From:	Smith, Randy
To:	Anderson, Betty Lise; Shanker, Balasubramaniam
Cc:	Andridge, Rebecca; Reed, Katie; Smith, Randy; Miriti, Maria; Orr, James; Duffy, Lisa; Quinzon-Bonello, Rosario; Tomasko, David
Subject:	Proposal to establish a 3a and 3b Graduate Certificate in Semiconductor Devices
Date:	Friday, May 19, 2023 2:44:01 PM
Attachments:	image001.png

Betty Lise and Shanker:

The proposal from the Department of Electrical and Computer Engineering to establish a 3a and 3b Graduate Certificate in Semiconductor Devices was reviewed by the Council on Academic Affairs at its meeting on May 16, 2023, and electronically approved by the Council on May 19, 2023. Thank you for attending the meeting to respond to questions/comments.

No additional level of internal approval is necessary. This action will be included in the Council's next Annual Activities Report to the University Senate (July 2023).

The Office of the University Registrar will work you with any implementation issues.

Please keep a copy of this message for your file on the proposal and I will do the same for the file in the Office of Academic Affairs.

If you have any questions please contact the Chair of the Council, Professor Rebecca Andridge (.1) or me.

Randy

THE OHIO STATE UNIVERSITY

W. Randy Smith, Ph.D.
Vice Provost for Academic Programs
Office of Academic Affairs
203 Bricker Hall, 190 North Oval Mall, Columbus, OH 43210
614-292-5881 Office
smith.70@osu.edu

From:	Carpenter, TJ
To:	Reed, Katie
Cc:	Miriti, Maria; Anderson, Betty Lise; Quinzon-Bonello, Rosario
Subject:	Graduate Certificate in Semiconductor Devices
Date:	Tuesday, April 11, 2023 2:54:53 PM
Attachments:	Graduate Embedded Certificate in Semiconductor Devices Rev 1.pdf image001.png Academic (Stand-Alone) Graduate Certification in Semiconductor Devices Rev 1.pdf

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Katie,

Please find two proposals attached from the Department of Electrical and Computer Engineering in the College of Engineering to establish a 3A and 3B Graduate Certificate in Semiconductor Devices.

The Department of Electrical and Computer Engineering in the College of Engineering is proposing to establish a 3A and 3B graduate certificate in semiconductor devices. The development of this certificate is engaged by the anticipated opening of semiconductor fabrication lines in central Ohio by Intel and nationwide by several semiconductor companies is expected to stimulate much interest in students and professionals acquiring skills in semiconductor devices, device physics, fabrication, and electronics. The goal is to provide a mechanism for working professionals and current students in engineering, math, and the physical sciences to demonstrate competency in semiconductor devices to potential employers. These certificates will be comprised of 12 credit hours with one required course and the remaining 9 credit hours to be chosen from a list of electives and will delivered in-person with a laboratory component.

This proposal has been reviewed and approved by the combined GS/CAA subcommittee and Graduate Council. The contacts for the proposal are cc'd on this email.

Please let me know if you need additional information to add this proposal to the agenda of the upcoming CAA meeting.

THE OHIO STATE UNIVERSITY
GRADUATE SCHOOL

Dr. Maria N. Miriti
Professor, Dept. of Evolution, Ecology, and Organismal Biology
Interim Associate Dean of Academic Affairs, Graduate School
Carole A. Anderson Faculty Fellow, OSU Office of Academic Affairs
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Pronouns: He/Him/His

TO: Randy Smith, Vice Provost for Academic Programs

FROM: Graduate School Curriculum Services

DATE: April 11, 2023

RE: Proposal to establish a new 3A Graduate Certificate in Semiconductor Devices in the Department of Electrical and Computer Engineering in the College of Engineering

The Department of Electrical and Computer Engineering in the College of Engineering is proposing to establish a new 3A Graduate Certificate in Semiconductor Devices.

