Microelectronics – Photonics (MEPH)

Faculty
Simon S. Ang, Professor
Juan Carlos Balda, University Professor
Salvador Barraza-Lopez, Assistant Professor
Ed Beam, Adjunct NANO Institute Scientist
Robert R. Beitle Jr., Professor
Laurent Bellaiche, Professor
Mourad Benamara, Assistant Professor
Jingyi Chen, Assistant Professor
Russell DePriest, Adjunct Assistant Professor
Magda O. El-Shenawee, Professor
Ron Foster, Adjunct Assistant Professor
Ingrid Fritsch, Professor
Huaxiang Fu, Associate Professor
Dorel Guzun, NANO Institute Scientist
Michael E. Hawkridge, Assistant Professor
Joseph Herzog, Visting Assistant Professor
Jamie A. Hestekin, Associate Professor
Colin David Heyes, Assistant Professor
Po-Hao Adam Huang, Associate Professor
Sha Jin, Assistant Professor
Jin-Woo Kim, Professor
Jerzy Krasinsky, Adjunct Professor (Oklahoma State University)
Vasyl Kunets, NANO Institute Scientist
Jiali Li, Associate Professor
Yanbin Li, Professor
Alex Lestetter, Adjunct Assistant Professor
Ajay P. Malshe, Distinguished Professor, Twenty-First Century Chair of Materials, Manufacturing and Integrated Systems
Omar Manasreh, Professor
Alan Mantooth, Distinguished Professor, Twenty-First Century Chair in Mixed-Signal IC Design and CAD
Mansour Mortazavi, Adjunct Professor (University of Arkansas at Pine Bluff)
Timothy J. Muldoon, Assistant Professor
Hameed A. Naseem, Professor
William Oliver III, Associate Professor
Errol Porter, Research Associate
Donald K. Roper, Associate Professor
Gregory J. Salamo, Distinguished Professor
R. Panneer Selvam, University Professor
Shannon Servoss, Assistant Professor
Woodrow L. Shew, Assistant Professor
Surendra P. Singh, Professor
Douglas E. Spearot, Associate Professor
Julie A. Stenken, Professor
Jak Tchakhalian, Associate Professor
Ryan Tian, Associate Professor
Steve Tung, Professor
Rick Ulrich, Professor
Vijay K. Varadan, Distinguished Professor, Twenty-First Century Endowed Chair in Nano- and Bio-Technologies and Medicine
Ken Vickers, Research Professor
Morgan Ware, NANO Institute Scientist
Uchechukwu C. Wejinya, Assistant Professor
Min Xiao, Distinguished Professor

Kaiming Ye, Professor
Min Zou, Professor

Ken Vickers
Program Chair
103 Nanoscale Material Science and Engineering Building
479-575-2875
E-mail: microEP@cavern.uark.edu

http://microEP.uark.edu/

Degrees Conferred:
M.S., Ph.D. in Microelectronics-Photonics (MEPH)

This multidisciplinary program prepares students for careers in the development and manufacturing of micro- to nanoscale materials, processing, and devices in such industries as biosensing, photonics, telecommunications, microelectronics, and MEMs. Typical students in this program will be full-time students residing on campus, but provisions may be made to support remotely located part-time students already engaged in professional careers.

Philosophy of Graduate Education: All entering graduate students from June 1 through May 31 of the following year are formed into a Cohort. Cohort members form a natural work group during their first twenty-four months of graduate school, and the Cohort receives training in how to effectively apply their academic knowledge in professional group environments such as research- or teaching-based academic departments, large governmental research labs, or industrial settings. The Cohort training also fosters a supportive graduate community atmosphere that enhances the likelihood of academic success of all the program's graduate students.

The techniques used for this training have been developed at the University of Arkansas under the financial sponsorship of the NSF Integrative Graduate Education and Research Training (IGERT) program, and the Department of Education’s Fund for Improvement of Post Secondary Education (FIPSE) program. Through these methods, our graduate students exit our degree programs with the equivalent of one and a half years of on-the-job training in management techniques useful in a technology-based professional career setting.

Prerequisites to Degree Program: Applicants to the program must satisfy the requirements of the Graduate School as described in this catalog and have the approval of the Graduate Studies Committee of the Microelectronics-Photonics program (GSCMEP).

Candidates typically have completed a Bachelor of Science degree in either engineering or science, and candidates’ academic backgrounds will be evaluated by the GSCMep for suitability to the graduate program. To be admitted to graduate study in Microelectronics-Photonics (microEP) without deficiency, candidates are required to have completed a math course sequence through differential equations, a calculus-based physics course sequence through introduction to quantum mechanics, and an introduction to electricity and magnetism or electronic circuits. Other undergraduate deficiencies may be identified during the evaluation process, and degree completion will be contingent on successful completion of these identified deficiencies.

