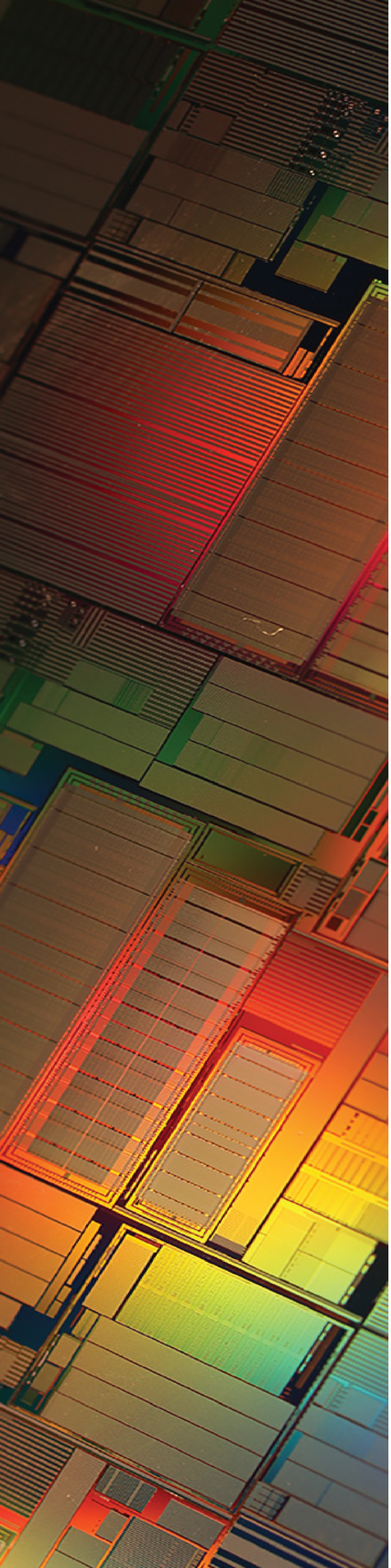

semi | SEMI FOUNDATION

Learning About Semiconductor Technology

INTRODUCTION TO SEMICONDUCTOR PROCESSING

MIDDLE SCHOOL SCIENCE
HIGH SCHOOL SCIENCE

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Introduction to Semiconductor Processing

Lesson Overview	Career Highlight
Students will learn the basic steps that a semiconductor device undergoes as it transforms from a raw material to a useful item they utilize constantly throughout the day. We will identify and explain its life cycle, from a silicon ingot to a microchip that can be installed in a complex electronic device, including global transportation and logistical challenges.	Computer Hardware Engineer Industrial Machinery Technician Supply Chain Manager Semiconductor Process Technician

STEM Course Connections	21st Century Skills	CTE Alignment
Middle School Science High School Chemistry High School Biology High School Physics High School Engineering	Critical Thinking Asking Questions	Manufacturing and Product Development Pathway

Engineering Activity	
Science and Engineering Practice #1	Students will participate in a gallery walk and interactive board game to learn about the semiconductor manufacturing process.

Materials

- [Case Study Handout]
- Dice
- [Gallery Walk Printout]
- [Student Handout]
- [Semiconductor Process Board Game]
- Tape

Essential Questions

1. How does the manufacturing of microchips impact the global economy?
2. How does the global economy impact the manufacturing of microchips?
3. How can these precise and delicate manufacturing methods be employed effectively in other disciplines?

Prerequisite Knowledge
Students should have a basic knowledge of what a microchip is, and the uses for microchips within the semiconductor industry. Recommended HTU lessons include: Introduction to Semiconductors; What are Semiconductors?; Education and Career Pathways; Semiconductor Industry Introduction + Pathways

Engage

Cell Phone Usage (10 mins)

- In Section A of the Student Handout, students will pair off and answer the following questions:
    - How many hours do you think you spend on your phone per week? *Answers will vary*
    - How much screen time does your phone report? *Answers will vary*
    - Is this above or below the average screen time per average person? *70 hours per week*
    - What percentage of your life is spent using your cell phone? *Answers will vary*
- As a class, discuss averages, share any surprising data that students calculated.

Life Before Cell Phones (15 mins)

- Imagine what life was like before the invention of cell phones. How would you get around? How would you communicate with friends and family?
- Students will write a short first-person narrative in Section B of the Student Handout about their life as if they were living in the pre-cell phone era.
- Students will share their narrative in small groups or with a partner.

Explore

Microchips Make Phones Work (10 mins)

- Students watch the video as a class and answer the following questions in Section C of the Student Handout:
    1. What is the chemical compound in which Silicon naturally occurs? *Silicon Dioxide*
    2. What is the purpose of Dopants in a semiconductor processing plant? *To increase electrical conductivity of parts of the semiconductor.*
    3. What conclusions can you draw about the types of machinery used in the semiconductor treatment process? *They are very precise and highly technically complex.*
- Students will share their responses as a class.

Semiconductor Manufacturing Process Explained (10 mins)

- Students watch the video as a class and answer the following questions in Section D of the Student Handout:
    1. What are the 8 key steps in the semiconductor manufacturing process? *Wafer manufacturing, oxidation, photolithography, etching, deposition/ion implantation, metal wiring, electrical die sorting, and packaging.*
    2. In the Etching phase, what is the difference between “wet etching” and “dry etching?” *Wet etching uses a liquid chemical solution, while dry etching uses gas or plasma instead.*
    3. What is the step that gives the Silicon wafer its electrically conductive qualities? *Deposition and ion implantation (also called “doping”).*
- Students will share their responses as a class.

Academic Vocabulary (10 mins)

- Students will develop their academic vocabulary in Section E of the Student Handout.
    - Wafers
    - Semiconductors

- Microchip
- Supply chain
- Silicon Mining
- Ingot Processing
- Wafer Manufacturing
- Cleaning
- Oxidation Process
- Photolithography
- Etching
- Deposition
- Interconnection
- Testing
- Packaging

Explain

Semiconductor Company Case Study (35 mins)

- Each student within a group of five will be provided with a case study company.
- Students will spend approximately 10 minutes reading from the provided materials and answering the questions in Section F of the Student Handout.
- Intel:
  1. What is the company's primary purpose? *The company produces microprocessors.*
  2. What do semiconductors have to do with your company? *Semiconductors are the basis of their main product.*
  3. What can your company do to further the development of more advanced semiconductors or the semiconductor field as a whole? *They are working to produce smaller and more efficient microchips for electronic devices.*
- Apple:
  1. What is the company's primary purpose? *The company produces computers and end-user devices.*
  2. What do semiconductors have to do with your company? *The processors that run the computers are semiconductor-based.*
  3. What can your company do to further the development of more advanced semiconductors or the semiconductor field as a whole? *They are currently creating their own microprocessors in-house for their own devices.*
- Tesla:
  1. What is the company's primary purpose? *The company produces cars.*
  2. What do semiconductors have to do with your company? *The self-driving function requires a great deal of processing power, which is provided by semiconductor-based microchips.*
  3. What can your company do to further the development of more advanced semiconductors or the semiconductor field as a whole? *The advent of self-driving cars is only possible because of semiconductors, so by improving their computing power, they can make self-driving cars more prevalent.*
- Google:
  1. What is the company's primary purpose? *The company disseminates information and produces some end-user devices.*
  2. What do semiconductors have to do with your company? *They are required for the hardware of all of their products.*
  3. What can your company do to further the development of more advanced semiconductors or the semiconductor field as a whole? *They are conducting research into artificial intelligence, which can be used to problem solve much more quickly than humans.*
- DARPA:

1. What is the company's primary purpose? *The company works in research and development for national defense projects.*
2. What do semiconductors have to do with your company? *Many of the systems utilized by DARPA have complex electronics that rely on semiconductor components.*
3. What can your company do to further the development of more advanced semiconductors or the semiconductor field as a whole? *They are researching electronics manufacturing practices that may improve the industry's ability to produce new semiconductor components.*

- Students will then extend their research by going online and answering the questions about their case study company in Section F of the Student Handout.
    1. What is your company most widely known for? *Answers will vary.*
    2. What types of jobs are available at your company? *Answers will vary.*
    3. What is one interesting fact about your company that you think the rest of your class might not know? *Answers will vary.*
- Once the research has been conducted, students will take turns sharing about their case studies and will take notes in Section F of the Student Handout.