The proposal was received by the Graduate School on February 24, 2023. The combined GS/CAA subcommittee first reviewed the proposal on March 20, 2023, and recommended it for approval by the Graduate Council. The proposal was approved by the Graduate Council on April 4, 2023, pending the addition of a clarification memo. The memo was received from the program on April 6, 2023.

THE OHIO STATE UNIVERSITY

Department of Electrical and Computer Engineering

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MEMORANDUM

Date: April 5, 2023

To: Dr. Maria N. Miriti, Randy Smith

Re: Clarification on overlap rules for stacking ECE Certificates

Dear Dr. Miriti,

The Department of Electrical and Computer Engineering has recently submitted proposals for three graduate certificates, plus two undergraduate minors and two undergraduate certificates. They are listed below for completeness. The purpose of this memo is to clarify the requirements should a student decide to do more than one certificate (stacking).

CERTIFICATES:

Undergraduate Embedded Certificates:
Undergraduate (embedded) certificate in Semiconductor Devices (13 credits).
Undergraduate (embedded) certificate in Signal Processing (15 credits).
(Minors in Semiconductor Devices and Signal Processing are also being proposed)

Embedded graduate Certificates:
There are three pairs, each pair containing one graduate embedded certificate and one stand-alone graduate certificate. The proposals in each pair are the same in terms of requirements, courses etc.

Graduate Embedded Certificate in Semiconductor Devices (13 credits)
Graduate Embedded Certificate in Semiconductor Fabrication Technology (13 credits)
Graduate Embedded Certificate in Semiconductor Optoelectronics (12 credits)

Academic Stand-alone Graduate Certificate in Semiconductor Devices (13 credits)
Academic Stand-alone Graduate Certificate in Semiconductor Fabrication Technology (13 credits)
Academic Stand-alone Graduate Certificate Semiconductor Optoelectronics (12 credits)

The ones that are 13 credits require a 4-credit lab and three 3-credit courses. The 12-credit ones allow for four 3-credit classes.

Overlap for stacking:
For stacking, there are multiple scenarios:

1) A graduate student desires to obtain more than one certificate.
    a. Embedded: In this case, for Certificate 1, the student would take 12 or 13 credits (depending on the certificate), and could count up to six of those credits toward their graduate degree. For Certificate 2, we propose allow them to count up to 6 credits (overlapping from the degree) toward the

second Certificate; thus to get the second one they would take an additional two unique courses.

b. Stand-alone:
    i. If the student has no prior degree from OSU, then for Certificate 1 they would take four courses. ("All courses applied to the Certificates but be taken at OSU.") For Certificate 2, they could double-count two of those courses toward the second Certificate. If they have taken similar courses somewhere else, we would waive the duplicate course and have them an additional course from the pick-list.
    ii. If they had a prior degree from OSU and had taken some of the Certificate courses, they could count up to 50% of the credit hours from those OSU courses to the Certificate.

c. Labs: The Certificates in Semiconductor Devices and in Semiconductor Device Fabrication both require a lab. There are multiple lab courses available, but they are four credit hours, while the lectures are three credit hours. Since the rule is that they may not double-count more than 50% of the certificate, they would have a choice to double-count a lab and take three additional lecture courses, or to double-count two lectures and take an additional lab. This would be up to the student.

d. Third Certificate: In this scenario, students would take an additional unique two courses (or 6 or 7 credits), overlapping 6 credits from the previous certificates with Certificate 3.

2) An OSU undergraduate selects the Undergraduate Minor or Undergraduate Embedded Certificate in Semiconductor Devices, but stays for graduate school at OSU and wants to do an additional Certificate:

a. They have already counted some courses (all of the courses in the minor or half of the courses in the undergraduate certificate) to their BS degree. For the Graduate Certificates, they could count up to 50% of those same credits (from the BS) toward a graduate certificate. It is possible that the second certificate would also be in Semiconductor Devices; there are enough courses to support this with only 50% double counting. The difference on the transcript would be that one says "Undergraduate Certificate in Semiconductor Devices" and the other would say "Graduate Certificate in Semiconductor Devices." Or the student may elect one of the other Graduate Certificates instead. For Certificates 2 and 3 (should they choose), the same rules above would apply.

b. The student is a BS/MS student who also completed the minor and the certificate, and is double-counting 12 credits of semiconductor courses toward both the BS and MS degree, with 6 of them also counting toward the embedded UG certificate (or all of them to the minor). In this scenario, they could count 6 of those credits toward a graduate certificate but have to take two additional unique courses.

