MET-1060: SEMICONDUCTOR MANUFACTURING PROCESSES AND CLEANROOMS

Cuyahoga Community College

Viewing: MET-1060 : Semiconductor Manufacturing Processes and Cleanrooms

Board of Trustees:
January 2024

Academic Term:
Fall 2024

Subject Code
MET - Mech Eng/Manuf Ind Eng Tech

Course Number:
1060

Title:
Semiconductor Manufacturing Processes and Cleanrooms

Catalog Description:
Exploration of career opportunities within the semiconductor industry. Learn how people effectively work in a cleanroom environment and adhere to chemical safety best practices. Covers how semiconductor wafers are manufactured and processed to become an integrated circuit used in a variety of industries. Students will demonstrate problem-solving, critical thinking and communication skills while learning how the microelectronic manufacturing environment focuses on punctual delivery of products and tasks, according to the Standard Operating Procedure (SOP)/checklist.

Credit Hour(s):
3

Lecture Hour(s):
3

Lab Hour(s):
3

Requisites

Prerequisite and Corequisite
None

Outcomes

Course Outcome(s):
Explore career opportunities in the semiconductor industry and work efficiently and safely in a microelectronic manufacturing environment with a focus on on-time delivery of products and completion of tasks in a digital checklist or procedure.

Objective(s):
1. Describe semiconductor processing.
2. Explore career opportunities and identify local semiconductor organizations.
3. Describe the typical work environment of semiconductor manufacturing technicians.
4. Differentiate processes performed at a semiconductor fabrication facility from a foundry used in the manufacturing of integrated circuits (IC).

Course Outcome(s):
Demonstrate the capability of working safely in a cleanroom environment by donning, wearing, and doffing a cleanroom suit (bunny suit).

Objective(s):

1. Explain the purpose of a cleanroom in the semiconductor industry.
2. Demonstrate effective use of equipment and/or tools in the cleanroom environment.
3. Describe process for donning and doffing PPE and test that it is functioning (operating) correctly.
4. Interpret a Safety Data Sheet and National Fire Protective Agency Diamond.
5. Explain appropriate use of PPE for handling and storing chemicals and responding to spills/exposure.
6. Describe gowning protocol safety and typical visual and audio safety indicators.
7. Explain purpose and use of bunny suit in a cleanroom environment.
8. Describe maintenance processes associated with a cleanroom as well as overall cleanliness of the technician.

Course Outcome(s):

Articulate how a semiconductor wafer is manufactured and processed into an integrated circuit.

Essential Learning Outcome Mapping:

Oral Communication: Demonstrate effective verbal and nonverbal communication for an intended audience that is clear, organized, and delivered effectively following the standard conventions of that language.
Written Communication: Demonstrate effective written communication for an intended audience that follows genre/disciplinary conventions that reflect clarity, organization, and editing skills.

Objective(s):

1. Identify the basic processes, tools and chemistry involved in semiconductor manufacturing.
2. Explain the history of integrated circuit technology with a focus on function, size, power usage, and application.
3. Articulate a high-level broad overview of semiconductor manufacturing.
4. Describe a semiconductor product, such as a silicon wafer, and how becomes part of other products/technologies.
5. Complete a non-quantitative introduction to electricity.
6. Review the Neil Bohr model atom and the relation to electricity.
7. Describe industrial chemicals and gases in use in the semiconductor industry.
8. Describe the concept of sizes used in the semiconductor processing industry.
9. Describe how a wafer is made.
10. Review elements on the Periodic Table of the Elements relevant to the semiconductor industry.
11. Describe integrated circuit (IC) devices contain dopants of both n and p type.
12. Articulate the Czochralski process of going from sand to ingot to silicon.
13. Describe the size of wafers used in Integrated Circuits (IC) and MEMS devices.
14. Explain the typical timeline of creating a multi-layer integrated circuit.
15. Describe the final steps in the wafer's IC process.
16. Describe how the wafer is diced.
17. Describe packaging and the backend process.

Course Outcome(s):

Articulate chemistry and safety awareness in semiconductor manufacturing including gases used in plasma, gases used in thin film deposition, and chemistry used to clean silicon wafers.

Essential Learning Outcome Mapping:

Critical/Creative Thinking: Analyze, evaluate, and synthesize information in order to consider problems/ideas and transform them in innovative or imaginative ways.