Prospective students from foreign countries in which English is not the native language must submit nationally recognized standardized testing results on written English proficiency for consideration by the Graduate School during the admission process. Students may be given conditional admittance pending demonstration of English language skills
in appropriate courses at the University of Arkansas. Students wishing to apply for graduate assistantships that require direct contact with students in a teaching or tutorial role must meet the Graduate School’s English Language proficiency test requirements for such GA positions.

Requirements for the Master of Science Degree: Students choosing this degree program will be assigned an initial adviser upon acceptance to the program. This adviser will be their Cohort Manager during that academic year. Students will work with the Director of the Microelectronics-Photonics program to define their M.S. path to best support their career goals after graduation, with three curricula paths available to Microelectronics-Photonics students:

- **Non-thesis path:** Students who are funded by personal resources or by graduate assistantships not associated with research or educational grants may complete an M.S. degree with additional course work in place of independent research. While there may be specific narrow career options where this is an appropriate path, the Microelectronics-Photonics program strongly recommends the Professional or Academic paths as providing a much better overall career preparation for working in a technical position. Students completing this path cannot be accepted for the Ph.D. Microelectronics-Photonics program.

- **Professional path:** Students who plan to enter the technical marketplace after M.S. completion will find this path most beneficial as it requires independent graduate-level research in collaboration with an external technical organization. The research may be in the form of a traditional M.S. six-hour research topic and thesis, or may instead be in the form of two three-hour independent research efforts resulting in written reports with the clarity, style, analysis, and conclusions expected of a journal paper submission. Both the thesis and the written reports will be orally defended before the appropriate student committee. Students in this path will also be required to complete at least one internship of at least six weeks duration to experience a non-academic technical environment. Students completing this path may be considered by the GSCMEP for admission to the Ph.D. Microelectronics-Photonics program based on the strength of their academic course grades, their independent research depth, and the quality of the written research document.

- **Academic path:** Students who plan to complete an academic campus-based research thesis will take this path, although the research topic may include funding and collaboration with outside technical organizations. Students who complete all requirements for M.S. graduation, including an independent research project and thesis acceptable to their thesis committee, will be eligible without GSCMEP review for admission to the Ph.D. Microelectronics-Photonics program.

Students will form either a theses committee or an advisory committee after they have chosen their M.S. path, defined any independent research areas, and been accepted into a research group if appropriate. A thesis committee will be made up of at least three faculty members, with at least one faculty member each from the Fulbright College of Arts and Sciences and the College of Engineering (the student’s research professor will chair the thesis committee). The advisory committee will include at least one GSCMEP member, the supervising faculty member for a research experience, and the student’s cohort leader. If the student is in the Professional path, then either committee must also include at least one technical professional from the partner external organization as an adjunct faculty member or an ex officio committee member.

Students in this degree program can choose an Academic path, a Professional path, or a Non-thesis path. The course hours to meet the minimum requirements for each paths are as follows:

<table>
<thead>
<tr>
<th>Subject Area</th>
<th>Academic Path/Hours</th>
<th>Professional Path/Hours</th>
<th>Non-Thesis Path/Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Engineering</td>
<td>9</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>MEPH 5383 Research Commercialization</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>MEPH 5811/5911/6811/6 Open Seminar</td>
<td>&gt;=3</td>
<td>&gt;=3</td>
<td>&gt;=3</td>
</tr>
<tr>
<td>MEPH 5821 Ethics In Ph.D. Curriculum</td>
<td>1</td>
<td>Recommended</td>
<td></td>
</tr>
<tr>
<td>MEPH 5832 Proposal Writing and Management In Ph.D. Curriculum</td>
<td>Recommended</td>
<td>Recommended</td>
<td></td>
</tr>
<tr>
<td>Technical Elective</td>
<td>6</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>DEPT 600V Research Thesis</td>
<td>6</td>
<td>(Option) 6</td>
<td>0</td>
</tr>
<tr>
<td>MEPH 5513 Proposed External Research</td>
<td>Not Available</td>
<td>(Or Option) 3 + 3</td>
<td>Not Available</td>
</tr>
<tr>
<td>MEPH 5523 Applied Internal Research</td>
<td>Not Available</td>
<td>(Or Option) 3 + 3</td>
<td>Not Available</td>
</tr>
<tr>
<td>MEPH 588V Independent Project</td>
<td>Not Available</td>
<td>Not Available</td>
<td>(&lt;=3 as technical elective)</td>
</tr>
<tr>
<td>MEPH 555V External Technical Internship Recommended in 1 &lt;=V &lt;=3</td>
<td>Not Available</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If a University of Arkansas undergraduate student is pursuing a Bachelor of Science degree in a department that has implemented an accelerated B.S./M.S. program (typically allowing six hours of graduate-level course work to be shared between the two degrees), the student may implement the same acceleration for a B.S. departmental degree/ M.S. Microelectronics-Photonics degree set. Both the undergraduate department and the Microelectronics-Photonics program Director must approve the shared courses prior to enrollment.

