THE UNIVERSITY OF ARIZONA

New Academic Program Workflow Form

General

Proposed Name: Semiconductor Manufacturing

Transaction Nbr: 00000000000192

Plan Type: Minor

Academic Career: Undergraduate

Degree Offered:

Do you want to offer a minor? N

Anticipated 1st Admission Term: Fall 2024

Details

Department(s):

ENGR

DEPTMNT ID	DEPARTMENT NAME	HOST
2302	Systems & Industrial Engineering	N
2303	Electrical & Computer Engineering	N
2803	Chemical & Environmental Engineering	N
2804	Materials Science & Engineering	Y

Campus(es):

MAIN

LOCATION	DESCRIPTION
TUCSON	Tucson

Admission application terms for this plan: Spring: Y Summer: Y Fall: Y

Plan admission types:

Freshman: Y Transfer: Y Readmit: Y Graduate: N

Non Degree Certificate (UCRT only): N

Other (For Community Campus specifics): N

Plan Taxonomy: 15.0616, Semiconductor Manufacturing Technology/Technician.

Program Length Type: Program Length Value: 0.00

Report as NSC Program:

SULA Special Program:

Print Option:

Diploma: Y Minor in Semiconductor Manufacturing

Transcript: Y Minor in Semiconductor Manufacturing

Conditions for Admission/Declaration for this Major:

n/a

Requirements for Accreditation:

n/a

Program Comparisons

University Appropriateness

The Materials Science and Engineering Department has been at the forefront of teaching many semiconductor manufacturing courses that are critical for training a robust workforce, leading to many students finding employment in industries focused on semiconductor manufacturing (Intel, TSMC, ON Semiconductors, L3, Applied Materials, Micron, Global Foundries, Raytheon). With the renewed focus on bringing back manufacturing jobs back to the USA, coupled with enormous investments coming into the state of Arizona (~$ 50 Billion), there is an immediate as well as long term need to create many more engineers and technologists in semiconductor manufacturing; in this regard, the Minor in Semiconductor Manufacturing will establish a comprehensive and holistic curriculum by integrating and curating relevant courses across various departments within the College of Engineering (CoE) at the UA. The Minor will thus serve as the primary mechanism of establishing and sustaining a pipeline of a highly trained workforce and thought leaders that are required to keep pace with the requirements of the growing semiconductor manufacturing industry. The minor will also provide a new mechanism for student credit transfer and curriculum access in partnership with Pima Community College. In addition to existing transfer opportunities with PCC's Engineering program, the AM minor will also directly connect to the Applied Technology (AT) program at PCC, leveraging an established manufacturing-based curriculum and large-scale teaching facility. In conclusion, the Minor will provide a state-of-the-art educational and professional preparatory option for our CoE majors in an area of significant impact in the engineering field as well as develop new interest and enhanced recruitment opportunities in the College.

Arizona University System

NBR	PROGRAM	DEGREE	#STDNTS	LOCATION	ACCRDT

Peer Comparison

see attached chart.

Resources

Library

Acquisitions Needed:

none.

Physical Facilities & Equipment

Existing Physical Facilities:

existing facilities are adequate and appropriate.

Additional Facilities Required & Anticipated:

none.

Other Support

Other Support Currently Available:

existing faculty and staff support is sufficient.

Other Support Needed over the Next Three Years:

none.

Comments During Approval Process

11/16/2023 1:59 PM

TIN

Comments
Approved.

12/19/2023 4:49 PM

MELANIECMADDEN

Comments
Approved.

12/20/2023 10:36 AM

DHERRING

Comments
Approved.

12/20/2023 10:51 AM

MHWU

Comments
Approved.