Semiconductor Gallery Walk (55 mins)

Teacher Note: Print out the twenty Semiconductor Gallery Walk sheets and tape each of them to the walls around the classroom. They should be evenly spaced out to the maximum extent possible to prevent students from bunching up around them.

- Students will each start at a station (pair students into groups of 2 or 3 if class size exceeds 20)
- Students will spend 2 minutes at each station reading the description and will write 1-2 sentences in Section G of the Student Handout summarizing what they have read.
- After the Gallery Walk, students will answer reflection questions on Section G of the Student Handout.
    1. What part of the semiconductor process was most surprising to you? *Answers will vary.*
    2. What part of the semiconductor process is the most interesting to you? *Answers will vary.*
    3. What questions do you still have about the semiconductor process? *Answers will vary.*

Elaborate

Semiconductor Manufacturing Board Game (40 mins)

- *Teacher Note: To prepare the game boards, print out the instructions and read through the set up. The cards should be cut out, folded over and glued, stapled, or taped together. They can also be cut and pasted onto index cards. The teacher should do this ahead of class.*
- Group students into teams and distribute board games to each group.
- Allow students time to set up and play the game.
- After the game is over, students will answer reflection questions in Section H of the Student Handout:
    1. What did you learn about the semiconductor manufacturing process? *Answers will vary.*
    2. What part of the semiconductor manufacturing process would you like to learn more about? *Answers will vary.*

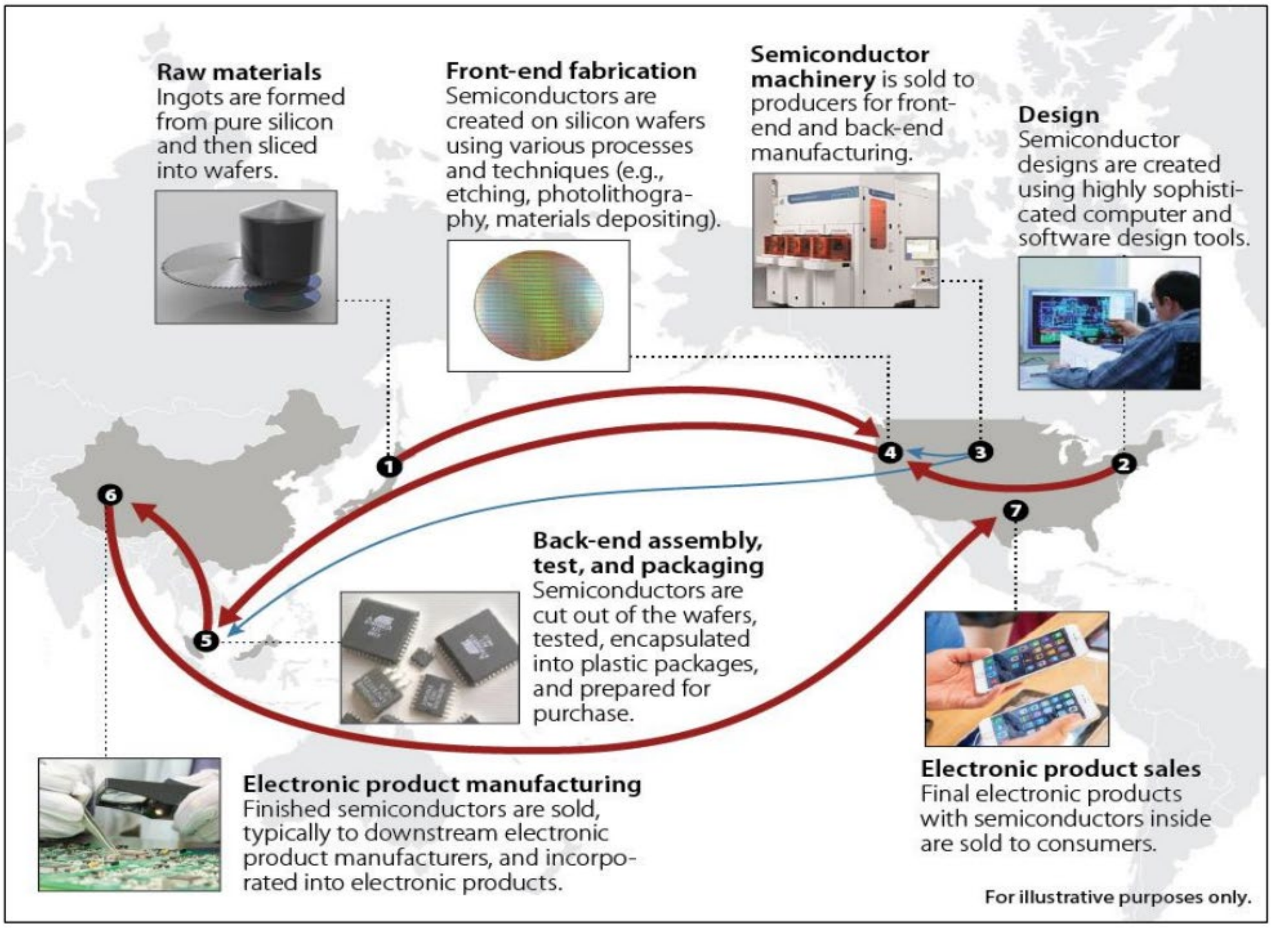
Evaluate

Reflect on the Semiconductor Manufacturing Process (10 mins)

- Students will respond to the following reflection questions in Section I of the Student Handout:
    1. How does the manufacturing of microchips impact the global economy? *Cheaper and more massively-produced microchips will lead to cheaper and more widespread technological devices.*

2. How does the global economy impact the manufacturing of microchips? *The supply chains of consumer electronics products rely heavily on the available supply of raw materials, as well as developmental capability of the chip manufacturers.*

Figure 5. Typical Global Semiconductor Production Pattern



Source: CRS, adapted from information provided by SIA.

- Use the visual in Section I of the Student Handout to illustrate the steps in the process.
- Share responses as a whole class.

Extend

Students can learn more about the individual steps in this process by engaging with other HTU lessons.

CA NGSS Standards

HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

CTE Alignment

B11.0 Understand and defend the purposes and processes of inspection and quality control in machining and forming processes.

D1.0 Understand the basic product design and development process as it relates to the design of a product, line of products, system design, or services.

D8.0 Understand and apply basic business and entrepreneurial principles and identify potential markets and/or other business opportunities for distribution of the product.

Resources

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Name		Date	

Introduction to Semiconductor Processing Student Handout

Directions: Students read the prompts and answer in complete sentences in the box to the right.

Engage

Section A: Cell Phone Usage	
How many hours do you think you spend on your phone per week?	
How much daily screen time does your phone report?	
Is this above or below the average screen time per average person?	
What percentage of your life is spent using your cell phone?	
Section B: Life Before Cell Phones	
Imagine what life was like before the invention of cell phones. How would you get around? How would you communicate with friends and family?	

