

## Curricular Affairs Committee of the Faculty Senate

### MEMO

**To:** Faculty Senate

**From:** Colby Kervick, Co-Chair Curricular Affairs Committee of the Faculty Senate

**Date:** 3/20/23

**Re:** Approval of a proposal from Department of Electrical and Biomedical Engineering and the Department of Physics in the College of Engineering and Mathematical Sciences (CEMS)

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The CAC discussed a proposal for a new undergraduate certificate in Semi-conductor Engineering and Physics (UCSEP) put forth by the Department of Electrical and Biomedical Engineering and the Department of Physics in the College of Engineering and Mathematical Sciences (CEMS) at our March 2, 2023 meeting. Subsequently an electronic vote was held following the proposal's completion of the 30 day public comment period during which no comments were received.

#### ***Program Description and Rationale***

This certificate will certify that undergraduate students have received specific instruction and experiences in semiconductor engineering and/or physics. Students will complement coursework in the areas of semiconductor device physics, design, processes and/or metrology **with a significant experiential learning experience**. This interdisciplinary certificate will be accessible to students from electrical engineering, physics, and other technical majors.

The goal is to provide unique and relevant education that will better prepare our graduates to work in the semiconductor industry and/or pursue further studies in this field. This program will provide pathways for students from electrical engineering, physics, and other STEM majors to gain relevant training and experiences in the areas of semiconductor device physics, design, processes and/or metrology. The expectation is that students who graduate with this certificate will be well recruited by both industry and graduate programs in this field.

#### ***Justification and Evidence for Demand***

The semiconductor field is of immense importance to today's society and, in particular, to the Nation's economic well-being and security. In addition, this field has significant and historical relevance to the economy of Vermont and neighboring states. The necessity to prepare students for this field is further supported by the recent passage of the CHIPS and Science Act of 2022, which provides over \$50B for American semiconductor research, development, manufacturing, and workforce development.

#### ***Relationship to Existing Programs***

This proposal was co-developed by faculty in the Department of Electrical and Biomedical Engineering and in the Department of Physics, both of which reside in the College of Engineering and Mathematical Sciences. The UCSEP program will be co-directed by faculty from each Department.

The UCSEP program is the result of a proposal submitted by the University in 2021 to Senator Leahy's Office as a Congressional Direct Spending Request, which subsequently provided the opportunity to receive the Department of Education award titled "A New Semiconductor Engineering Curriculum at the University of Vermont." With the expectation of passage of the CHIPS and Science Act of 2022, UVM's Office of the Vice President for Research (OVPR) began holding meetings in early 2022, facilitated by the

firm Lewis-Burke Associates, to identify research and workforce development funding opportunities for the University in the field of Semiconductor Engineering. The proposed UCSEP certificate is directly aligned with the latter and will help develop student expertise to contribute on projects related to the former.

The Department of Electrical and Biomedical Engineering offers a Minor in Electrical Engineering. This 18-credit program must be met with only Electrical Engineering courses but is broader and more flexible than the certificate considered herein. Beyond one required course, students can take any EE 2XXX or higher course and apply it to their minor. Most students who have received the Minor in Electrical Engineering degree have been from Mechanical Engineering and have primarily taken courses in control systems or energy systems. No experiential coursework is required for the EE minor. The Department of Physics offers a Minor in Physics. This 15-credit program must be met with only PHYS courses and is targeted more broadly towards basic science than the certificate considered herein. A three-course introductory physics sequence is required. Beyond the three required courses, students can take any PHYS 3XXX or higher course and apply it to their minor. Students who have received the Minor in Physics degree have been from a range of majors, the largest numbers being from other physical science, engineering, or mathematics majors. No experiential coursework is required for the Physics minor. In contrast to these minors, students pursuing the proposed UCSEP (i) can take only pre-approved courses from either electrical engineering or physics and (ii) must have related experiential learning credits. Note that it is possible that non-major students completing the UCSEP Program may as a result also complete the requirements for the EE and/or Physics minors. However, there is no expectation that they do so. There are no related certificates.

No other minors or undergraduate certificate programs are similar in title or content.

### **Curriculum**

The UCSEP program will provide three pathways for completion: one for students with a primary interest in electrical engineering (EE), one for those pursuing a physics major, and one for those from other STEM fields (e.g., chemistry or mechanical engineering). The expectation is that students will enter the certificate program in their sixth semester, nominally in the Spring of their Junior year.

The 17-credit UCSEP program has four components (i) pre-requisites according to student's major (not included in the 17-credit total), (ii) required coursework (8 credits), (iii) preapproved electives (6 credits), and (iv) a culminating experience that is a credit-bearing internship, undergraduate research, or Capstone Design project that is related to the semiconductor field (3 credits). Students must maintain a 3.0 average in these courses to receive the UCSEP upon graduation.

Students pursuing majors not in Electrical Engineering or Physics will need to work with their UCSEP advisor to identify courses that will meet the prerequisite requirement. These courses should be suitable prerequisites for allowing the students to take courses from the preapproved electives list and will consist of courses related to fundamentals of materials and circuits.