Each student’s curriculum must also address a need for a focus field. Each student completing a Microelectronics-Photonics degree must define a curriculum containing the following core requirements in the focus field to cover five aspects of micro- to nanoscale materials and devices. In the Applications aspect, every student must complete ELEG 4203 Semiconductor Devices (Irregular). In the Materials aspect, students must take at least one course emphasizing the nature of the materials applied in their chosen focus field. In the Fabrication aspect, students must take at least one course emphasizing the theory of micro- or nanoscale fabrication in their focus field. In the Fabrication Practice aspect, all students are highly encouraged to complete at least one course containing hands-on laboratory fabrication experience. In the Management of Technology aspect, every student must complete MEPH 5383 Research Commercialization and Product Development (Sp).

The Graduate Handbook of the Microelectronics-Photonics Graduate Program will contain a current list of approved courses in each of these areas that will allow students to optimize their curriculum within their focus
field. Students may choose a course not listed in the handbook to fill an aspect’s required course with the permission of their thesis committee and the Microelectronics-Photonics Director. Students who have acquired the knowledge contained in these courses through prior education may petition the Microelectronics-Photonics program Director for permission to substitute other classes for these core courses.

Additional core courses to develop operations management skills also have been defined for Microelectronics-Photonics students. During year one of their graduate studies at the University of Arkansas, students are required to take MEPH 5811 1st Year Operations Seminar - Infrastructure Management (Fa) and MEPH 5911 1st Year Operations Seminar - Personnel Management (Sp) in the fall and spring semesters and MEPH 5821 Ethics for Scientists and Engineers (Su) in their first summer. During year two, students are required to take MEPH 6811 and MEPH 6911 Operations Management Seminars in both fall and spring semesters and MEPH 5832 Proposal Writing and Management (Su) in their second summer. In addition, all cohort members participate in two days of industrial-style inventiveness and team training during the week directly preceding the start of fall classes. Three to five of these seven credit hours may be used in M.S. curricula, shown in the table, and the remaining credit hours may be applied as Ph.D.-level technical electives.

Students are required to attend monthly Microelectronics-Photonics Research Communication Seminars during the first three semesters of their M.S. degree program, and will enroll in MEPH 5611 Research Communication Seminar of MS Students (Sp, Fa) in their third semester.

Research thesis hours will be chosen from the department of the student’s research adviser (e.g., PHYS 600V, ELEG 600V, etc.) and will require a written thesis successfully defended in a comprehensive oral exam given by the thesis committee.

A research thesis is required for Academic path students, and is optional for Professional path students. Professional path thesis research must include direct collaboration with an external technical organization.

A student in the Professional path may substitute two Applied Research efforts for a thesis under MEPH 5513 (External location) or MEPH 5523 (Internal on-campus location), provided each semester’s research is of graduate-level quality and is reported at the end of the semester through a written paper and in an oral presentation to the advisory committee (note that the written paper must match the clarity, style, analysis, and conclusions expected of a journal paper submission). Regardless of where the research is performed, it must include direct collaboration with an external technical organization.

Independent project hours in support of the Non-thesis path may be either MEPH 598V Special Problems in Microelectronics-Photonics (Irregular) or a departmental Special Problems course number, and will require a written project report modeled after a professional journal submission that is then defended in a comprehensive oral exam given by the advisory committee.

If a student is taking either a special problems independent study course (such as MEPH 588V) or a special topics course (such as MEPH 587V) to meet partial requirements for their M.S. degree, then the instructor must supply the Microelectronics-Photonics program office with a syllabus of that class to be included in their program records. They syllabus must include at least the course title, semester, instructor name, a list of specific course objectives, sources of content knowledge, and method by which the student’s mastery of the learning objectives is demonstrated.

Each student is required to enroll in at least one hour of course work each fall and spring semester until the M.S. degree is issued. If all required course work has been completed, the student may enroll in one hour of master’s thesis, or in one hour of a special problems course for credit only.

Requirements for the Doctor of Philosophy Degree: Students choosing this degree program will be assigned an initial adviser upon acceptance to the program. This adviser will be their Cohort Manager during that academic year. Students will work with the Director of the Microelectronics-Photonics program to define their dissertation committee after they are accepted by a research faculty for a research project. This committee will be made up of at least four faculty members, with at least one faculty member each from the Fulbright College of Arts and Sciences and the College of Engineering. The student’s research professor will chair the dissertation committee.