Explore

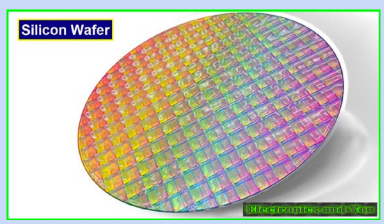
Section C: Microchips Make Phones Work	
What is the chemical compound in which Silicon naturally occurs?	

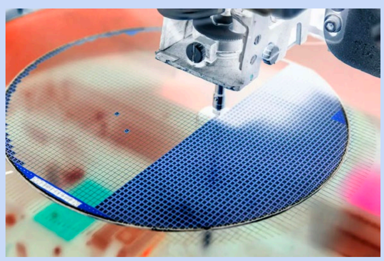
What is the purpose of Dopants in a semiconductor processing plant?	
What conclusions can you draw about the types of machinery used in the semiconductor treatment process?	

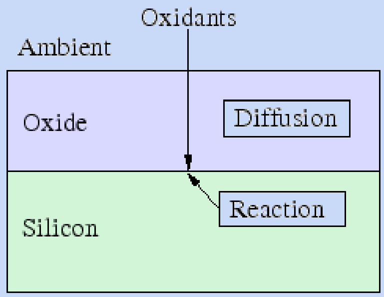
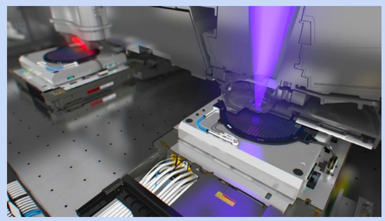
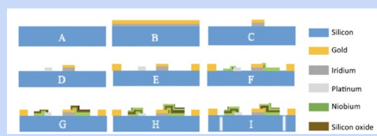
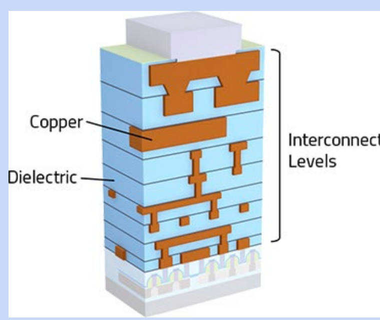
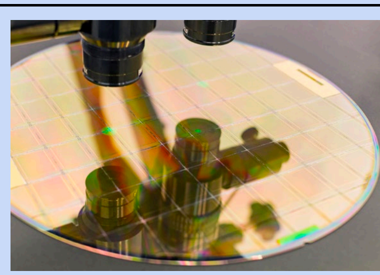
Section D: Semiconductor Manufacturing Process Explained

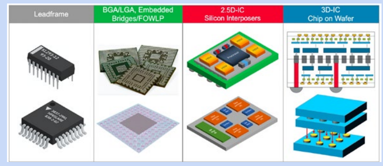
What are the 8 key steps in the semiconductor manufacturing process?	
In the Etching phase, what is the difference between "wet etching" and "dry etching?"	
What is the step that gives the Silicon wafer its electrically conductive qualities?	

Section E: Academic Vocabulary

Word	Definition	Image	Description in Own Words
Wafers	A thin slice of crystal semiconductor, such as a material made up from silicon crystal, which is circular in shape.		
Semi-conductors	A substance, such as Silicon or Germanium, with electrical conductivity intermediate between that of an insulator and a conductor.		
Microchip	A tiny slice of semiconducting material, generally in the shape of a few square millimeters long, cut from a larger wafer of the material, on which a transistor or an entire integrated circuit is formed.		

Supply chain	The series of growers, manufacturers, distributors, shippers, etc., involved in producing goods of a particular kind and bringing them to market.		
Silicon mining	Silicon is chiefly obtained from quartz, which is not much more difficult to mine than scooping up sand. Silicon is also obtained from the minerals mica and talc.		
Ingot processing	A silicon ingot is a salami-shaped bar of silicon, which is a single crystal, technically known as a "boule." The ingot is the first step in chip making.		
Wafer manu-facturing	A wafer is a slice taken from a salami-like silicon crystal ingot. The larger the wafer, the more chips produced at the same time. The production process comprises a series of photomasking, etching and implantation steps that can take days and weeks to create the final product.		
Cleaning	Dry and wet cleaning work involves using chemical solutions or gases to successfully remove dust, metal ions, and organic impurities that have remained on the wafer.		

Oxidation Process	The oxidation process creates an SiO2 layer, which serves as an insulating layer that blocks leakage current between circuits. The oxide layer also protects the silicon wafer during the subsequent ion implantation and etching processes.		
Photo-lithography	A process whereby integrated and printed circuits are produced by photographing the circuit pattern on a photosensitive substrate and chemically etching away the background.		
Deposition	A series of processes where materials at atomic or molecular levels are deposited on the wafer surface as a thin layer to contain electrical properties.		
Inter-connection	Through multiple stages of masking, etching, and diffusion, the sublayers on the chip are created. The final stage lays the top metal layer (usually aluminum), which interconnects the transistors to each other and to the outside world.		
Testing	Each chip is tested on the wafer. Bad chips are marked for elimination while the good ones are sliced out, placed into packages and connected by tiny wires or solder balls. The package is then sealed and tested as a complete unit.		

Packaging	The housing that integrated circuits (chips) are placed in. The package is then either plugged into (socket mount) or soldered onto (surface mount) the printed circuit board.		

Explain

Section F: Semiconductor Company Case Study	
With the materials provided by your teacher, answer the following questions.	
Company Name:	
What is the company's primary purpose?	
What do semiconductors have to do with your company?	
What can your company do to further the development of more advanced semiconductors or the semiconductor field as a whole?	
After doing some additional online research about your company, answer the following questions.	
What is your company most widely known for?	
What types of jobs are available at your company?	
What is one interesting fact about your company that you think the rest of your class might not know?	
Take notes on the other companies from the members of your group as they present.	

Company Name:	
Company Name:	
Company Name:	
Section G: Semiconductor Gallery Walk	
For each station, write the title of the page and 1-2 sentences summarizing the content that you read.	
Section Title:	
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Answer the reflection questions below after the gallery walk.	
1. What part of the semiconductor process was most surprising to you?	
2. What part of the semiconductor process is the most interesting to you?	
3. What questions do you still have about the semiconductor process?	

