

## New Doctoral Program in Microsystems Engineering

Mustafa A.G. Abushagur, Harvey J. Palmer

**Kate Gleason College of Engineering**  
**Rochester Institute of Technology**  
Rochester, NY 14623  
[maaeen@rit.edu](mailto:maaeen@rit.edu)

### Abstract

This paper describes the new doctoral program in Microsystems Engineering in the Kate Gleason College of Engineering at the Rochester Institute of Technology. The program is intended to address the need for training engineers and researchers in the emerging fields of microsystems and nanotechnology. The program is designed to cater to incoming students with diverse backgrounds, to prepare the students for new challenges in the workplace, and to provide a curriculum with strong multidisciplinary foundation that can evolve with changing technology. The new curriculum consists of a set of core courses and several focus research areas. It provides students with extensive hands-on experience, a comprehensive experience in teamwork and technical communication, and the opportunity to exercise and develop their creativity and innovation.

### I. Introduction

The integration of entire systems into micron scale devices and the sensing technology to interface these devices to the real world is and will be core disciplines required for next generation technology. Within the past decade, microsystems (micro-optical, micro-electrical, and micro-mechanical systems) have emerged as a critical technology worldwide. A microsystem is an ensemble of integrated components, the functionality of which derives from micron-size (or smaller) elements that collectively perform mechanical, electrical, optical, logical, and even biological functions. Microsystems technology will integrate small computer chips with tiny sensors, probes, lasers, and actuators to allow the chip to sense, analyze, and communicate. It is an enabling technology that will add functionality and reduce cost in many product applications, particularly in the areas of telecommunications, imaging, electronics and biomedical diagnostics and treatment. In short, micro-scale devices and systems will be smaller, faster, cheaper, and more reliable than their macroscopic counterparts.

The need within the international scientific and engineering communities for engineers trained in microsystems has prompted Rochester Institute of Technology to combine resources and create the Doctoral Program in Microsystems Engineering. The educational program prepares students and future engineers and researchers with the scientific and engineering foundations and skills required to fill-in the gap in the market place. This multidisciplinary degree provides the student with a fundamental background in sciences

and engineering which should prepare the student for a successful career. Rochester Institute of Technology offers a unique educational and research program that leads to a Ph.D. in Microsystems Engineering. This multi-disciplinary program builds on the strengths in microelectronic fabrications, photonics, imaging and micro-power research programs at the institute. The program is designed to be application oriented without sacrificing the scientific and engineering fundamentals. Students will be involved in cutting edge research and have access to modern facility, the largest of its kind in any academic institution. The program is designed for students with excellent preparation in the physical sciences and engineering and implemented by a multidisciplinary faculty sharing resources and expertise

## II. Curriculum Structure

The Ph.D. program is multidisciplinary in nature building on diverse fields in science and engineering. The students targeted come from several disciplines. The goal of the curriculum is to prepare the students to have a common scientific and engineering background as well as depth in a specific area. This requirement will be developed through a core curriculum and a set of selective elective courses. A key objective of the core curriculum is to provide students with the requisite knowledge base to be versatile, productive researchers and problem-solvers in the multi-disciplinary area of microsystems engineering. The broad range of scientific and engineering principles covered in the core curriculum is a significant strength of the proposed program, distinguishing it from traditional Ph.D. degree programs that specialize in a conventional engineering discipline. Almost exclusively, these other programs reside within traditional disciplines. Therefore, they do not have the explicit, multi-disciplinary focus of the Ph.D. program being introduced in this paper. Also, because the faculty members in these other programs reside in traditional departments that grant discipline-specific Ph.D. degrees, the incentive for these faculty to foster a fully multi-disciplinary curriculum and culture is substantially less than at RIT where no such discipline-specific Ph.D. degree programs exist.

A further strength of the core curriculum is the systems engineering focus. Industry need graduates who are not only have mastered the complex elements of their discipline but also understand how to bring together all of the various components of a complex device or product into a functional system that is manufacturable and will work reliably and efficiently.

In summary, as an outcome of the core curriculum, the graduates from the proposed Ph.D. program will have a background and a set of educational experiences that will be distinctive, unique, and marketable. Furthermore, the faculty and students in the program will be better equipped to contribute to technological innovations that require a multi-disciplinary team and a systems-oriented perspective. The expectation is that the program can capitalize on this uniqueness and compete aggressively and successfully against well-established research universities for research funding in many venues.