Objective(s):

1. Describe industrial chemicals and gases.
2. Describe the thin film sputtering process including a broad introduction to DC sputtering, RF sputtering, and ion beam sputtering/assisting.
3. Describe chemistry used in manufacturing processes to etch and clean semiconductors.
4. Describe/demonstrate removal of water and skin oils from wafer processing.
5. Describe the application of a spin rinse drier to silicon wafers.
6. Describe chemistry used in thin film deposition.
7. Describe/demonstrate high-level overview of thin film processing.
8. Describe a mask and scale of the artwork on the mask.

9. Describe a fiducial is and how it's used for alignment.
10. Describe the maintenance on photolithography systems.
11. Describe chemistry used to etch & clean semiconductors.
12. Describe photolithography and purpose of the photoresist.
13. Explain the concept and safety of wavelengths of light.
14. Explain chemistry used in photoresist.
15. Describe the photoresist process.
16. Explain photolithography processing, exposure, and development.
17. Describe oxidation both wet and dry.
18. Describe etching and how etching works with photolithography.
19. Explain wet chemical etching and chemical safety.
20. Differentiate Anisotropic and Isotropic etches.
21. Identify the basic processes, tools and chemistry involved in semiconductor manufacturing dry etching.
22. Describe how plasma is used to clean or dry-etch a wafer and the overall process that uses vacuums.
23. Describe cleaning and maintenance processes around plasma RIE systems and their associated vacuum systems.
24. Differentiate historical methods of diffusion from newer processes of diffusion.
25. Explain the process of ion implantation.
26. Explain maintenance processes around diffusion systems and associated vacuum systems.
27. Describe the chemistry used in semiconductor diffusion.
28. Describe Plasma Enhanced Chemical Vapor Deposition (PECVD).
29. Explain materials processed using PECVD.
30. Describe atomic layer deposition.
31. Describe thin film evaporation using thermal and electron beam (e-beam) processing.
32. Explain maintenance required on vacuum systems.
33. Explain safety practices for major gases and chemicals used in PECVD.
34. Describe how cleaning, thin film deposition, etching, and photolithography are used to create multiple layers that constitute the fabrication of an integrated circuit (IC).

Methods of Evaluation:

1. Tests
2. Quizzes
3. Laboratory Assignments/Reports
4. Homework
5. Projects

Course Content Outline:

1. Introduction to the Semiconductor Industry
   a. How Microchips are Made
   b. History of Transistors
   c. Future of Semiconductors
   d. Introduction to Semiconductor Industry
   e. Innovation
2. Introduction to Cleanrooms
   a. Cleanroom Safety
   b. Cleanroom Gowning
   c. Cleanrooms and ISO
   d. SMART Facility Location and Description
   e. SMART Microsystems
3. Nanotechnology, Semiconductor History and Fabrication Process Overview
   a. Introduction to Nanofabrication
   b. Nanofabrication History
   c. Cleanroom Best Practices
   d. Nanofabrication Processes
   e. History of Transistor Applications

4. Semiconductor Materials Science
    a. Silicon
    b. Dopants
5. Semiconductor Devices-Ingot & Wafer Fabrication
6. Wafer Cleaning and Thin Film Sputtering
    a. Semiconductor Wafer Cleaning - Thin Film Supporting
    b. Semiconductor Wafer Cleaning - Thin Film Disposition
7. Lithography
    a. Semiconductor Lithography
    b. Datasheets
8. Wet Etching
    a. Introduction to Wet Etching
    b. Aluminum Etchant
9. Dry Etching
10. Diffusion Process
    a. Introduction to Diffusion Process
    b. Ion Implantation
11. Thin Film Deposition-PVD & CVD
12. Multi-Layer IC and Backend Process
    a. Dicing
    b. Packaging

Resources

Lian, Yaguang. *Semiconductor Microchips and Fabrication: A Practical Guide to Theory and Manufacturing*. 1st ed. Wiley, 2022.

Richard, Corey. *Understanding Semiconductors: A Technical Guide for Non-Technical People*. 1st ed. Apress, 2022.

Whyte, William. *Cleanroom Technology - Fundamentals of Design, Testing and Operation*. 3rd ed. Independent, 2023.

Resources Other

OACC Semiconductor Collaboration Network Course - Semiconductor 101

https://ohiolink.oercommons.org/courseware/lesson/2706/overview (https://ohiolink.oercommons.org/courseware/lesson/2706/overview/)

Top of page

Key: 5195