Elaborate

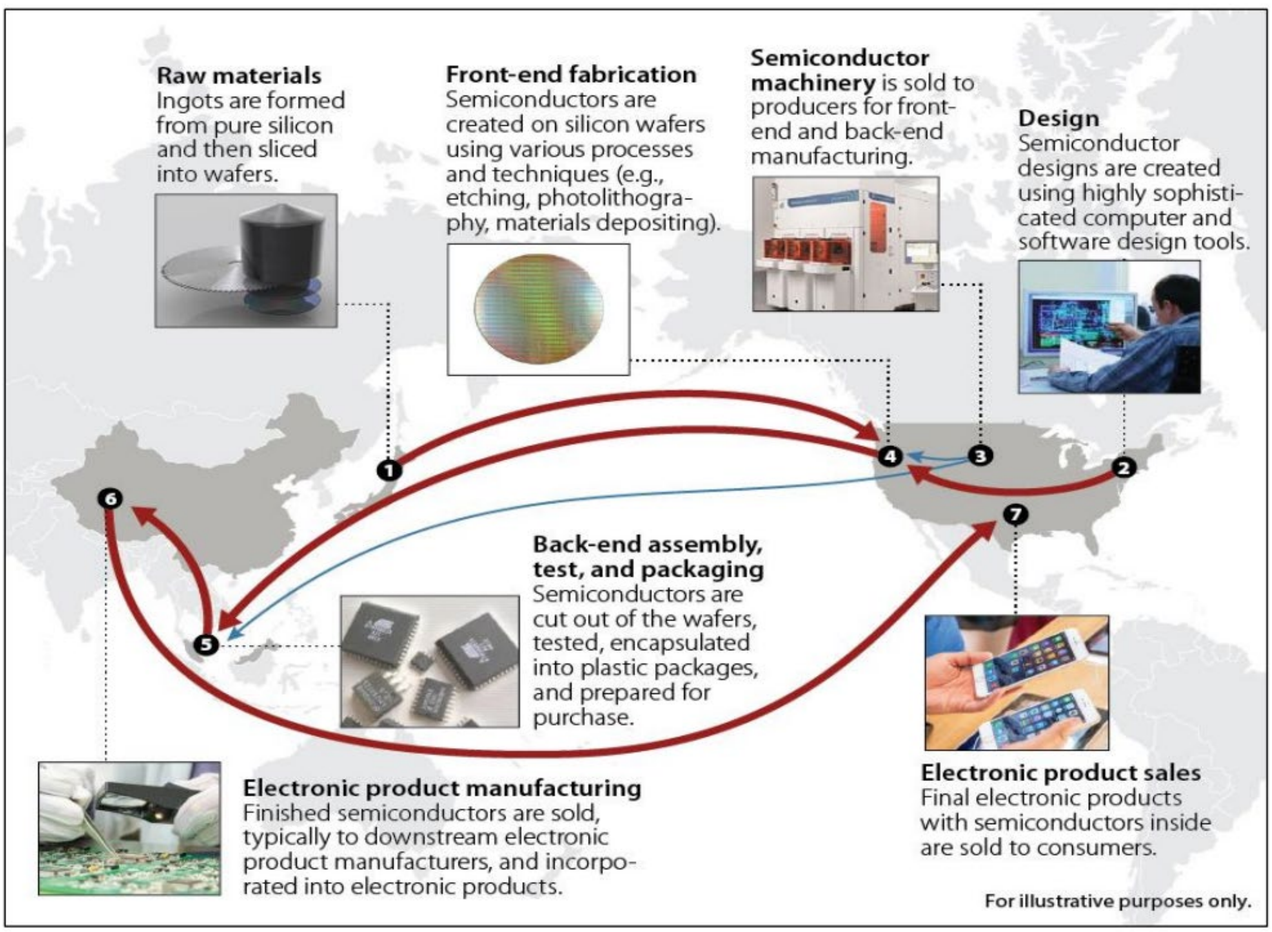
Section H: Semiconductor Manufacturing Board Game	
1. What did you learn about the semiconductor manufacturing process?	
2. What part of the semiconductor manufacturing process would you like to learn more about?	

Evaluate

Section I: Reflect on the Semiconductor Manufacturing Process	
How does the manufacturing of microchips impact the global economy?	

How does the global economy impact the manufacturing of microchips?	

Figure 5. Typical Global Semiconductor Production Pattern



Source: CRS, adapted from information provided by SIA.

Intel Case Study

Intel Corporation is a technology company headquartered in Santa Clara, California. Founded in 1968, Intel is a leading manufacturer of semiconductor devices, such as microprocessors, system-on-chips, and memory chips. Intel is one of the most innovative companies in the semiconductor industry, and their contributions have led to significant advances in technology.

One way that Intel contributes to the development of semiconductor devices is by investing heavily in research and development. Intel has a large team of engineers and scientists who are constantly working on new technologies to improve their products. For example, in 2018, Intel invested $13.1 billion in R&D, which accounted for over 20% of their revenue. This investment has led to significant advances in semiconductor design, manufacturing, and packaging, allowing Intel to produce chips that are faster, more efficient, and more powerful than ever before.

Another way that Intel contributes to the development of semiconductor devices is by collaborating with other companies in the industry. Intel has partnerships with a range of companies, from small startups to large corporations, to share knowledge and resources to develop new technologies. For example, in 2020, Intel announced a partnership with MediaTek to develop 5G modem solutions for PCs. This collaboration allows Intel to leverage MediaTek's expertise in wireless technology to create better products, while also helping MediaTek expand into new markets.

Overall, Intel's contributions to the development of semiconductor devices have been significant and have helped to shape the industry. By investing in research and development and collaborating with other companies, Intel has been able to push the boundaries of what is possible with semiconductor technology, and their products continue to be at the forefront of innovation in the industry.

Apple Case Study

Apple Inc. is a multinational technology company headquartered in Cupertino, California. Founded in 1976, Apple is known for its innovative products, including the iPhone, iPad, Mac, and Apple Watch. In recent years, Apple has also become a significant player in the semiconductor industry, developing their own chips for use in their products.

One way that Apple contributes to the development of semiconductor devices is through their in-house chip design team. In 2010, Apple acquired P.A. Semi, a semiconductor design company, and has since expanded its chip design capabilities. Apple's chip design team is responsible for developing the company's A-series chips, which power the iPhone, iPad, and iPod touch, as well as the M-series chips, which are used in Macs. These chips are designed specifically for Apple's devices, allowing the company to optimize performance and power efficiency.

Another way that Apple contributes to the development of semiconductor devices is through its use of advanced manufacturing technologies. In 2020, Apple announced that it would be transitioning its Macs to use its own processors, based on ARM architecture, rather than the Intel processors that it had been using for over a decade. This move allows Apple to have more control over its hardware and software, while also taking advantage of advanced manufacturing technologies that allow for smaller, more power-efficient chips.

Overall, Apple's contributions to the development of semiconductor devices have been significant, and the company's in-house chip design team and use of advanced manufacturing technologies have allowed it to produce chips that are highly optimized for its products. As Apple continues to innovate in the technology industry, its contributions to the semiconductor industry are likely to continue to play a significant role in shaping the future of technology.

Tesla Case Study

Tesla, Inc. is an American electric vehicle and clean energy company headquartered in Palo Alto, California. Founded in 2003, Tesla has revolutionized the automotive industry by producing high-performance electric vehicles that have gained widespread popularity among consumers. One key component of Tesla's vehicles is the advanced semiconductor technology used to power them.

One way that Tesla contributes to the development of semiconductor devices is through its in-house chip design team. In 2019, Tesla announced that it had designed its own chip, known as the Full Self-Driving (FSD) chip, which is used in its autonomous driving system. This chip is designed specifically for Tesla's vehicles, allowing the company to optimize performance and power efficiency. By developing its own chips, Tesla can control the entire technology stack in its vehicles, from the hardware to the software.

Another way that Tesla contributes to the development of semiconductor devices is through its use of artificial intelligence (AI) and machine learning (ML) technologies. Tesla's autonomous driving system relies on a complex network of sensors and cameras that generate vast amounts of data. The FSD chip is designed to process this data in real-time, allowing Tesla's vehicles to make split-second decisions to avoid accidents and improve safety. Tesla's use of AI and ML technologies is pushing the boundaries of what is possible with semiconductor technology and is helping to pave the way for the future of autonomous vehicles.

Overall, Tesla's contributions to the development of semiconductor devices have been significant, and the company's in-house chip design team and use of advanced AI and ML technologies have allowed it to produce chips that are highly optimized for its vehicles. As Tesla continues to innovate in the electric vehicle and clean energy industries, its contributions to the semiconductor industry are likely to continue to play a significant role in shaping the future of transportation.