Exclusions:

We should probably state explicitly the following exclusions:

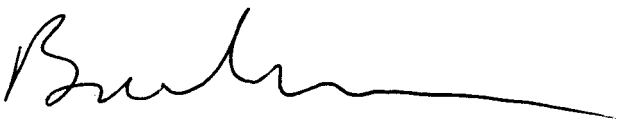
- A student may not get credit both BOTH a Graduate Embedded Certificate and a Graduate Stand-Alone Certificate in the same topic (e.g. Semiconductor Devices). They have to select one.
- A student may not get credit for BOTH an undergraduate minor and an undergraduate embedded certificate in the same topic (e.g. Signal Processing).

Advising:

We will post the detailed rules for the Certificates, including overlap rules, on the department web site. Our graduate and undergraduate advisors will be able to counsel students on the most advantageous path for them. I will request time at New Graduate Student Orientation to briefly explain the certificates and direct students to more thorough resources. For undergraduate certificates and minors, we will do all those thing above, but substitute Freshman Survey for Grad Orientation. Finally, we will hold an information session once a year for all students interested in minors or certificates.

Future:
We are aware of a proposal before OAA to allow 100% overlap between a certificate and the degree (as opposed to the current 50%). Since we want to get these certificates in place in time for Autumn, we are keeping our proposals as using the 50% criteria. If the 100% is approved, we will re-evaluate and request formal changes later. [Possibly we would allow the 100% overlap with the degree but keep the 50% overlap between stacked certificates. We haven't, however, formally discussed this yet.]

Sincerely yours,



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THE OHIO STATE UNIVERSITY

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Memo

To: Maria Miriti, Interim Associate Dean of the Graduate School
From: Rosie Quinzon-Bonello, Assistant Dean for Curriculum and Assessment
Date: February 24, 2023

Re: Graduate Stand-Alone Certificate in Semiconductor Optoelectronics

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On February 3, 2023, the College of Engineering Committee for Academic Affairs voted unanimously to approve the Graduate Stand-Alone Certificate in Semiconductor Optoelectronics proposal submitted by the Department of Electrical and Computer Engineering.
If you require additional information, feel free to contact me.

Yours sincerely,

Rosie Quinzon-Bonello

Academic (Stand-alone) Certificate in Semiconductor Devices

November 19, 2022

Betty Lise Anderson, Department of Electrical and Computer Engineering

I. Program definition

A. Title of program

Academic (Stand-alone) Certificate in Semiconductor Devices

B. Certificate Category and Justification

The reshoring of microelectronics manufacturing, and the anticipated opening of semiconductor fabrication lines in central Ohio by Intel and nationwide by several semiconductor companies is expected to stimulate much interest in students acquiring skills in semiconductor devices, device physics, fabrication, and electronics.

C. Purpose of program

1. This certificate can be completed by professionals in engineering, math, and the physical sciences. It is expected that Intel and supporting industries will be seeking students with expertise in semiconductor devices.
2. Method of delivery will be primarily in-person, in accordance with current offering of the courses in the certificate. Additionally, there is a required laboratory component.

D. Methods of delivery

The courses are primarily offered in-person currently.

E. Timing

Desired start up is Autumn 2023.

F. Goals

The goal is to provide a mechanism for working professionals in engineering, math, and the physical sciences to demonstrate competency in semiconductor devices to potential employers.

G. Outcomes

Upon completion of the academic certificate in Semiconductor Devices, learners will be better prepared to:

1) Understand advanced semiconductor physics
2) Understand advanced electronic and optical properties of semiconductors
3) Understand the principles of new electronics devices as new technologies develop.

