THE REGISTERED APPRENTICESHIP OCCUPATIONS AND STANDARDS CENTER OF EXCELLENCE (AOSC)

Semiconductor Processing Technician National Occupational Framework

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RAPIDS Code: 3096

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Introduction to Using This Document

Under the Registered Apprenticeship Technical Assistance Centers of Excellence award, the Urban Institute leads the Occupations and Standards work. One of the main objectives of Urban's project is to create high-quality, well-researched, consensus-based work process schedules that are nonproprietary and widely available. This document is a product of that work and contains three sections: the occupational overview, the work process schedule, and the related technical instruction.

The **occupational overview** is a general introduction, including alternative job titles, any prerequisites, and, if applicable, the total number of hours needed to complete a time-based or hybrid program.

The **work process schedule** outlines the major job functions, competencies, and/or hours an apprentice completes in a registered apprenticeship program. It outlines what apprentices are expected to learn on the job with the support of a mentor or journeyworker (a worker mastering the competencies of an occupation in a particular industry), including both core competencies and those deemed optional by experts in the field. The work process schedule is the foundational document guiding a program.

Urban works with numerous experts to ensure the content is thoroughly researched and vetted to reflect the expectations of industry, educators, labor unions, employers, and others involved in apprenticeship for this occupation. Sponsors and employers can use the work process schedule as their program standards with assurances it has been approved by experts in the field.

The **related technical instruction** presents considerations for the coursework that apprentices will undertake to supplement on-the-job learning. It is intended to serve as a reference to sponsors exploring their options for the accompanying classroom, virtual, or hybrid training.

How to Use the Work Process Schedule

Sponsors can adapt the work process schedule to accommodate their needs for competency- or time-based or hybrid programs. In a **competency-based** apprenticeship, sponsors assess apprentices' progress across core and optional competencies listed in the work process schedule. In a **time-based** apprenticeship, apprentices complete a predetermined number of hours across major job functions and the program overall. In a **hybrid** apprenticeship, sponsors monitor apprentices' hours spent on major job functions and assess their proficiency across competencies.

Each program type has a different method of assessment:

- **For a competency-based program**, apprentices engage in activities and make progress toward proficiency in the identified competencies. Sponsors overseeing apprentices' work assess their mastery of the outlined competencies using the following rating scale:

  4—Competent/proficient (able to perform all elements of the task successfully and independently)

  3—Satisfactory performance (able to perform elements of the task with minimal assistance)

  2—Completed the task with significant assistance

  1—Unsuccessfully attempted the task

  0—No exposure (note the reason—absence, skill isn't covered, etc.)

  The competencies may be completed in any order. Apprentices must perform at a level 4 or 3 in all competencies listed as "core" to complete the apprenticeship program successfully.

- **For a time-based program,** sponsors monitor apprentices' completion of hours in training across major job functions. The total number of hours recommended for this occupation is listed in the occupational overview and is based on guidance from the US Department of Labor. Generally, apprentices must have at least 2,000 hours overall for on-the-job learning, but occupations of greater complexity may require more hours. Sponsors will provide apprentices with supervised work experience and allocate the total number of hours across the major job functions to adequately train their apprentices.

- **The hybrid approach** blends both competency- and time-based strategies. Sponsors measure apprentices' skills acquisition through a combination of completing the minimum number of hours of on-the-job learning successfully demonstrating identified competencies. Sponsors will assess apprentices' proficiencies as described for competency-based programs with a rating scale of 0–4 for every core competency. Generally, apprentices have at least 2,000 hours overall for on-the-job learning, but occupations of greater complexity may require more hours. Sponsors will document apprentices' completion within a minimum and maximum range of hours assigned for each major job function.

Semiconductor Processing Technician Occupational Overview

Occupational Purpose and Context

Semiconductor processing technicians play a vital role in the manufacturing of electronic semiconductors, contributing to the production of various electronic devices, such as computer chips, sensors, and integrated circuits. Operating within highly controlled environments, semiconductor processing technicians engage in a series of specialized tasks aimed at transforming semiconductor materials into functional components. During these tasks, semiconductor processing technicians adhere to strict protocols outlined in work orders and control charts to ensure compliance with specifications. They monitor equipment operation, performing maintenance or adjusting controls as necessary to produce semiconductors with ideal electronic properties. Additionally, semiconductor processing technicians are responsible for prioritizing safety protocols, wearing protective equipment, and adhering to procedure to mitigate exposure to hazards.