Google Case Study

Google LLC is a multinational technology company headquartered in Mountain View, California. Founded in 1998, Google is best known for its search engine and online advertising platform, but the company also develops a range of hardware products, including smartphones, laptops, and smart home devices. One key component of these products is the semiconductor technology used to power them.

One way that Google contributes to the development of semiconductor devices is through its work on artificial intelligence (AI) and machine learning (ML) technologies. Google is a leader in AI and ML research and has developed its own custom chips, known as Tensor Processing Units (TPUs), to power its AI and ML applications. These chips are highly optimized for AI and ML workloads and allow Google to process vast amounts of data in real-time, making its products more intelligent and responsive.

Another way that Google contributes to the development of semiconductor devices is through its partnerships with other companies in the industry. For example, Google has partnered with Samsung to develop the Pixel smartphone line, which features custom-designed chips that are optimized for Google's software. This collaboration allows Google to leverage Samsung's expertise in semiconductor manufacturing to create better products, while also helping Samsung expand into new markets.

Overall, Google's contributions to the development of semiconductor devices have been significant, and the company's work on AI and ML technologies and partnerships with other companies in the industry have helped to push the boundaries of what is possible with semiconductor technology. As Google continues to innovate in the technology industry, its contributions to the semiconductor industry are likely to continue to play a significant role in shaping the future of technology.

Defense Advanced Research Projects Agency (DARPA) Case Study

The Defense Advanced Research Projects Agency (DARPA) is a research and development agency of the United States Department of Defense. Established in 1958, DARPA's mission is to develop new technologies that enhance national security. One area of focus for DARPA is the development of semiconductor devices that can be used for a range of military applications.

One way that DARPA contributes to the development of semiconductor devices is through its support of research in the field. DARPA funds a wide range of research projects focused on semiconductor technologies, including projects aimed at developing new materials, manufacturing processes, and design techniques. This funding enables researchers to explore new ideas and push the boundaries of what is possible with semiconductor technology.

Another way that DARPA contributes to the development of semiconductor devices is through its development of advanced semiconductor manufacturing technologies. DARPA's Electronics Resurgence Initiative (ERI) is focused on advancing the state-of-the-art in electronics manufacturing, including the development of new processes and tools for fabricating semiconductor devices. These efforts are aimed at improving the performance, reliability, and scalability of semiconductor technology, which is critical for military applications.

Overall, DARPA's contributions to the development of semiconductor devices have been significant, and the agency's funding of research and development efforts and its development of advanced manufacturing technologies have helped to drive innovation in the industry. As DARPA continues to pursue its mission of enhancing national security through technology development, its contributions to the semiconductor industry are likely to continue to play a significant role in shaping the future of technology.

Semiconductor Game Rules

LEARNING OBJECTIVE: To increase students' knowledge of the semiconductor manufacturing process.

GAME OBJECTIVE: To be the first team to make it to the Finish (Consumer) square on the game board. To win, one must correctly answer a semiconductor question from each color on the board along the processing journey.

MATERIALS:

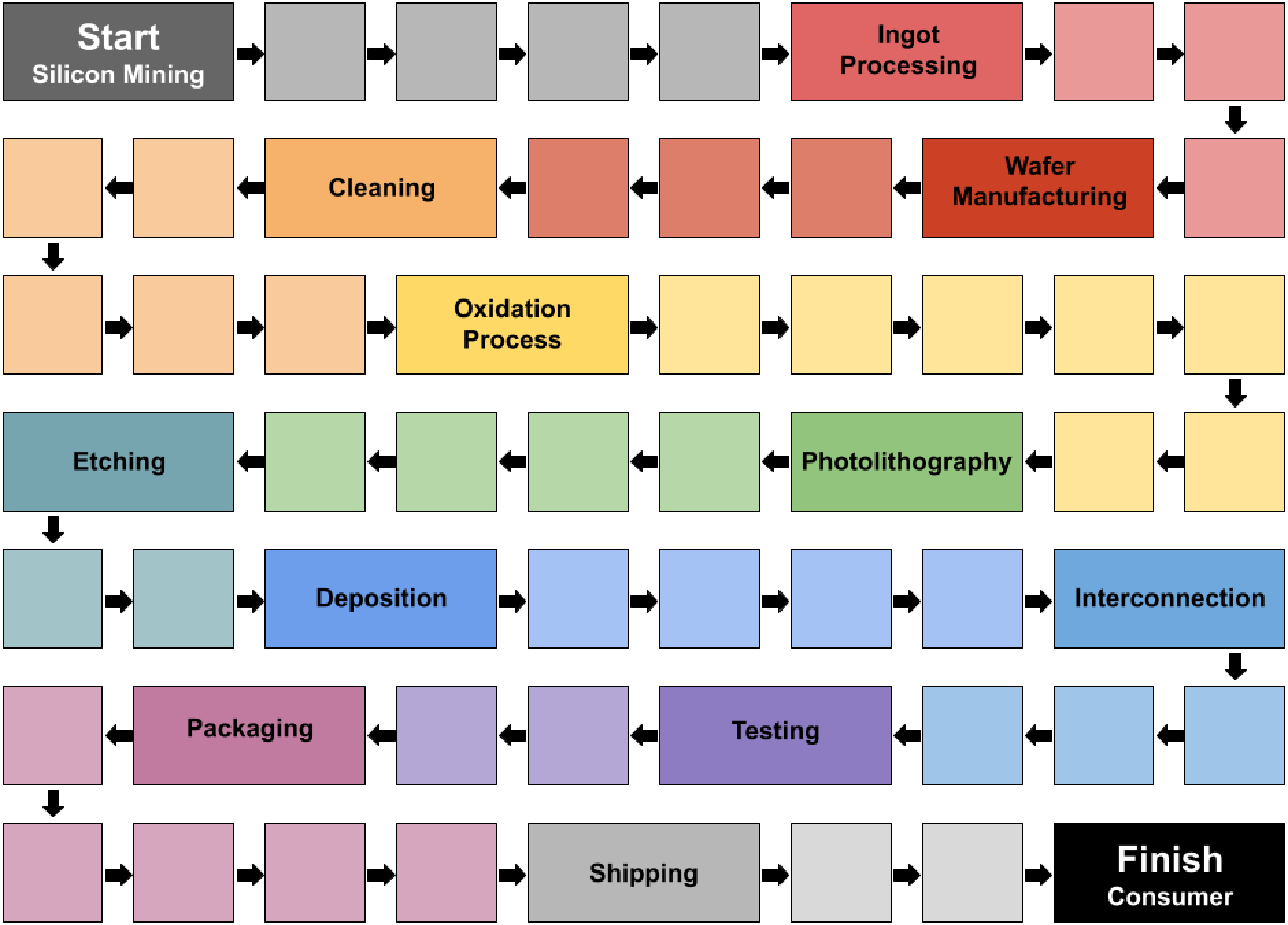
- Game board
- Question cards
- Timer
- One 6-sided die
- Token for each team (optional)

HOW TO PLAY THE GAME:

1. Have students form competing teams, each with two or three players.
2.
3. Distribute items listed under "Materials" to each pair of competing teams. The question cards should be cut out, folded over and glued, stapled, or taped together. They can also be cut and pasted onto index cards.
4. Set out the game board, place a game token from each team on the Start square, and place the color-coded stacks of question cards alongside the game board, image-side up.
5. Present the game's objective and rules to the class as a whole, or have competing teams review them independently.