H. Minimum requirements

A bachelor of science in engineering or the physical sciences, or equivalent experience. Participants should be familiar with chemistry, calculus-based physics, and differential equations.

A minimum GPA of 3.0 in the certificate courses is required for completion. Only grades of C- or better may be counted toward the certificate.

Completion of the certificate requires a minimum of 13 credit hours. Of these, ECE 5530 is required. Additionally, at least one lab (5037 or 5537) is required (the labs are 4 credit hours each). The remaining six credits can be chosen from a pick list.

I. Methods of delivery

Number	Title	Online	In-person	In-person or online
ECE 5530	**Fundamentals of Semiconductors for Microelectronics and Photonics**		X	
ECE 5037	**Semiconductor Device Fabrication Lab**		X	
ECE 5537	**Semiconductor Device Characterization and Modeling Lab***		X	
ECE 5244	**Si and Wide Band Gap Power Devices**		X	
ECE 5832	**Photovoltaics and Energy Conversion**		X	
ECE 5833	**Organic and Printed Flexible Electronics**		X	
ECE 6244	**Design and Process Integration for Wide Band Gap Power Devices**		X	
ECE 6531	**Fundamentals of Semiconductors Devices**		X	
ECE 6532	**Nanofabrication and Nanoscale Devices**		X	
ECE 6533	**Infrared Detectors and Systems**		X	
ECE 6535	**Semiconductor Optoelectronic Devices**		X	
ECE 7032	**Physical Electronics of Advanced Semiconductor Devices**		X	

*ECE 5537 is currently being piloted under ECE 5194.17; permanent number is being applied for.

J. MOU with ODEE

Not required.

K. List of required and elective courses

1. Required:

E**CE 5530 Fundamentals of Semiconductors for Microelectronics and Photonics** (3 credits)

Prereq: 3030, or Grad standing in Engineering, Biological Sciences, or Math and Physical Sciences.

Commented [FS1]: Need grad standing or equivalent? Enrollment in certificate program

Proposed changes: modify course topics to include more device physics and specifically silicon devices; course change request in progress. Add "or enrollment in graduate certificate program" to prerequisites.

2. Pick at least one:

ECE 5037 Solid State Electronics and Photonics Laboratory (4 credits)

Proposed name change: Semiconductor Device Fabrication Lab
Current Prereqs: Prereq or concur: 3030, and acceptance in ECE, MSE or EngPhysics major; or Grad standing in Engineering, Biological Sciences, or Math and Physical Sciences.
Proposed new prereqs: Prereq or concur: 3030; or Grad standing in Engineering, Biological Sciences, or Math and Physical Sciences.
Proposed changes: Add "or enrollment in graduate certificate program" to prerequisites.

ECE 5537 Semiconductor Device Characterization and Modeling Lab (4 credits)

Prereq: ECE 3030; or grad standing in Engineering or Physics.
Proposed changes: Add "or enrollment in graduate certificate program" to prerequisites.
This course is currently being piloted as ECE 5194.17, but the permanent number of 5537 has been applied for.

3. Additional courses (pick 2)

ECE 5244 Si and Wide Band Gap Power Devices (3 credits)

3030 or grad standing in engineering or physics.
Proposed changes: Add "or enrollment in graduate certificate program" to prerequisites.

ECE 5832 Photovoltaics and Energy Conversion (3 credits

Prereq: 3030, or Grad standing in Engr or Physics.
Proposed changes: Add "or enrollment in graduate certificate program" to prerequisites.

ECE 5833 Organic and Printed Flexible Electronics (3 credits)

Prereq: 3030, or permission of instructor for non-ECE majors; or Grad standing in engineering, biological sciences, or math and physical sciences.
Proposed changes: Add "or enrollment in graduate certificate program" to prerequisites.

