of molecular beam epitaxy-grown RITD on silicon with a record peak-to-valley current ratio and the first circuit demonstration of a monostable-bistable transition logic element. Success in this work and in another project in on-chip magnetics has led to a new three-year National Science Foundation grant on the integration of spin-based magnetic tunnel junctions with quantum RITD for the next generation of high-density memory applications.

ories and Research Centers at RIT

ndustry and government sponsors in a number of fields through its laboratories and centers:

Microsystems Technology

- NanoPower Research Laboratory
- Semiconductor and Microsystems Fabrication Laboratory
- Center for Electronic Manufacturing and Assembly
- Center for Nanolithography Research
- RF/Analog/Mixed Signal Laboratory
- Thermal Analysis and Microfluidics Laboratory
- Analog Devices Integrated Microsystems Laboratory

National Technical Institute for the Deaf

- International Center for Hearing and Speech Research
- Postsecondary Educational Network International

Multidisciplinary Research Centers

- The IT Collaboratory*
- Center for Quality and Applied Statistics
- ACT Center, Outreach Education and Training
- RIT Venture Creation
- Program for Innovation and Entrepreneurship

** The IT Collaboratory is a NYSTAR designated STAR Center*

Printing and Graphic Media

- Sloan Printing Industry Center
- Printing Applications Laboratory
- Image Permanence Institute

Computing and Information Sciences

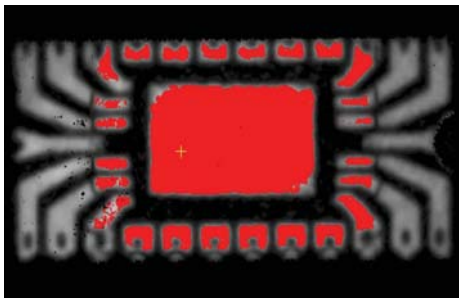
- Center for Advancing the Study of Cyberinfrastructure
  A collection of applied research laboratories addressing:
  - Interaction
  - Infrastructure
  - Informatics

Multicarcinogen Deposition in Teenagers

Hollow cast lung models

Dr. Risa Robinson of the Kate Gleason College of Engineering and colleagues from the University California, Irvine and the University of Oklahoma are evaluating "safer" cigarettes. Using high-resolution computer tomography, anatomically accurate 3-D digitized lung images are created to simulate carcinogen dosimetry in the respiratory tract and construct hollow cast models for experimental measurements. NNKs and PAHs (carcinogens) are measured via liquid chromatograph-tandem mass spectroscopy and high-pressure liquid chromatography, respectively, and utilized in model simulation. These carcinogens present a particular concern for adolescents, whose unique geometries make them more susceptible to retaining large quantities of tobacco smoke. This research will provide quantitative multicarcinogen dosimetry data describing how children's lungs are exposed to carcinogens, and whether safer cigarettes pose a lower risk for these young smokers. This work is sponsored by the American Cancer Society.

Delamination Phenomena in Plastic Packages



Acoustic microscope image of die delamination in a surface-mount electronic component

Professor S. Manian Ramkumar, director of the Center for Electronics Manufacturing and Assembly, and Professor Scott Anson, assistant professor in manufacturing and mechanical engineering technology, carry out research addressing electronic and optoelectronic manufacturing techniques. In a recent industry-sponsored project, they investigated the delamination phenomenon in plastic packages. Delamination is the separation of adjacent, bonded material layers caused by the absorption of moisture during the course of shipping, storage and assembly of packages. This project utilized C-mode scanning acoustic microscopy and cross-sectioning techniques to analyze the delamination defect. As a result of the study, the client was able to address the root cause of the failure and improve assembly yield. The analysis tools employed were acquired through a National Science Foundation grant.

Success Factors for Deaf and Hearing Students

Dr. Schley's research will lead to increased success for hearing-impaired students.

Dr. Sara Schley of RIT's National Technical Institute for the Deaf has won a prestigious National Science Foundation Career Award for her work on the educational and career success of deaf children and their hearing siblings. This research focuses on specific individuals from the National Longitudinal Survey of Youth, a large-scale educational survey of a nationally representative sample of people entering the work force in the late 1960s. Children of the original sample of young women were added in the mid-1980s and followed biennially. Dr. Schley will develop profiles of K-12, college, and work-force success in the deaf and hearing children and young adults from this group. She is also mentoring undergraduate and graduate students in this method of secondary analysis, using previously collected data to extract new data for research purposes.

First in Class

FIRST IN CLASS

First in Class is an RIT strategic initiative to invest in emerging technologies that will provide our partners, students, faculty, and the community with the technology to be successful in a rapidly changing world.

Through First in Class, RIT:

- creates education and research programs in emerging technologies;
- prepares graduates with tools they need for successful careers in these fields;
- supports industrial and government partners with technology, resources, and people they need to remain competitive; and
- fosters economic growth by creating the workforce of the future.

RIT's First in Class concentrations:

- Imaging Science and Systems
- Computing and Information Sciences
- Microsystems Technology
- Sustainable Design
- Biotechnology and Bioinformatics
- Printing and Graphic Media

More information on the First in Class program can be found on our website at www.rit.edu/firstinclass or by contacting:

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RIT at a Glance

- Founded in 1829 and emphasizing career education, RIT is a privately endowed, coeducational university.
- The campus occupies 1,350 acres in suburban Rochester, New York.
- The RIT student body consists of more than 15,000 full- and part-time undergraduate and graduate students in 360 career-oriented programs
- Enrolled students represent all 50 states and 90 countries.
- RIT alumni number more than 95,000 worldwide.
- Cooperative education provides career-related work experience in many degree programs, annually placing over 4,000 students in co-op positions with 1,300 employers.

RIT's eight colleges:

- College of Applied Science and Technology
- College of Business
- Kate Gleason College of Engineering
- B. Thomas Golisano College of Computing and Information Sciences
- College of Imaging Arts and Sciences
- College of Liberal Arts
- National Technical Institute for the Deaf
- College of Science

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