New Academic Program – Minor (Undergraduate)
CURRICULAR INFORMATION

I. MINOR DESCRIPTION:

The University of Arizona College of Engineering is pleased to offer a College-wide Minor in Semiconductor Manufacturing (SM). The Minor provides students with critical interdisciplinary skills required to pursue a successful career in the broad area of semiconductor manufacturing and technology. The SM Minor's curriculum draws from a comprehensive collection of elective course offerings, providing the student a strong foundation in semiconductor processing, device design and fabrication, advanced packaging, and semiconductor supply chain management.

II. JUSTIFICATION/NEED FOR THE MINOR:

A versatile curriculum that includes relevant courses that focus on semiconductor manufacturing and technology is critical for training a robust workforce and enabling students to find employment in semiconductor manufacturing (Intel, TSMC, ON Semiconductors, L3, Applied Materials, Micron, Global Foundries, Raytheon). With the renewed focus on bringing manufacturing jobs back to the USA, coupled with enormous investments coming into the state of Arizona (~$ 50 Billion), there is an immediate as well as long term need to create many more engineers and technologists in semiconductor manufacturing. The Minor in Semiconductor Manufacturing will establish a comprehensive and holistic curriculum by integrating and curating relevant courses across various departments within the College of Engineering (CoE) at the UA. The Minor will establish and sustain a pipeline of a highly trained workforce and thought leaders required to keep pace with the requirements of the growing semiconductor manufacturing industry. Based on market analysis and inputs from the Arizona Commerce Authority, there would be a perpetual need for at least 500-1000 new engineers annually to fill in the needs of the semiconductor industry.

The minor will also provide a new mechanism for student credit transfer and curriculum access in partnership with Pima Community College. In addition to existing transfer opportunities with PCC's Engineering program, the SM minor will also directly connect to the Applied Technology (AT) program at PCC, leveraging an established manufacturing-based curriculum and large-scale teaching facility. In conclusion, the Minor will provide a state-of-the-art educational and professional preparatory option for our CoE majors in an area of significant impact in the engineering field as well as develop new interest and enhanced recruitment opportunities in the College.

III. MINOR REQUIREMENTS:

Undergraduate Minor:

Minimum total units required	19
Minimum upper-division units required	9
Total transfer units that may apply to minor	10

List any special requirements to declare/admission to this minor	Complete all pre-requisite coursework; GPA of 2.5 or higher
Minor requirements. List all required minor requirements including core and electives. Courses listed must include course prefix, number, units, and title. Mark new coursework (New). Include any limits/restrictions needed (house number limit, etc.). Provide email(s)/letter(s) of support from home department head(s) for courses not owned by your department.	Students are assumed to have successfully completed foundational, freshman-level coursework consistent with major program requirements. Required courses (9 credits): three "anchor" courses 1. *one required anchor course from the following:* **Chem 152 (4) – Chemical Thinking II** *Prerequisites:* CHEM 151 or 141/143 or 161/163 and 1 of the following: PPL 60+ or SAT I MSS 610+ or ACT MATH 26+ or one course from MATH 108, 112, 113, 119A, 120R, 122B, 125, 129, or 223. Test scores expire after 2 years. ***or*** **Chem 142 (3)– General Chemistry Lecture II: Quantitative Approach and** *Prerequisites:* CHEM 151 or 141 or 161 and 1 of the following: PPL 60+ or SAT I MSS 610+ or ACT MATH 26+ or 1 course from MATH 108, 112,113, 119A, 120R,122B,125,129, or 223. Test scores expire after 2 years. **Chem 144 (1) - General Chemistry Lab II: Quantitative** *Prerequisites:* CHEM 151 or 141/143 or 161/163. Concurrent enrollment or completion of CHEM 142 and 1 of the following: PPL 60+ or SAT I MSS 610+ or ACT MATH 26+ or one course from MATH 108, 112, 113, 119A, 120R, 122B, 125, 129, or 223. Test scores expire after 2 yrs. ***or*** **Chem 162 (3)– Honors Chemical Thinking II and** *Prerequisites:* CHEM 161 or department consent. Student must be active in the Honors College. **Chem 164 (1)– Honors Fundamental Techniques of Chemistry** *Prerequisites:* CHEM 161 and CHEM 163 or department consent. Concurrent enrollment or completion CHEM 162. Honors active. ***or*** **MSE 110 (4): Introduction to Solid State Chemistry** *Prerequisite: Chem 151* 2. *Select two anchor courses from the following:* **MSE 365 (3): Physical Properties of Materials** *Prerequisites: MSE 222 or MSE 223R or concurrent enrollment in OPTI 240 or department consent.* **MSE 446 (3): Semiconductor processing** *Prerequisite: Advanced Standing in Engineering*