ECE 6244 Design and Process Integration for Wide Band Gap Power Devices (3 credits)

Prereq: Grad standing in Engineering or Physics.
Proposed changes: Add "or enrollment in graduate certificate program" to prerequisites.

ECE 6531 Fundamentals of Semiconductors Devices (3 credits)

Prereq: 5530 (730), or Grad standing in Engineering, Biological Sciences, or Math and Physical Sciences.
Proposed changes: Add "or enrollment in graduate certificate program" to prerequisites.

ECE 6532 Nanofabrication and Nanoscale Devices (3 credits)
Prereq: 6531, 5531, or 730, or Grad standing in Engineering, Biological Sciences, or Math and Physical Sciences.
Proposed changes: Add "or enrollment in graduate certificate program" to prerequisites.

ECE 6533 Infrared Detectors and Systems (3 credits)
Prereq: 5530 or permission of instructor.

ECE 6535 Semiconductor Optoelectronic Devices (3 credits)
Grad standing in engineering or physics
Proposed changes: Add "or enrollment in graduate certificate program" to prerequisites.

ECE 7032 Physical Electronics of Advanced Semiconductor Devices (3 credits)
Prereq: 5530 or 6531.

ECE 7831 Microwave Semiconductor Devices (3 credits)
Prereq: Grad standing in Engr or Physics.
Proposed changes: Add "or enrollment in graduate certificate program" to prerequisites.

Note: A student completing the certificate must take at least one lab, but may choose another in addition as an elective.

L. Length of program compared to similar programs

Comparable. (See section VI)

M. Semesters of offering

Number	Title	Even Aut	Odd Spr	Odd Aut	Even Spr
5530	**Fundamentals of Semiconductors for Microelectronics and Photonics**	X		X	
5037	**Semiconductor Device Fabrication Lab**	X		X	
5537	**Semiconductor Device Characterization and Modeling Lab***		X		X
5244	**Si and Wide Band Gap Power Devices**	X		X	
5832	**Photovoltaics and Energy Conversion**			X	
5833	**Organic and Printed Flexible Electronics**		X		
6244	**Design and Process Integration for Wide Band Gap Power Devices**		X		X
6531	**Fundamentals of Semiconductors Devices**		X		X
6532	**Nanofabrication and Nanoscale Devices**	Runs ≈ every 3 years			
6533	**Infrared Detectors and Systems**	X			
6535	**Semiconductor Optoelectronic Devices**		X		X

7032	**Physical Electronics of Advanced Semiconductor Devices**		X		X
7831	**Microwave Semiconductor Devices**	Runs ≈ every 3 years			

*ECE 5537 is currently being piloted under ECE 5194.17; permanent number is being applied for.

N. Transfer Credits

All courses in the Certificate must be taken at Ohio State.

O. Arranged/Individual Study Courses

Arranged individual study courses may not be applied to the certificate.

P. Overlap

A maximum of 6 credit hours from a previous undergraduate or graduate degree may overlap with the credits required for the academic certificate.

II. Enrollment

A. Projected enrollment

We have no experience with these certificates, so we can only guess at the number of students who might be interested, potentially 10-20 per year

1. Will there be problems if too many students enroll in the certificate program?

This is not expected to happen, but if it does, class sizes will increase, or we could potentially open additional sections or offer some electives more often. These classes generally have modest enrollments (≈20-30) so this problems is not anticipated. The labs may experience bottlenecks and require additional sections to accommodate large enrollments, which in turn requires additional GTAs. We have been promised additional GTA support by the College of Engineering.

2. Will there be problems if too few students enroll in the certificate program?

No.

B. Opportunities for graduates

Due to the CHIPS Act, semiconductor manufacturing in the US is expected to grow rapidly in the next decade. There is a clear need for graduates at all academic levels to support this industry in the coming year. Some of these are right here in Ohio, with the coming Intel fabs, but there are many additional jobs in places like California, Arizona, Vermont, New York, Oregon, and others.

C. Admission requirements

A bachelor of science in engineering or the physical sciences, with a GPA of 3.0, or equivalent experience. Participants should be familiar with chemistry, calculus-based physics, and differential equations.