Potential Job Titles

Semiconductor processing technician, semiconductor manufacturing technician, semiconductor maintenance technician

Apprenticeship Prerequisites

This occupation typically requires that an individual possess a high school diploma, GED, or equivalent.

Recommended Length of Apprenticeship

The recommended time for on-the-job learning in a semiconductor processing technician apprenticeship is 2,700 to 4,000 hours.

Work Process Schedule

Semiconductor Processing Technician

ONET Code: 51-9141

RAPIDS Code: 3096

Instructions for Use:

Competency-based programs: In the "performance level achieved" column of the work process schedule (see examples starting on the next page), assess apprentices' performances on each competency with the scale below. No monitoring of hours is required for this approach. See "Guidelines for Competency-Based, Hybrid and Time-Based Apprenticeship Training Approaches," US Department of Labor, Employment and Training Administration, Office of Apprenticeship, October 20, 2015, https://www.apprenticeship.gov/sites/default/files/bulletins/Cir2016-01.pdf.

4—Competent/proficient (able to perform all elements of the task successfully and independently)

3—Satisfactory performance (able to perform elements of the task with minimal assistance)

2—Completed the task with significant assistance

1—Unsuccessfully attempted the task

0—No exposure (note the reason—absence, skill isn't covered, etc.)

Time-based programs: In the "hours" row, specify the number of hours apprentices will fulfill for each job function. No assessment of competencies is required for this approach.

Hybrid programs: In the "performance level achieved" column, assess apprentices' performances on each competency using the 0–4 scale above. In the "hours" row, identify a range of hours apprentices should spend working on each major job function.

Job Function 1: Equipment operations		
Hours (time-based and hybrid programs only):		
Competencies	**Core or optional**	**Performance level achieved (0–4)** (competency-based and hybrid programs only)
A. Monitors or operates equipment or processes using control mechanisms	Core	
B. Enters commands or specifications into various pieces of equipment as necessary	Core	
C. Troubleshoots out of line equipment or reports to appropriate supervisor	Core	
D. Uses electronic test equipment, precision measuring instruments, microscope, and standard operating procedures properly	Core	
E. Sets, adjusts, and readjusts computerized or mechanical equipment controls to regulate process	Core	
F. Enters key commands into software or control panels to initiate semiconductor processing cycles	Optional	
G. Monitors or operates mounting devices to mount crystal ingots or wafers on blocks or plastic laminate; facilitates their positioning in the holding fixtures of sawing, drilling, grinding, or sanding equipment	Optional	
H. Loads and unloads equipment chambers or monitors overhead tracking system to safely transport finished product to storage or to area for further processing	Optional	

Job Function 2: Monitors, records, and uses fault detection control processes for data output		
Hours (time-based and hybrid programs only):		
Competencies	**Core or optional**	**Performance level achieved (0–4)** (competency-based and hybrid programs only)
A. Monitors processing, production, inspection information, and control charts per employer processes	Core	
B. Records processing, production, and inspection information, control charts per employer processes	Core	

C. Examines operational and production data over time using appropriate software	Core	
D. Interprets information from process control charts to identify outliers and uses employer processes to determine course of action	Core	
E. Applies relevant knowledge to continuously improve data maintenance procedures	Optional	

Job Function 3: Performs quality inspection and quality checks		
Hours **(time-based and hybrid programs only):**		
Competencies	**Core or optional**	**Performance level achieved (0–4)** (competency-based and hybrid programs only)
A. Performs preventative maintenance at appropriate intervals to reduce equipment failure	Core	
B. Performs predictive maintenance to identify defective or out-of-specification processed materials and follows procedures for tool specification or waste management	Core	
C. Monitors equipment using control charts to assess the performance of electronic systems and their components	Core	
D. Follows auditing procedures to identify any errors	Core	
E. Inspects materials, components, or products for defects	Optional	
F. Measures circuitry using organization-specific processes and tools, like electronic test equipment, precision measuring instruments, microscopes, and standard procedures	Optional	
G. Informs or creates a schedule for assessing performance of electronic systems and their components	Optional	
H. Informs or creates inspection auditing procedures and schedule for all materials	Optional	

Job Function 4: Utilizes appropriate technology		
Hours (time-based and hybrid programs only):		
Competencies	**Core or optional**	**Performance level achieved (0–4)** (competency-based and hybrid programs only)
A. Uses appropriate industrial control software	Core	
B. Uses proprietary software for data collection and control	Core	
C. Follows all cybersecurity procedures during technology use to protect intellectual property and other confidential information	Core	