	CHEE 415 (3): Microelectronics Manufacturing and the Environment *Prerequisites: Advanced Standing in Engineering* **ECE 352 (3): Device Electronics** *Prerequisite: Major: ECE. Prerequisite or concurrent enrollment in ECE 351C.* *Course Attribute* *Special Exam Credit Only* **ECE 304A (3): Design of Electronic Circuits** *Prerequisites: Advanced Standing: Engineering. Major: ECE. ECE 320A.* 3. <u>Electives (9 credits): choose from the following course listing (can double count from major degree electives as allowed by CoE and department program requirements)</u> **ECE 351C (4): Electronic Circuits** *Prerequisite: Advanced Standing: Engineering. Major: ECE. ECE 320A.* **MSE/ECE 404/504 (3): Optical Spectroscopy of Materials** *Prerequisites: PHYS 141 or PHYS 241, MATH 223, MSE 110, and ECE 360.* **ECE 407 (3): Digital VLSI System Design** *Prerequisites: Advanced Standing: Engineering. Major: ECE. ECE 274A and ECE 351C.* **ECE/OPTI 414A (3): Photovoltaic Solar Energy Systems** *Prerequisite: Advanced Standing in Engineering.* **MSE/CHEE 432 (3): Organic Electronic Materials and Devices** *Prerequisites: CHEM 151 or CHEM 141/143 or CHEM 161/163. MSE 110 or CHEM 152. MSE 365 or PHYS 371 or CHEM 480B* **MSE/ECE 434 (3): Electrical and Optical Properties of Materials** *Prerequisites: Phys 241* **MSE/ECE 447/547 (2): Semiconductor Processing Laboratory** *Prerequisites: Background in semiconductor/MEMS processing or equivalent work experience.* **ECE 450 3): Analog Integrated Circuits**

	Prerequisites: Advanced Standing: Engineering. Major: ECE. ECE 351C. **ECE 451A (3): Introduction to Physical Electronics** *Prerequisites: Advanced Standing: Engineering. Major: ECE. ECE 381A.* **ECE 456 (3): Optoelectronics** *Prerequisites: Advanced Standing: Engineering. Major: ECE. ECE 381A.* **MSE/ECE 465 (3): Microelectronic Packaging Materials** *Prerequisites: Advanced Standing in Engineering* **MSE 480 (3): Advanced Characterization Methods in MSE** *Prerequisites: Advanced Standing in Engineering* **MSE 488 (3): Scanning Electron Microscopy** *Prerequisites: Advanced Standing in Engineering* **MSE 489 (3): Transmission Electron Microscopy** *Prerequisites: Advanced Standing in Engineering* **SIE 305 (3): Introduction to Engineering Probability and Statistics** *Prerequisites: Advanced standing and completion of MATH 129* **SIE 408 (3): Reliability Engineering** *Prerequisites: Advanced Standing and SIE 305* **SIE 406 (3): Quality Engineering** *Prerequisites: Advanced Standing and SIE 305* **SIE 430 (3): Engineering Statistics** *Prerequisites: Advanced Standing and SIE 305* **SIE 465 (3): Supply Chain Management** *Prerequisites: Advanced Standing and SIE 305, SIE 340* **SIE 482 (3): Lean Engineering** *Prerequisites: Advanced Standing and SIE 305* **SIE 483 (3): Computer-Integrated Manufacturing Systems** *Prerequisites: Advanced Standing and SIE 383*
Internship, practicum, applied course requirements (Yes/No). If yes, provide description.	No
Additional requirements (provide description)	No