RULES OF THE GAME:

1. Choose a team to go first. The team going first is referred to as Team A; the team going second, Team B.
2. Each team puts their marker in the Start square to begin. Each step of the semiconductor process is color-coded.
3. Team B pulls the first question card from the Silicon Mining stack and reads the question to Team A, whose players have one minute to discuss and decide on their answer. (The answer is specified on the card.)
4. If Team A players do not answer the question correctly, their turn is over and the question card goes to the bottom of the stack. However, if they do answer correctly, they receive the question card, roll the die, and advance that number of squares on the game board. If they advance to another phase in the semiconductor process, the team must stop on this square, even if they have more available squares to advance. Team A can now answer a question for the next step in the semiconductor process, and so on until they incorrectly answer a question and their turn is over.
5. Team B now repeats the same process.
6. To win, a team must be the first to successfully travel through all steps in the semiconductor process on the game board, and receive a question card from each by correctly answering the corresponding question.


Start
Silicon Mining
Ingot Processing
Wafer Manufacturing
Cleaning
Oxidation Process
Photolithography
Etching
Deposition
Interconnection
Testing
Packaging
Shipping
Finish
Consumer

Silicon Mining	Silicon comes from: a. Sand b. Soil c. Water d. Granite
Silicon Mining	Silicon is most commonly found in: a. Hematite b. Granite c. Quartzite d. Anthracite
Silicon Mining	Silicon makes up more than one quarter of the mass of the earth's crust. a. True b. False
Silicon Mining	Which nation mines the most Silicon? a. United States b. China c. Saudi Arabia d. Germany
Ingot Processing	Silicon ingots only need to be 99% pure to be suitable for use in a microchip. a. True b. False
Ingot Processing	What is the melting point of Silicon? a. 140ºC b. 2050ºC c. 1420ºC d. 1750ºC
Ingot Processing	Silicon ingots are made in a crucible. a. True b. False
Ingot Processing	Silicon is able to easily be cast into molds like many other metals. a. True b. False

Wafer Manufacturing	Silicon wafers need to be thoroughly polished after being sliced into their desired shape. a. True b. False
Wafer Manufacturing	What types of blades are used to cut through Silicon ingots to create wafers? a. Folded steel b. Tungsten c. Diamond
Wafer Manufacturing	Silicon wafers are typically slightly wider than a human hair. a. True b. False
Wafer Manufacturing	A wafer can be used to create _____ of individual transistors. a. Hundreds b. Thousands c. Millions d. Billions
Cleaning	Wafers undergoing treatment need to be kept in a clean room environment with fewer than ______ particles per cubic foot. a. 100 b. 1,000 c. 10,000
Cleaning	The purpose for eliminating contaminants on the wafer is to: 1. Prevent interruption in current transfer in the wafer 2. Create a barrier for later steps in the process 3. Reduce operating costs of the manufacturing plant 4. Lessen the likelihood of workers inhaling silicon dust
Cleaning	Wafers need to have a mirror-like reflection when they are done with the polishing process. a. True b. False
Cleaning	Wafers do not need to be checked for quality after the cleaning process. a. True b. False

Oxidation Process	What is the chemical formula of Silica, or Silicon Dioxide? a. SnO_2 b. 2SiO c. Sn_2O d. SiO_2
Oxidation Process	What is the purpose of a Silicon Dioxide insulating layer? 1. To protect the wafer in subsequent stages 2. It strips the top layer of contaminants from the wafer 3. Enables workers to safely handle the wafer by hand 4. To add iron substrates to the wafer.
Oxidation Process	There are two main types of oxidation: Wet and Dry. a. True b. False
Oxidation Process	Silicon Dioxide serves as a conductor on the surface of the wafer. a. True b. False
Photolithography	Before a pattern can be etched onto the wafer, it must first be coated with: a. Photocathodes b. Photoresist c. Silica dust
Photolithography	What component is used to create a pattern on a wafer? a. Substrate b. Oxidizer c. Photomask d. Diffuser
Photolithography	The photolithography process relies on the use of: a. X-Rays b. Infrared light c. Microwaves d. Ultraviolet light
Photolithography	Industrial photolithography can be completed without the aid of Computer-Aided Drafting. a. True b. False

Etching	Dry etching uses gasses and reactive ions in lieu of the chemical solutions used in wet etching. a. True b. False
Etching	Wet etching is also sometimes called "plasma etching." a. True b. False
Etching	Dry etching requires careful monitoring of: a. Etch rate and uniformity of speed b. Chemical impurities c. Electrical power d. UV radiation
Etching	Plasma used in plasma etching is generated by: a. Chemical interactions b. An ignition source c. A powerful magnetic field d. Temperatures exceeding 2500ºC
Deposition	Modern semiconductor chips are typically only composed of a single layer. a. True b. False
Deposition	The two types of Deposition are: a. Wet and Dry b. Primary and Secondary c. Paramagnetic and Ferromagnetic d. Physical and Chemical
Deposition	Plasma is most commonly used in Deposition because: 1. It can be used to form films at low temperature 2. It helps regulate uniformity 3. It easily processes high volumes 4. All of the above
Deposition	The film formed through Deposition has what two layers? c. Conductive and Insulating d. Positive and Negative e. Wet and Dry f. None of the above

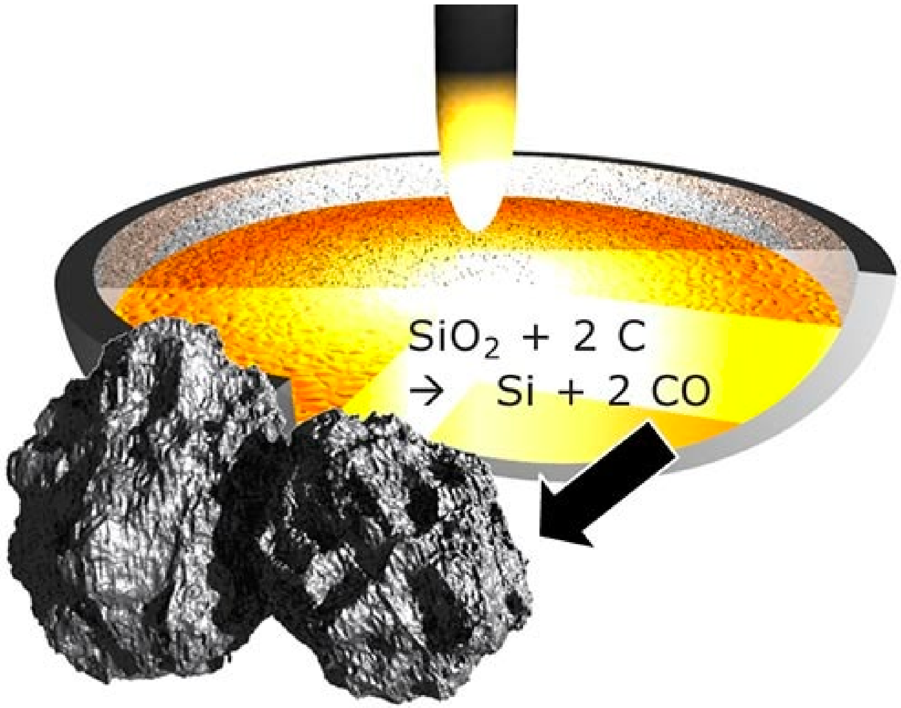
Interconnection	Semiconductors are capable of behaving as both conductors and insulators. a. True b. False
Interconnection	Semiconductors do not need to be treated with additional additives after the photolithography stage. a. True b. False
Interconnection	The most common material used in Interconnects is: a. Copper b. Aluminum c. Lithium d. Silicon
Interconnection	The Interconnection phase primarily focuses on: 1. Laying metal wires to provide “electrical highways” 2. Connecting two wafers to each other 3. Electrically testing the integrity of the transistors 4. Removing all insulating components from the wafer
Testing	The purpose of testing semiconductor wafers is: 1. Identifying defective chips 2. Repairing chips that are defective 3. Identifying issues with the manufacturing process 4. All of the above
Testing	Defective chips that are beyond repair are marked when? a. Inking b. Electrical Test c. Repair d. Hot/Cold Test
Testing	After the testing process, the wafer is sent to: a. The Consumer b. Quality Control c. The Shipping Manager d. Repair Facilities
Testing	The Electrical Test step involves applying varying AC and DC power to the chips to ensure they are not defective. a. True b. False