Job Function 5: Exhibits effective communication and teamwork skills		
Hours (time-based and hybrid programs only):		
Competencies	**Core or optional**	**Performance level achieved (0–4)** (competency-based and hybrid programs only)
A. Utilizes effective communication skills with management, coworkers, and stakeholders	Core	
B. Works with colleagues and collaborates across teams to resolve design or operational issues	Core	
C. Practices conflict resolution within a team environment, escalating issues or concerns to supervisor as needed and following appropriate hierarchy	Core	
D. Exhibits proficiency with company-identified software for communications of both technical and professional writing	Core	

Job Function 6: Follows appropriate instructions to complete assigned tasks to industry standards		
Hours (time-based and hybrid programs only):		
Competencies	**Core or optional**	**Performance level achieved (0–4)** (competency-based and hybrid programs only)
A. Follows instructions, blueprints, work orders, and other schematics to complete assigned tasks to meet business needs	Core	

B. Performs assigned tasks with system process checklist or instructions open or at hand	Core	
C. Calculates process parameters in line with production specifications	Optional	

Job Function 7: Ensures safety and security of equipment and personnel		
Hours (time-based and hybrid programs only):		
Competencies	**Core or optional**	**Performance level achieved (0–4)** (competency-based and hybrid programs only)
A. Maintains a high level of knowledge of relevant equipment, and company policies and procedures	Core	
B. Demonstrates proper company donning and doffing procedures for Personal Protective Equipment	Core	
C. Follows all Cleanroom Environment Protocols to maintain cleanroom-controlled environment	Core	
D. Adheres to any safety alarms (gas, fire, etc.)	Core	
E. Locates and uses safety data sheets when appropriate dependent upon materials	Core	
F. Notifies supervisor and follows chain of command for communicating equipment repair or maintenance needs	Core	
G. Follows protocols for IP security, phishing, and cyber-awareness	Core	
H. Safely handles chemicals and gases by following organizational procedures, adhering to safety signs, and understanding their uses	Optional	

Job Function 8: Exhibits model-based problem-solving skills		
Hours (time-based and hybrid programs only):		
Competencies	**Core or optional**	**Performance level achieved (0–4)** (competency-based and hybrid programs only)
A. Recognizes that there is a problem based on the situation's deviation from the norm	Core	

B. Analyzes information to evaluate the problem and available solutions	Core	
C. Practices active listening and creative thinking when handling challenges or inquiries	Core	
D. Resolves challenges within a team setting	Core	
E. Escalates challenges to the appropriate personnel	Core	

Job Function 9: Performs wafer handling		
Hours (time-based and hybrid programs only):		
Competencies	**Core or optional**	**Performance level achieved (0–4)** (competency-based and hybrid programs only)
A. Cleans semiconductor wafers using cleaning equipment, such as chemical baths, chemical cleaners, or ultrasonic scrubs	Optional	
B. Places semiconductor wafers in processing containers or equipment holders, using appropriate tools like a vacuum wand or robot	Optional	
C. Cleans and maintains equipment, including replacing etching and rinsing solutions and cleaning bath containers and work area while following all safety procedures	Optional	

Related Technical Instruction

Semiconductor Processing Technician

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RAPIDS Code: 3096

Program approach type (time-based, competency-based, hybrid):

Instructions for Use:

Registered apprenticeships must include at least 144 hours of related technical instruction (RTI). Courses offered by accredited colleges and universities may be assigned a credit hour determination rather than a contact hour determination. In general, an academic credit unit is the equivalent of 15 clock hours of instruction.

Development and Use of This RTI Outline: Employers and academic institutions may approach RTI in markedly different ways. Our goal was not to identify the single best way to provide RTI or to identify a single provider whose content we deemed to be superior. Instead, our goal was to survey numerous education providers, including employers, institutions of higher education, high schools, private continuing education providers, labor organizations, professional associations and, in some cases, municipalities that provide worker training, to identify topics or courses common among those providers that align with the job functions included in this work process schedule. Those common topics or courses are reflected in the RTI outline provided below, which may be useful in developing your RTI program or communicating your needs to an educational partner.