Any double-dipping restrictions (Yes/No)? If yes, provide description.	Yes. Can double count from major degree electives as allowed by CoE and department program requirements

IV. NEW COURSES NEEDED:

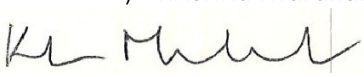
Course prefix and number (include cross-listings)	Units	Title	Pre-requisites	Modes of delivery (online, in-person, hybrid)	Course Form transaction number	Anticipated first term offered	Use in the program (required/ elective)
MSE XXX	3	Metrology of materials and devices	MSE 480	Hybrid		Fall 2025	elective
MSE XXX	3	Thin films science and engineering	MSE 223R	Hybrid		Spring 2026	elective
CHEE/MSE XXX	3	Plasma science		hybrid		Fall 2025	elective
SIE XXX	3	Smart and Autonomous Manufacturing Systems	SIE 383	hybrid		Spring 2026	elective

V. Learning Outcomes -

Learning Outcome #1: Demonstrate knowledge of the foundational scientific and technological concepts that underlie semiconductor manufacturing
Concepts: principles of performance-processing-fabrication of semiconductor devices.
Competencies: Demonstrate knowledge of properties of technological materials, and methods for fabrication of solid-state devices used for computing, communication, and data processing.
Learning Outcome #2: Demonstrate the ability to utilize modern engineering tools and statistical analysis methods that enable semiconductor manufacturing
Concepts: principles of semiconductor processing, testing, reliability analysis, packaging, circuit design, statistical methods, and supply chain management
Competencies: Demonstrate fundamental and working knowledge of different aspects of manufacturing of logic and memory devices as well as device integration and packaging. Demonstrate knowledge of different testing and characterization modalities and statistically driven reliability analysis. Demonstrate a working knowledge of the underlying semiconductor manufacturing supply chains

VI. REQUIRED SIGNATURES

Program Director/Main Proposer (print name and title): Krishna Muralidharan, Professor

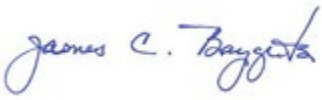
Program Director/Main Proposer signature: 
Date: 10/7/2023

Department Head (print name and title): Sammy Tin, Professor and Department Head

Department Head's signature:
Date: 10/7/2023

Associate/Assistant Dean (print name): James Baygents, Associate Dean, College of Engineering

Associate/Assistant Dean's signature:
Date: 09 November 2023



Dean (print name):

Dean's signature:
Date:

For use by Curricular Affairs:

Undergraduate:

Committee	Approval date
APS	
Undergraduate Council	
Undergraduate College Academic Administrators Council	
Faculty Senate	

Undergraduate:

Committee	Approval date
APS	
Undergraduate Council	
Undergraduate College Academic Administrators Council	
Faculty Senate	

THE UNIVERSITY OF ARIZONA

New Academic Program
PEER COMPARISON

Program name, degree, and institution	Proposed UA Program: Minor in Semiconductor Manufacturing (SM)	Rochester Institute of Technology Microelectronic Engineering Minor	Ohio State University Minor in Semiconductor Devices
Current number of students enrolled		12	5
Program Description	The University of Arizona College of Engineering is pleased to offer a College-wide Minor in Semiconductor Manufacturing (SM). The Minor provides students with critical interdisciplinary skills required to pursue a successful career in the broad area of semiconductor manufacturing and technology. The SM Minor's curriculum draws from a comprehensive collection of elective course offerings, providing the student a strong foundation in semiconductor processing, device design and fabrication, advanced packaging, and semiconductor supply chain management.	The microelectronic engineering minor provides basic integrated circuit fabrication skills to students from science and other engineering related disciplines whose career path may involve the semiconductor industry. RIT has one of the finest cleanrooms in the world specializing in undergraduate microelectronic education. This minor enables students to utilize these state-of-the-art facilities while they develop the skills they need for success in the industry.	A minor and embedded certificate in semiconductor devices will explore advanced semiconductor physics, electronic and optical properties of semiconductors, and the principles of new electronics devices as new technologies develop.
Target Careers	Process engineer Production engineer Manufacturing engineer Electrical engineer Materials engineer Device engineer Supply chain manager	Process engineer Manufacturing engineer Device engineer Electrical engineer	Process engineer Manufacturing engineer Electrical engineer Materials engineer Device engineer
Minimum # of units required	18 credit hours	15 credit hours	13 credit hours

