From:	Smith, Randy
To:	Anderson, Betty Lise; Shanker, Balasubramaniam
Cc:	Andridge, Rebecca; Reed, Katie; Smith, Randy; Orr, James; Duffy, Lisa; Quinzon-Bonello, Rosario; Tomasko, David
Subject:	Proposal to establish a 1b Undergraduate Certificate and Minor in Semiconductor Devices
Date:	Friday, May 19, 2023 2:42:16 PM
Attachments:	image001.png

Betty Lise and Shanker:

The proposal from the Department of Electrical and Computer Engineering to establish a 1b Undergraduate Certificate and Minor 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

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Memo

To: Randy Smith Vice Provost for Academic Programs
From: Rosie Quinzon-Bonello, Assistant Dean for Curriculum and Assessment
Date: February 24, 2023

Re: UG Embedded Certificate in Semiconductor Devices

On February 3, 2023, the College of Engineering Committee for Academic Affairs voted unanimously to approve the UG Embedded Certificate in Semiconductor Devices 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

Proposal for an Undergraduate Embedded Certificate in Semiconductor Devices

November 19, 2022

Betty Lise Anderson, Department of Electrical and Computer Engineering

I. Program definition

A. Title of program

Undergraduate Embedded 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 undergraduates currently pursuing BS degrees at Ohio State. 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 undergraduate students in engineering, math, and the physical sciences to demonstrate competency in semiconductor devices to potential employers, either in addition to their major degree outside electrical engineering, or beyond the requirements for their BS in Electrical and Computer Engineering degrees.

G. Outcomes

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

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

H. Minimum requirements

A minimum GPA of 2.0 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 3030 Semiconductor Electronic Devices (3 credits), is the gateway course, and required, although a similar course in another department may be approved by petition. ECE 5530 is also required. Additionally, at least one lab (either 5037 or 5537) is required; each is 4 credits. The remaining three credits can be chosen from a pick list.

Special Rules apply to ECE undergraduate students; see Section 1.Q.

I. Methods of delivery

Number	Title	Online	In-Person	In-person or online
3030	**Semiconductor Device Physics**		X	
5530	**Fundamentals of Semiconductors for Microelectronics and Photonics**		X	
5037	**Solid State Electronics and Photonics Laboratory**		X	
5537	**Semiconductor Electronics and Photonics Lab**		X	
5031	**Semiconductor Process Technology**		X	
5033	**Surfaces and Interfaces of Electronic Materials**		X	
5131	**Lasers**		X	
5132	**Photonics**		X	
5244	**Si and Wide Band Gap Power Devices**		X	
5832	**Advanced Photovoltaics**		X	
5833	**Organic and Printed Flexible Electronics**		X	

J. MOU with ODEE

Not required.

K. List of required and elective courses

1. Required:

ECE 3030 Semiconductor Device Physics (3 credits)

Current Prereqs: 2020, 2021, or 2100; and Physics 1251, 1261, or both 1240 and 1241; and Chem 1210, 1220, or 1250; and enrollment in ECE, MSE, or EngPhysics major. Prereq or concur: Math 2415 or 2174.

Proposed new prereqs: Physics 1251, 1261, or both 1240 and 1241; and Chem 1210, 1220, or 1250. Prereq or concur: Math 2415 or 2174. Offered every semester.

ECE 5530 Fundamentals of Semiconductors for Microelectronics and Photonics (3 credits)

Prereq: 3030, or Grad standing in Engineering, Biological Sciences, or Math and Physical Sciences.
Proposed changes: modify course topics to include more device physics and specifically silicon devices; course change request in progress

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.

ECE 5537 Semiconductor Device Characterization and Modeling Lab (4 credits)
Prereq: ECE 3030; or grad standing in Engineering or Physics.
This course is currently being piloted as ECE 5194.17, but the permanent number of 5537 has been applied for.

3. Additional courses (pick 1)

ECE 5031 Semiconductor Process Technology (3 credits)
Prereq: 3030, or Grad standing in Engineering, Biological Sciences, or Math and Physical Sciences. Offered every spring.

ECE 5033 Surfaces and Interfaces of Electronic Materials (3 credits)
Prereq: 3030, and Physics 1250 or 1250H; or Grad standing in Engineering, Biological Science, or Math and Physical Sciences. Offered odd springs

ECE 5131 Lasers (3 credits)
Prereq: 3010 and 3030 or Grad standing in Engineering, Biological Sciences, or Math and Physical Sciences.

ECE 5132 Photonics (3 credits)
Prereq: 3010 and 3030 or Grad standing in Engineering, Biological Sciences, or Math and Physical Sciences.

ECE 5244 Si and Wide Band Gap Power Devices (3 credits)
3030 or grad standing in engineering or physics.

ECE 5832 Photovoltaics and Energy Conversion (3 credits
Prereq: 3030, or Grad standing in Engr or Physics.

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.

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

L. Length of program compared to similar programs

Comparable.

M. Semesters of offering

Number	Title	Even Aut	Odd Spr	Odd Aut	Even Spr
3030	**Semiconductor Device Physics**	X	X	X	X
5530	**Fundamentals of Semiconductors for Microelectronics and Photonics**	X		X	
5037	**Solid State Electronics and Photonics Laboratory**	X		X	
5537	**Semiconductor Electronics and Photonics Lab***		X		X
5031	**Semiconductor Process Technology**		X		X
5033	**Surfaces and Interfaces of Electronic Materials**		X		
5131	**Lasers**			X	
5132	**Photonics**	X			
5244	**Si and Wide Band Gap Power Devices**	X		X	
5832	**Photovoltaics and Energy Conversion**			X	
5833	**Organic Conducting Devices**		X		

*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 of the major may overlap with the credits required for the academic certificate.

Q. Electrical and Computer Engineering Students

ECE has one major (Electrical and Computer Engineering), but two programs of study, electrical engineering program of study (EES) and computer engineering program of study (CES).

- EES students are required to complete three "domains", choosing two electives in one domain and one elective in each of two other domains. There are six domains. One of the domains is "solid state electronics and photonics." ECE students desiring to obtain this certificate may take four courses from the list above, including ECE 3030 (required of EES students). Of those, 3030 and one additional elective from the list above can count toward the solid state domain *and* the certificate. To complete the certificate as well, the student must take ECE 5530, and either 5037 or 5537, and one additional elective from the list above.

- CES students are not required to take ECE 3030 for their major. They must take 16 hours of technical electives, of which 9 must be from a list specific to computer engineers They may therefore take up to 7 hours of ECE technical electives outside that list, which may be solid state courses. Thus a CES student could count ECE 3030 and 5530 and count those six hours to the major degree *and* toward the certificate; they would need to take one of the labs (5537 or 5037) and one additional solid state elective from the table above to complete the 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 problem 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 help from 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 minimum GPA of 1.7 (C-) to apply. Initially admitted to the university as part of an Associates or Bachelors Degree program. An embedded certificate program is "declared" in a similar path to majors.

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 Lab 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

A google search did not turn up any undergraduate certificates in semiconductors in the US.

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

No similar programs exist as far as we know.