Packaging	Once the testing phase is completed, the chips are ready for consumer use immediately after being removed from the wafer. a. True b. False
Packaging	The purpose of the Packaging step is: 1. To put the chips into plastic containers to be shipped 2. To send the wafer to another processing facility 3. To connect an integrated circuit to electronics 4. None of the above
Packaging	What step connects the contact points and a substrate? a. Electronic synthesis b. Wire bonding c. Contact connection d. Chip integration
Packaging	The Molding step is what sets the chip package in its required shape, which is responsible for protecting the chip from heat and environmental concerns. a. True b. False
Shipping	Name a concern for companies who transport semiconductors a. Electro-static discharge b. Storage temperature c. Relative humidity d. All of the above
Shipping	Which country is the largest producer of semiconductors? a. United States b. China c. Taiwan d. Japan
Shipping	Semiconductors compose approximately what percentage of global trade? a. 1% b. 4% c. 8%
Shipping	Hong Kong is the largest importer of semiconductor devices. a. True b. False

Silicon Mining

Silicon mining typically involves extracting silica sand, which is abundant in the Earth's crust and is the primary source of silicon. The silica sand is extracted using various techniques such as open-pit mining, dredging, or underground mining. Once the silica sand is extracted, it undergoes a refining process to purify it into high-purity silicon, which is then used in various industries, including the semiconductor industry.

Silicon Purification



The purification of silicon typically involves several steps to remove impurities and increase the purity of the material. The first step is to reduce the silicon dioxide in the raw material to elemental silicon using a reducing agent, such as carbon or hydrogen. The resulting silicon is then further purified using techniques such as zone refining, chemical vapor deposition, or crystal pulling to produce high-purity silicon suitable for semiconductor manufacturing, solar cells, and other high-tech applications.

Warehouse Storage

Silica sand is typically stored in large warehouses or silos to protect it from moisture and other contaminants. The sand is often stored in bulk using conveyor belts or other material handling equipment for efficient storage and retrieval. The storage conditions are carefully monitored to ensure that the sand remains dry and free from impurities, which could affect the quality of the resulting silicon.

Dockyard Logistics

A shipyard dock worker is responsible for the loading and unloading of cargo onto and off of ships that come into the port. They may use heavy equipment, such as cranes or forklifts, to move cargo onto the ship or onto the dock. Additionally, they may assist in the maintenance and repair of ships while they are docked, such as cleaning or painting the vessel.

Trans-Oceanic Mass Shipping

A container ship crew member works on a ship that transports cargo in large shipping containers across the world's oceans. Their duties may include operating the ship's machinery, maintaining the vessel, loading and unloading cargo, and monitoring the ship's navigation and safety systems. They may work long hours in a variety of weather conditions and are responsible for ensuring the safe and timely delivery of cargo.

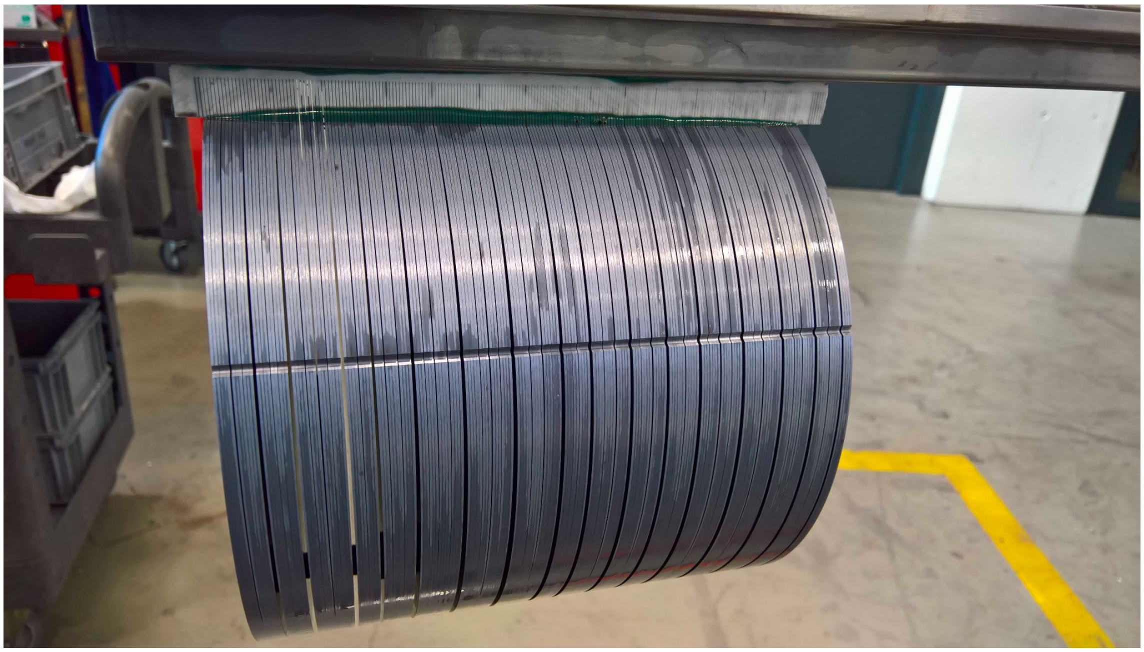
Cross-Country Transportation

A container truck driver is responsible for transporting shipping containers from ports or rail yards to their final destination. They must have a valid commercial driver's license and be knowledgeable about regulations related to the transport of cargo. The job may require long hours, and drivers must ensure that the cargo is delivered safely and on time while adhering to strict schedules and delivery deadlines.

Melting

Silicon melting involves heating high-purity silicon in a furnace to a temperature above its melting point, which is around 1,414°C (2,577°F). The process typically involves placing silicon chunks or granules into a crucible, which is then placed in the furnace and heated to the desired temperature. The melted silicon can then be used to create ingots or other shapes, which can be sliced into wafers for use in semiconductor device manufacturing.

Slicing



Silicon slicing is a process used to cut silicon ingots into thin wafers that can be used in semiconductor device manufacturing. The slicing process typically involves using a diamond saw or wire to cut the ingot into thin slices with a thickness of around 0.3 to 0.7 millimeters. The sliced wafers are then cleaned and polished to remove any surface defects and prepare them for the subsequent semiconductor processing steps.