Level of Math required	Calculus	Calculus	Calculus
Special requirements to declare/gain admission? (i.e. pre-requisites, GPA, application, etc.)	Complete all pre-requisite coursework; GPA of 2.5 or higher	3 prerequisite courses: 1. General chemistry for engineers 2. Calculus II 3. University Physics II	Open to all OSU students initially admitted to the university as part of and Associate or Bachelor Degree program. with GPA 1.7 or higher
Internship, practicum, or applied/experiential requirements?	No	No	No

Additional questions:

1. How does the proposed program align with peer programs?

The proposed Minor in Semiconductor Manufacturing has many similarities to the two peer Minor Programs at Ohio State University and Rochester Institute of Technology. The similarities include:

i. College hosting/offering the Minor: College of Engineering
ii. Target audience: Engineers are the primary set of targeted students. The overarching objectives of programs are to enable a steady and robust workforce pipeline for the semiconductor and microelectronics industry. (we note that semiconductors are the enabling material for microelectronics).
iii. Faculty expertise: Most if not all faculty involved in the Minor programs are from the respective Colleges of Engineering.
iv. Curriculum and thematic aspects: The curricula at the identified programs focus on technological and scientific aspects of semiconductors, and how semiconductors can be processed and manufactured as microelectronic devices.

2. How does the proposed program stand out or differ from peer programs?

While there are obvious similarities, we note that the proposed Minor in SM differs from the two peer programs by providing a more comprehensive curricula that includes courses in reliability engineering, advanced packaging, and supply chain management, thereby enabling a holistic educational experience for the students.

3. How do these differences make this program more applicable to the target student population and/or a better fit for the University of Arizona?

Semiconductor manufacturing in the state of Arizona is undergoing a transformational shift due to massive investments (~$50 Billion) from Intel and TSMC in setting up new 'Fab Plants'. In this regard, there is an urgent as well as a long-term need to develop robust and skilled workforce pipelines at the University of Arizona to keep up with the demand for engineers and technologists who will be required at semiconductor manufacturing corporations as well as the supporting engineering firms and businesses that are part of the semiconductor-ecosystem.

THE UNIVERSITY OF ARIZONA

BUDGET PROJECTION FORM

Note - the proposed minor provides an opportunity for students across the College of Engineering to collect existing courses related to semiconductor processing into a new minor focus. As such, no additional budget is required to provide this opportunity. While we do anticipate that having such a minor offering will be helpful for recruitment, we will be drawing on existing College of Engineering recruitment for the existing major programs and departments rather than initiating new activities focusing only on this minor.