Licensure or certification requirements: None
Degree requirements for licensure or certification, if applicable: Not applicable
Accreditation requirements of instructional provider for licensure or certification, if applicable: Not applicable
Anticipated changes in licensure or certification requirements, if known: None known
Examples of state licensure or certification requirements: None known

Examples of RTI providers for this occupation

Professional associations and labor organizations: The Association for Computing Machinery (ACM) offers a variety of educational resources for students and professionals in computing and informational technologies, including online books, courses, and training videos (https://www.acm.org/education/about-education). These resources are available to paid ACM members.

Military: Many opportunities are available for veterans or soon-to-be-veterans to prepare for careers in semiconductor technologies (https://ny-creates.org/vetstep). However, the military does not directly offer education or training opportunities to civilians.

Federal: Not applicable

States/municipalities: Not applicable

Colleges and universities: Many accredited colleges and universities offer coursework and educational programming leading to relevant degrees and certifications for semiconductor processing technicians.

No-cost online providers: Purdue University offers a cost-free online foundational course in semiconductor fabrication (https://engineering.purdue.edu/online/programs/masters-degrees/semiconductors). Successful participants receive a joint certificate from Purdue University, the University of Texas at Austin, and Intel. This course is informational and will not lead to a certificate or degree.

Continuing education or specialty education providers: The Institute of Electrical and Electronics Engineers (IEEE) offers continuing education courses in various topics, including advancing semiconductor innovations (https://iln.ieee.org/public/TrainingCatalog.aspx).

Prerequisite knowledge, skills or experience typically required by RTI providers for this occupation

RTI providers may require individuals to demonstrate their manual dexterity and attention to detail.

Employer Onboarding

Hours: 1–3

Sample learning objectives

- Explain the mission of the employer's organization.
- Explain the organizational structure of the employer's organization.
- Explain the chain-of-command in the employer's organization, as well as the steps and employee should take to report concerns about practices or behaviors in the workplace or to share ideas about how to improve processes or efficiencies.
- Explain the employer's policies for workplace conduct and ethics.
- Explain the employer's policies regarding medical leave and vacation.

- Explain the requirements of the apprenticeship program and the role of the apprentice in the organization's business activities.

Technical Mathematics

Hours: 35–45 (these hours correlate with a typical three-credit technical mathematics course)

Sample learning objectives

- Perform calculations involving addition, subtraction, multiplication and division.
- Convert fractions to decimals and decimals to fractions; add, subtract, multiply and divide fractions and decimals and calculate proportions and ratios.
- Calculate rates of change.
- Calculate percentages and use percentages to determine the amount of materials to be used.
- Measure properly using a tape measure, convert between measurement systems (such as English to metric), and determine unknown measurements using algebra, geometry or trigonometry.
- Use scientific notation and manipulate numbers expressed with exponents.
- Use algebraic techniques to solve for unknown variables, solve linear equations, follow correct order of operations, use the distributive law, solve systems of equations.
- Define the various types and components of triangles, determine interior and exterior triangle angles, use the Pythagorean Theorem to solve problems for right triangles, and determine perimeter and area of triangles.
- Identify squares, rectangles, parallelograms, trapezoids, hexagons, octagons, pentagons, and quadrilaterals and calculate their perimeter and area.
- Calculate the diameter, radius, circumference, and arc of a circle.
- Use the Laws of Sines and Cosines to determine angles.
- Define and use mean, median, mode and standard deviation.
- Create and interpret graphs.

Fundamentals of Electronics
Hours: 30–45
Sample learning objectives ▪ Explain the principles of voltage and current and how they apply to electrical transmission. ▪ Differentiate between cathodes and diodes. ▪ Describe atomic structure, the role of electrons, and the process of energy release. ▪ Describe electron current flow and differentiate between AC and DC circuits. ▪ Differentiate between direct and alternating voltage and current sources. Discuss the process by which voltage is converted to current. ▪ Explain the importance of grounding. ▪ Explain the different types of electron emissions. ▪ Define and explain the purpose of semiconductors, amplifiers, and digital circuits. ▪ Explain the principles of rectification, amplification, control, and generation. ▪ Discuss the conversion of light into electricity and electricity into lights. ▪ Explain and properly use fundamental laws of physics/electricity including Ohm's Law, Kirchoff's laws, Thevenin's theorem, and Norton's theorem. ▪ Identify and explain the function of diodes, transistors, and integrated circuits (active components), as well as resistors, capacitors, and inductors (passive components). ▪ Differentiate between discrete and integrated components and explain how each is used in electronics and electronics assemblies. ▪ Explain the function and structure of semiconductors and differentiate between the different types of commonly used semiconductors. ▪ Discuss the function and structure of semiconductor diodes. ▪ Describe the purpose and give examples of special purpose diodes. ▪ Discuss the structure, function, and purpose of transistors. ▪ Explain the key safety protocols used by individuals who work with electricity to safeguard themselves, other workers, and property. ▪ Explain the purpose of lock out/tag out procedures and demonstrate the ability to properly perform a lock out/tag out operation.