### **Pre- or Co-Required Courses (NOT officially part of the certificate)**

<b>Pathway</b>	<b>Course Number (Current)</b>	<b>Title</b>
Electrical Engineering	CEE 1160 EE 3110 EE 2810	Applied Mechanics Electronics II Fundamentals of Digital Design
Physics	PHYS 3650 PHYS TBD EE 2145 or EE 2125	Intro to Solid State Physics Microstructure and Surface Analysis Electrical Engineering Fundamentals, or Circuits I
Other STEM majors	PHYS 1550 or PHYS 1650 EE 2145 / EE 2175* ME 2110 / CE 2100 / CHEM 2600*	Physics II EE Fundamentals Materials

\*Courses substitutions to these courses are allowed with approval of SEP advisor

## Required Coursework (8 credits)

Course Number (Current)	Title	Credits
EE 3440*	Semiconductor Devices & Characterization	4
EE 3420*	Integrated Circuit Fabrication & Physical Analysis	4

\*Both courses to be cross-listed with PHYS

## Preapproved electives (6 credits minimum)

Course Number (Current)	Title
EE 5410	Digital VLSI Design
EE 5420	Analog VLSI Design
EE 3520*	Autonomy
EE 5430	RF Circuit Design
EE 5810	Digital Computer Design I
EE TBD (NEW)*	Physical Layout of Microcircuits
EMGT TBD (NEW)*	Industrial Processes
PHYS 4100	Experimental Physics II
PHYS 3650**	Intro to Solid State Physics
PHYS 3400	Thermal & Statistical Physics
PHYS TBD**	Microstructure and Surface Analysis

\* best for other STEM majors, \*\* Not for Physics majors

## Credit bearing experiences\* (3 credits required)

Course Number (Current)	Title
PHYS 3991 /CEMS 3991	Internship
PHYS 3995 / EE 3995	Undergraduate Research
EE 4200 / ME 4020	Capstone Design II
HON TBD / EE 2996 / ME 2996	Honors Thesis

\*topic must be relevant to semiconductor field

## Admission Requirements and Process

Like a minor, students would declare their intent to complete this certificate through banner/MyUVM. The expectation is that this would occur nominally in their junior year.

## Anticipated Enrollment and Impact on Current Programs

The intent is that this will increase interest in electrical engineering and physics and grow these two programs. The goal is that in 5 years time, ~10 students a year will complete this program.

## Advising

Each semester, it is expected that CEMS Student Services will assign each student “declaring the certificate” a secondary advisor from the participating factory. This process is what is currently done for majors and minors.

## Assessment Plan

This certificate is being developed as part of the Department of Education grant, which proposed the following assessment plan (text below). This plan will leverage the processes that are in place for assessing our ABET accredited EE curriculum.

"Several metrics will be utilized to evaluate the success of the activities in the undergraduate certificate programs:(i) student evaluations of individual courses, (ii) internship placement rates, (iii) certificate completion rates, (iv) employer advisory board input. In order to evaluate the progress made towards the learning objectives, a Semiconductor Concept Inventory (SCI) will be developed. This inventory tool will be administered to certificate participants at both the start and at the completion of their certificate coursework in order to evaluate their learning relative to the program goals, and to provide feedback that can be used to correct or enhance the courses and activities of the certificates. Outcomes will also be

evaluation by tracking internship placement rates and job placement rates of certificate recipients with semiconductor employers."

### **Staffing Plan, Resource Requirements, and Budget**

Presently there are three faculty from Electrical Engineering (Gallagher, Kay, Xia) and three faculty from Physics (Clougherty, Headrick, White) who teach the courses that have been listed as either required or electives. The Physics Program is presently searching for a new tenure track hire in the area of condensed matter/materials physics who will also teach courses that are required or electives for the UCSEP. Startup funds for this hire are being supplemented by the aforementioned Department of Education award. In addition, the Electrical Engineering Program is searching for a new lecturer, who will instruct UCSEP prerequisite, required and/or elective courses. The Department of Education award includes funds to support faculty as they develop new and/or enhance existing courses and facilities.

Significant infrastructure development in the area of semiconductor engineering and physics is in progress as a result of the aforementioned Department of Education award. This infrastructure development consists of (i) new instrumentation/equipment purchases, (ii) upgrades/repairs to existing instrumentation/equipment, and (iii) new software.

Existing library resources sufficient. No impact foreseen.

### **Cost Estimates**

All expenses below are to be covered by the Department of Education award "A New Semiconductor Engineering Curriculum at the University of Vermont". Additional costs (e.g., graduate and undergraduate teaching assistants, Capstone Design supplies) may come from this award, from departmental funds, and/or industry partnerships.

1. First year costs in addition to current budget;

<b>Item</b>	<b>Cost</b>
Faculty course development*	\$65,000
Staff lab development*	\$40,000
Project management*	\$12,500
Staff certificate promotion*	\$15,000
Lab equipment	\$350,000
Software	\$75,000
Total	\$557,500

\*including fringe

2. Total costs for first five years in addition to current budget.

<b>Item</b>	<b>Cost</b>
Faculty course development*	\$190,000
Staff lab development*	\$116,000
Project management*	\$36,500
Staff certificate promotion*	\$25,000
Lab equipment	\$450,000
Software	\$100,000
Total	\$917,500

\*including fringe

### **Evidence of Support**

Marilyn Cippola, Chair, Department of Electrical and Biomedical Engineering  
 Randall Headrick, Chair, Department of Physics  
 Greg Warrington, Chair, CEMS Curriculum Committee  
 Linda Schadler, Dean, CEMS

### **Summary**

This proposed undergraduate Certificate in Semiconductor Engineering and Physics (UCSEP) Program will certify that UVM undergraduate students have received specific instruction and experiences in semiconductor engineering and/or physics and will better prepare our graduates to work in the semiconductor industry and/or pursue further studies in this field. This 17-credit hour certificate complements coursework in the areas of semiconductor device physics, design, processes and/or metrology with a significant experiential learning experience and will be accessible to students from electrical engineering, physics, and other technical majors. The funds to develop the UCSEP coursework and laboratory infrastructure come from the recent Department of Education award: "A New Semiconductor Engineering Curriculum at the University of Vermont."

If approved by the Faculty Senate and Board of Trustees, this program will be implemented starting Fall 2023.