Name of Proposed Program or Unit: Minor in Semiconductor Manufacturing

Budget Contact Person:	Projected 1st Year 20 _24__ - 20 25	2nd Year 20 _25__ - 20 26	3rd Year 20 _26__ - 20 27
METRICS			
Net increase in annual college enrollment UG	20	30	40
Net increase in college SCH UG	120	180	240
Net increase in annual college enrollment Grad			
Net increase in college SCH Grad			
Number of enrollments being charged a Program Fee			
New Sponsored Activity (MTDC)			
Number of Faculty FTE			
FUNDING SOURCES			
Continuing Sources			
UG AIB Revenue	103,800	155,700	207,600
Grad AIB Revenue			
Program Fee Revenue (net of revenue sharing)			
F and A AIB Revenues			
Reallocation from existing College funds (attach description)			
Other Items (attach description)			
Total Continuing	$ 103,800	$ 155,700	$ 207,600
One-time Sources			
College fund balances			
Institutional Strategic Investment			
Gift Funding			
Other Items (attach description)			
Total One-time	$ -	$ -	$ -
TOTAL SOURCES	$ 103,800	$ 155,700	$ 207,600
EXPENDITURE ITEMS			
Continuing Expenditures			
Faculty			
Other Personnel			
Employee Related Expense			
Graduate Assistantships			
Other Graduate Aid			
Operations (materials, supplies, phones, etc.)			
Additional Space Cost			
Other Items (attach description)			
Total Continuing	$ -	$ -	$ -
One-time Expenditures			
Construction or Renovation			
Start-up Equipment			
Replace Equipment			
Library Resources			
Other Items (attach description)			
Total One-time	$ -	$ -	$ -
TOTAL EXPENDITURES	$ -	$ -	$ -
Net Projected Fiscal Effect	$ 103,800	$ 155,700	$ 207,600

THE UNIVERSITY OF ARIZONA

College of Engineering
Department of Chemical and
Environmental Engineering

1133 E. James E. Rogers Way
P.O. Box 210011
Tucson, AZ 85721-001
Tel: (520) 626-9323
Fax: (520) 621-6018
http://www.che.arizona.edu/

TO: Whom It May Concern

FROM: Kimberly L. Ogden
Professor and Chair

RE: Semiconductor manufacturing minor

DATE: October 6, 2023

Thank you for your recent message concerning the development of a new College of Engineering minor in Semiconductor Manufacturing. As a home department for one required course (ChEE 415/515) that has been included in the initial curriculum listing for the minor, this letter serves to confirm our support for this new curriculum opportunity in the College. Further, the courses involved in the minor are regularly offered as part of our existing curriculum and seats are available in these courses.

Please contact me if you have any questions. I look forward to working together on this effort.

ELECTRICAL & COMPUTER ENGINEERING
College of Engineering
1230 E. Speedway Blvd.
P.O. Box 210104
Tucson, AZ 85721-0104

Ofc: 520.621.6193

ece.engineering.arizona.edu

COLLEGE OF ENGINEERING
Electrical & Computer Engineering

October 5, 2023

To Whom It May Concern:

Thank you for your recent message concerning the development of a new College of Engineering minor in Semiconductor Manufacturing. As a home department for two required courses that has been included in the initial curriculum listing for the minor, this letter serves to confirm our support for this new curriculum opportunity in the College. Further, the courses involved in the minor are regularly offered as part of our existing curriculum and seats are generally available in these classes.

If there are further questions, please do not hesitate to contact my office.

Sincerely,

Michael Wu
Kenneth Von Behren Professor and Department Head

DEPARTMENT OF SYSTEMS & INDUSTRIAL ENGINEERING
Engineering Building
1127 E. James E. Rogers Way
Tucson, AZ 85721
Ofc: 520-621-6561

https://sie.engineering.arizona.edu/

THE UNIVERSITY OF ARIZONA
College of Engineering

October 5, 2023

Thank you for your recent message concerning the development of a new College of Engineering minor in Semiconductor Manufacturing. As a home department for eight elective courses that have been included in the initial curriculum listing for the minor, this letter serves to confirm our support for this new curriculum opportunity in the College. Further, the courses proposed for the minor are regularly offered as part of our existing curriculum and seats are generally available in these classes.

Regards,

Sincerely,

Ricardo Valerdi

Ricardo Valerdi, Ph.D.
Distinguished Outreach Professor and Head
Department of Systems & Industrial Engineering
Faculty Athletics Representative