Candidates for the Ph.D. program are expected to have completed a Master of Science degree in either engineering or science, with each candidate’s academic background being evaluated by the GSCMEP. Doctoral candidates in Microelectronics-Photonics are expected to have proficiency in the core curriculum of the Master of Science in Microelectronics-Photonics at the University of Arkansas. This core is described in detail above and in the handbook of the Microelectronics-Photonics program and is the knowledge that will be tested in the Microelectronics-Photonics specific candidacy exam administered in the spring semester of each academic year.

Students who have graduated with a Master of Science degree in Microelectronics-Photonics from the University of Arkansas will be expected to take the Microelectronics-Photonics written Ph.D. candidacy exam in the spring semester after M.S. graduation. Students requesting admission to the Ph.D. program with a Master of Science degree in another discipline will be required to take the Microelectronics-Photonics written Ph.D. candidacy exam within four semesters after M.S. graduation, but not before completing MEPH 5911 1st Year Operations Seminar - Personnel Management (Sp) and MEPH 5383 Research Commercialization and Product Development (Sp).

A second part of the candidacy exam, a detailed Ph.D. research proposal, must be presented to the student’s committee prior to substantive work being performed in the research area. This research proposal is not linked to the written candidacy exam and may be presented to the committee when appropriate.

Students who fail to pass their written candidacy exam will have a joint consultation with their major professor and their Cohort Manager to formulate a specific action plan to correct student deficiencies identified by the exam. The student will be allowed to retake the written exam only one additional time, which must be during the next scheduled written examination period.

A Ph.D. curriculum will be defined to meet each student’s research interests as well as the Microelectronics-Photonics program’s interest in course breadth. It is to be expected that certain Master of Science degrees will be poorer matches to the Microelectronics-Photonics program focus areas and will therefore require a greater number of graduate courses in the Ph.D. curriculum as a requirement for graduation.

The course plan for each student must include a minimum of 27 hours of graduate coursework beyond the Master of Science degree requirements. Specific courses will be chosen by the student and must be approved by the student’s doctoral advisory committee. The coursework list for the Ph.D. degree will then be combined with the courses completed during
the student’s Master of Science studies to assure that the combined course list includes:

1. at least 27 hours of 5000- and 6000-level courses in science and engineering,
2. at least six hours of courses relevant to the management of technology,
3. no more than six hours of special problems and no more than nine hours of special topics courses,
4. and no more than four hours of:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEPH 5811</td>
<td>1st Year Operations Seminar - Infrastructure Management (Fa)</td>
<td>1</td>
</tr>
<tr>
<td>MEPH 5911</td>
<td>1st Year Operations Seminar - Personnel Management (Sp)</td>
<td>1</td>
</tr>
<tr>
<td>MEPH 6811</td>
<td>2nd Year Operations Seminar - Management and Leadership (Fa)</td>
<td>1</td>
</tr>
<tr>
<td>MEPH 5821</td>
<td>Ethics for Scientists and Engineers (Su)</td>
<td>1</td>
</tr>
<tr>
<td>MEPH 5832</td>
<td>Proposal Writing and Management (Su)</td>
<td>2</td>
</tr>
</tbody>
</table>

If a student is taking either a special problems independent study course (such as MEPH 588V) or a special topics course (such as MEPH 587V) to meet partial requirements for their Ph.D. degree, then the instructor must supply the Microelectronics-Photonics program office with a syllabus of that class to be included in their program records. The syllabus must include at least the course title, semester, instructor name, a list of specific course objectives, sources of content knowledge, and method by which the student’s mastery of the learning objectives is demonstrated.

Students are required to attend monthly Microelectronics-Photonics Research Communication Seminars during the first five semesters of their Ph.D. degree program, and will enroll in MEPH 6611 Research Communication Seminar of PhD Students (Sp, Fa) in their fifth semester.

In addition to these conditions, the 21 hours of research dissertation will be taken under departmental course numbers such as PHYS 700V, CHEG 700V, CHEM 700V, ELEG 700V, etc. as appropriate to match to the department of each student’s major research professor. The dissertation format must meet all Graduate School published guidelines and the Microelectronics-Photonics guidelines as listed in the Microelectronics-Photonics Graduate Student Handbook. A Ph.D. candidate wishing to use a compilation of published papers for the dissertation must receive explicit permission from the GSCMEP to use this style dissertation at least six months prior to his or her dissertation defense, with a meeting between the student’s committee chair and the GSCMEP required before permission can be granted.