Clean Room Standards and Operations

Hours: 5

Sample learning objectives

- Describe the role of cleanrooms and why they are important to the semiconductor processing industry.
- Describe the types of filters that are used to clean and decontaminate air.
- List and describe the different classifications of clean rooms and indicate which type of clean room is needed for chip production and electronic assembly.
- Explain how contamination is measured and what levels of contamination are permissible in the semiconductor industry.
- Explain the role of personal protective devices to reduce the risk of contamination.
- Explain the process of cleaning a clean room and select materials and processes to perform this function.

The Semiconductor Industry

Hours: 20

Sample learning objectives

- Define conductors and insulators and provide examples of materials that function in each capacity.
- Describe the various processes used in the semiconductor industry, including design, production, assembly, inspection and distribution.
- Describe the various types of companies that are part of the semiconductor industry: integrated device manufacturer (IDM), foundry, and fabless. Give examples of well-known companies that exist in each space.
- Explain the role of design houses in chip design and manufacturing.
- Explain the properties of semiconductors that make them ideal for electronics applications.
- List the types of devices that rely on semiconductor technology to function.
- Define integrated circuits (IC) and microchips and describe the elements and compounds used to produce them.
- Explain the composition and role of a transistor and describe how transistors come together on a semiconductor chip to perform a function.
- Compare and contrast semiconductor “fabless” firms with semiconductor “foundries” and integrated device manufacturers (IDMs)
- Describe the role of IP companies in licensing technologies to fabless companies.
- Describe the role of objective structured assessments of technical skills (OSATs) in improving chip reliability and performance.

- Discuss significant advances as well as shortfalls in semiconductor research and development.
- Discuss the challenges that the US semiconductor industry faces as it competes with global semiconductor innovators.
- Describe the global semiconductor supply chain and list current vulnerabilities in the semiconductor marketplace.
- Explain the purpose and goals of the US CHIPS and Science Act.
- Discuss the relative strengths, weaknesses, and policy goals of the US and other semiconductor markets.
- Describe the world energy demands created by computers, mobile devices, and data centers.

Semiconductor Production

Hours: 40–50

Sample learning objectives

- Explain the process by which sand is turned into a silicon rod or ingot and then sliced into wafers.
- Explain the process by which silicon wafers are polished to remove surface defects.
- Explain how oxidation is used to make the wafers conductive.
- Explain the process of photolithography to create a circuit pattern on wafers, including through the use of photomasks and photoresist materials.
- Describe the etching process using liquid/chemical (wet etchants) or gas etchants (dry etchants) to remove unnecessary materials.
- Describe the role of thin films to provide insulation between the various layers of circuits on a wafer.
- Describe the process of deposition and ion implementation and explain its importance to circuit function.
- Describe the metal wiring process which applies current to the circuit.
- Explain how the diameter of the wafer determines the number of chips that can be placed on it.
- Explain the process of electrical die sorting (EDS) and how it is used to make sure that each chip has reached the necessary quality level.
- Explain how wafers are cut into individual semiconductor chips are bonded, wired, and molded to package the semiconductor chip.
- Explain the final testing that takes place to ensure quality of the processed chip.
- Explain how chip yield is calculated and what yield defines a high-quality chip.

Relevant military experience
35F MOS - Army Special Electronic Devices Repairer* *The closest related occupation in the military is Army Special Electronic Devices Repairer with code 35F, which covers occupational functions that are relevant for semiconductor processing technicians, such as performing maintenance or repair on specialty electronic devices, including semiconductors and related machinery.

Occupational Insights
Women and people of color are underrepresented in the semiconductor industry. In the US, 25 percent of computing jobs and 14 percent of engineering-related jobs are occupied by women. In the tech workforce, 7 percent of workers are Black, and 8 percent are Latinx. The SEMI Foundation has implemented initiatives to attract and recruit talent to the semiconductor industry: http://www.semi.org/en/workforce-development.

Works Consulted

"SAM-TAP Semiconductor and Advanced Manufacturing Technician Apprenticeship Program," National Institute for Industry and Career Advancement, accessed March 15, 2024, https://www.niica.org/sam-tap.

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