III. Sufficient resources

A. Adequacy and availability of facilities and staff

All courses listed above exist and are already offered. They run on the schedule listed under Section I.M. There are two caveats, both pertaining to the labs:

- ECE 5537 is currently running as a Group Studies; a permanent number is being applied for
- ECE 5037 has not run in several years because substantial equipment and facilities upgrades are needed. We list it here in the hopes of acquiring those upgrades; meanwhile 5537 remains available to students.

B. Projected resource needs and plans to meet those needs

The certificate can run and serve students immediately. We have sufficient semiconductor faculty that we can add sections and new courses if there is enough demand.

The labs are expensive to run. ECE 5537 is running now (under a group studies pilot number). ECE 5037 has not run for several years due to failing equipment. We have a new plan, however, to run ECE 5037 (fabrication laboratory) either in Dreese, or in Nanotech West, or in a combination of these facilities. We are seeking funds to upgrade the existing equipment in the 5037 lab, which already has dedicated space in the Dreese basement cleanroom (specialized environment needed to fabricate chips). If we can secure money for updated equipment, repairs to the air handlers, and staff to maintain the lab, we can re-open this course. Resources and facilities are being arranged to run the course, and to repair equipment. If, however, that doesn't happen soon, we can still offer the certificate with only the ECE 5537 laboratory course.

If demand increases for the labs, we will need more GTAs to run the additional sections. Six GTAs have been promised by the College of Engineering from the Intel funds.

IV. Justifiable expenses

A. Additional Faculty

We currently have enough faculty with the appropriate expertise to offer the certificate.

B. Course additions or deletions

No new courses are needed at this time. The characterization lab is currently (Autumn 2022) being piloted under a group studies (ECE 5195.17). We have applied for a permanent number, ECE 5537.

C. Necessary budget adjustments

We can run the certificate with existing resources.

D. Available and anticipated funding

Funding from an Intel grant for teaching assistants and equipment is available. Further resources, if needed, will be arranged in coordination with the college and university.

V. Adequate demand

A. Evidence of sufficient demand by students faculty, general public, and/or business

Intel is opening the first two of eight semiconductor fabrication lines (fabs) in central Ohio, scheduled to open 2025. They are recruiting interns now, who will spend 12-18 months in established Intel plants before returning to Ohio. The initial fabs will employ 3,000 people and more will be needed as the additional fabs come online. Additionally, there will be other support industries that will need graduates at all levels with semiconductor expertise.

B. Duration of demand (long/short term)

Intel is hiring people now so they can be trained now while the factory is being built, thus the demand is immediate. If the first two fabs are successful, Intel plans to build six more; thus the demand is expected to be ongoing for the foreseeable future.

C. Ability of other programs to meet demand

The Department of Electrical and Computer Engineering has a world-class faculty in semiconductor materials and devices, and already has many specialized courses in these areas. We welcome the opportunity to add courses from other departments to these certificates as they become available, for example in Physics or Materials Science and Engineering.

VI. Competitiveness with other institutions: limited overlap within the University

A. Overlap with other programs or departments

ECE has cordial relationships with Physics as well as Materials Science and Engineering, with multiple faculty members having joint appointments with those departments. We hope to add courses from those departments to these certificates as time goes by. We are trying to get the certificates approved quickly, so are starting with existing ECE courses.

B. Duplication of effort by other areas in the University, another university or another school

- Arizona State University has one professional graduate certificate semiconductor processing for people with BS or MS in engineering or related fields. It is online, and appears to have no lab component. 15 Credits hours.
- Portland State University has a professional graduate certificate in Semiconductor Materials and Manufacturing Overview, offered on campus (in Mechanical Engineering). Two of the available 8 courses have labs.
- Purdue is rapidly developing a semiconductor degree and certificate, and credentialing work force development

C. Similar programs at other universities in Ohio, or in the United States, and their levels of success

See above. Levels of success are not known.