A total of 92 quarter credit hours of graduate course work are required of which 36 quarter credit hours are in designated microsystems core courses. 32 quarter credit hours elective courses in one or two specialized areas will be required. An additional 24 quarter credit hours (minimum) are expected in dissertation research. Students are also required

to complete three quarters of Seminar (1 credit per semester). An overall B average must be maintained to stay in the microsystems engineering program. In addition all requirements of the graduate enrollment must be met to remain in good standing. The program will constitute three phases:

**Phase I:** In this phase the student is required to take nine core courses. In order to complete this phase of the program and continue to the focus area; the student must pass the Preliminary Examination that is based on these core courses (only two attempts will be allowed).

**Phase II:** Phase II consists of course work in the program of study (which includes a Focus Area). Much of this course work will support the dissertation research to be conducted in Phase III. This phase will be completed when the student has finished most of the formal course work as prescribed in the program of study and by passing the Qualifying Examination.

**Phase III:** Phase III consists of all experimental and/or theoretical work needed to complete the student's dissertation. The students' advisor will supervise these activities. The Final Examination will consist of a public, oral presentation and defense of the dissertation.

### III. Courses

The core curriculum has three key elements: the scientific principles of micro-scale systems; the fundamentals of systems engineering; and the design and fabrication of micro-scale devices.

#### *Scientific Principles of Micro-Scale Systems*

- Fundamentals of Material Science
- Nanoscale Physics and Chemistry
- Advanced Math Elective

#### *Fundamentals of Systems Engineering*

- Systems Engineering
- Engineering Mechanics for Microsystems
- Micro-Optics and Photonics

#### *Design and Fabrication of Microsystems*

- Fundamentals of Integrated Systems
- Microelectronics Processing
- Microsystems Design and Packaging

A course grid for a typical student who enters the program with a B.S. degree is presented in Table 1. For students whose research is primarily in engineering (eg., supervised by an engineering faculty member), it is anticipated that the vast majority of their elective courses will be selected from among the many graduate level courses offered routinely in the College of Engineering (although there is no requirement of this nature in the program). Alternatively, for those students whose research is supervised by a faculty member in the College of Science, it is expected that the vast majority of elective courses will be selected from among the graduate course offerings in the College of Science.

**Table 1. Course Grid for a Typical Student in the Program**

**First Year**

<b>Fall Term</b>	<b>Winter Term</b>	<b>Spring Term</b>
Fundamentals of Integrated Systems (4 credits) Advanced Mathematics Elective (4 credits) Technical Elective (4 cr) Introduction to Research (1 cr) Research Seminar (0 cr)	Systems Engineering (4 credits) Microelectronics Processing (4 credits) Technical Elective (4 cr) Introduction to Research (1 cr) Research Seminar (0 cr)	Engineering Mechanics for Microsystems (4 credits) Micro-Optics and Photonics (4 credits) Technical Elective (4 cr) Introduction to Research (1 cr) Research Seminar (0 cr)

**Second Year**

<b>Fall Term</b>	<b>Winter Term</b>	<b>Spring Term</b>
Fund. of Materials Science (4 credits) Technical Elective (4 cr) Doctoral Research (4 cr) Research Seminar (0 cr)	Nanoscale Physics & Chemistry (4 credits) Technical Elective (4 cr) Doctoral Research (4 cr) Research Seminar (0 cr)	Microsystems Design and Packaging (4 credits) Technical Elective (4 cr) Doctoral Research (4 cr) Research Seminar (0 cr)

Many of these courses have laboratory elements in to provide the students with hands-on experience. RIT has an extensive clean-room equipped with state of the art CMOS, microelectromechanical systems and microsystems fabrication and testing equipment.

**IV. Conclusion**

Rochester Institute of Technology is introducing a novel program in the education of future engineers in the critical area of nanotechnology and microsystems. There is critical national need for future engineers and researchers in vital new technology. The curriculum reflects the interdisciplinary nature of the program. RIT builds on its experience in multidisciplinary program such as its Ph.D. in Image Sciences.