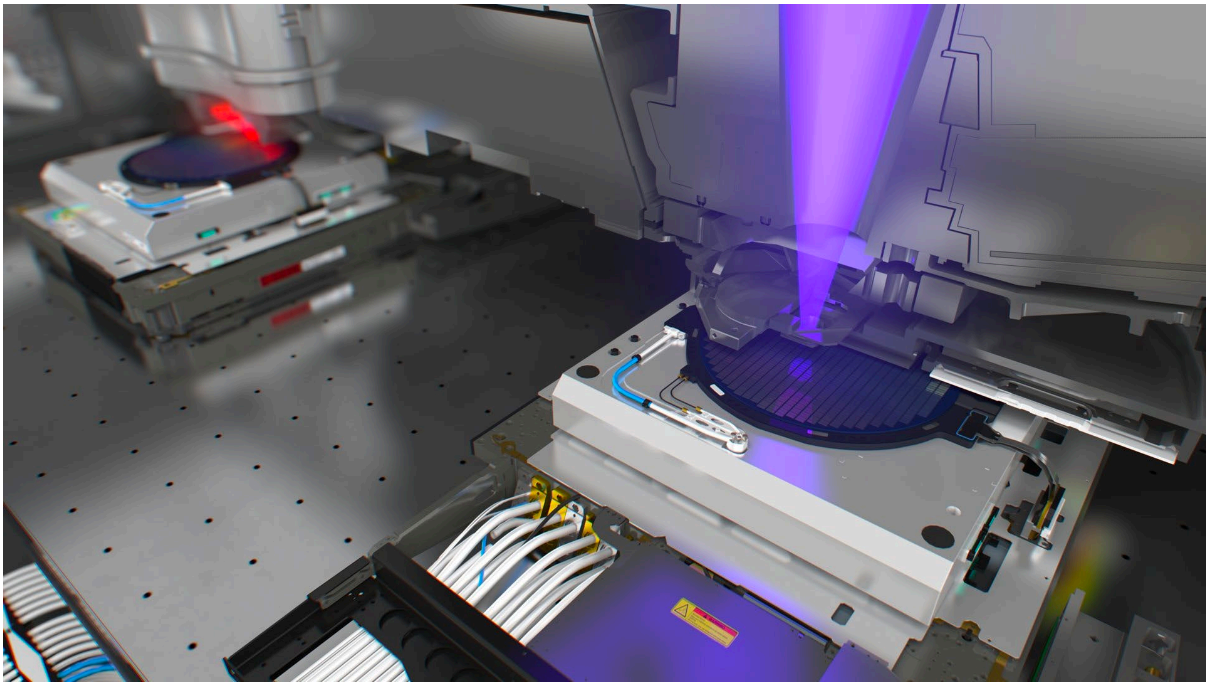
Cleaning

After slicing, the silicon wafers are cleaned to remove any surface contaminants or particles that could affect their electrical properties. The cleaning process typically involves using a series of chemical and mechanical cleaning steps to remove any residues from the slicing process, such as saw marks or particles. The wafers are then rinsed with deionized water and dried before being subjected to further semiconductor processing steps, such as doping and photolithography.

Doping

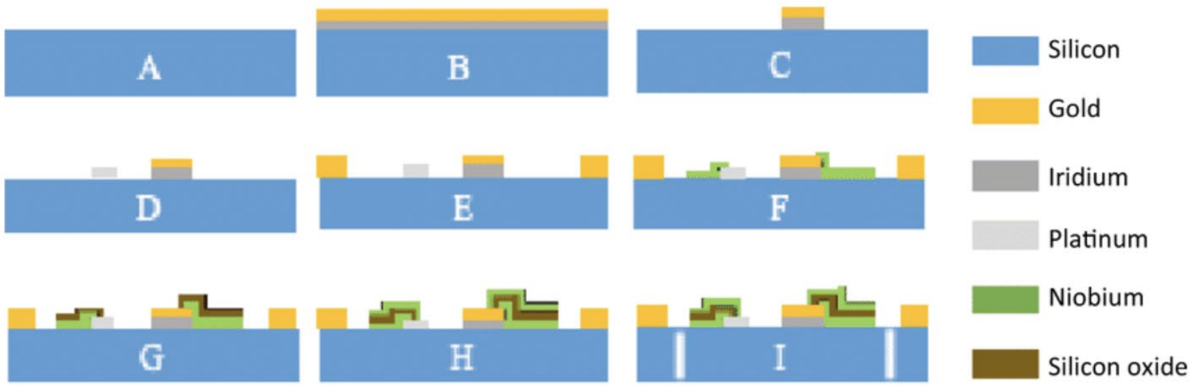
Silicon doping is the process of intentionally adding impurities to a pure silicon crystal to alter its electrical properties. Doping is typically achieved by introducing small amounts of specific elements, such as boron or phosphorus, to the crystal lattice structure of the silicon. The resulting doped silicon material can then be used to manufacture a variety of semiconductor components, such as diodes, transistors, and integrated circuits.

Photolithography



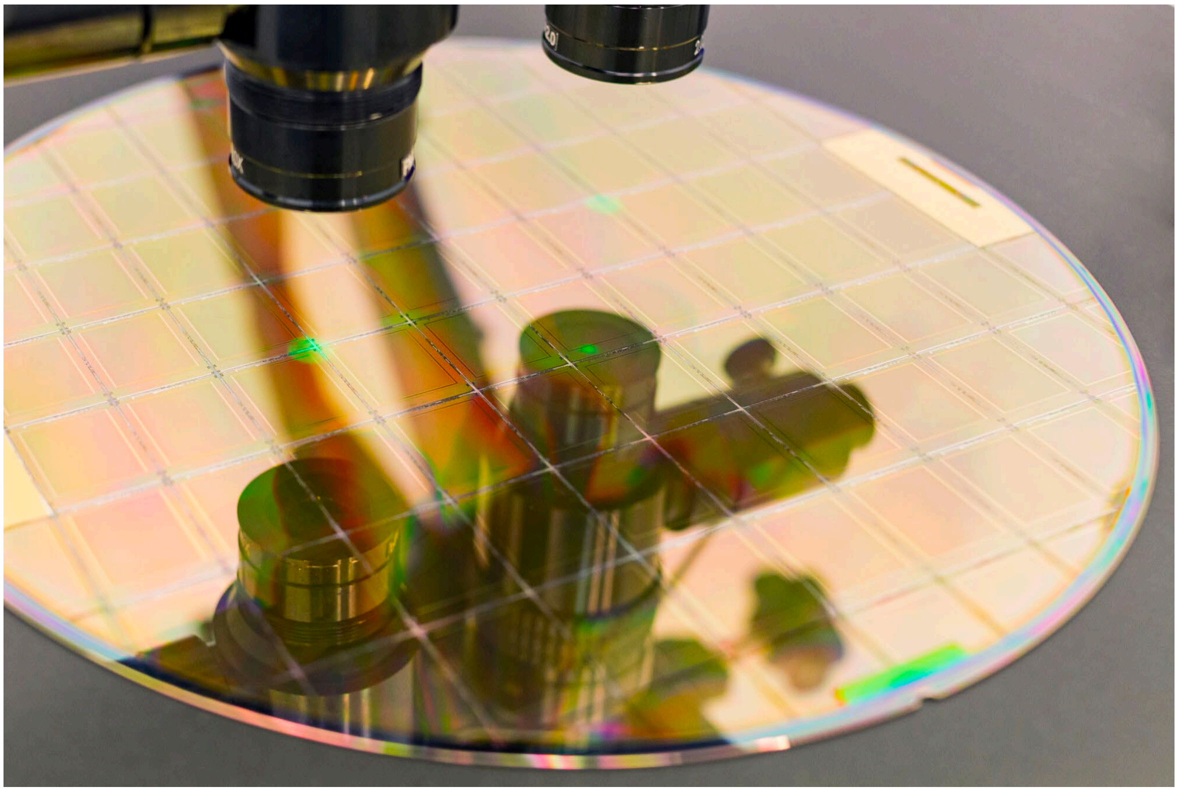
Photolithography is a process used to create patterns on a silicon wafer by selectively exposing it to light. The process involves coating the wafer with a photosensitive material, called a photoresist, and using a mask to selectively expose the material to light. The exposed areas of the photoresist are then removed to create a pattern, which is transferred to the underlying silicon material through a series of chemical etching and deposition steps to create the desired semiconductor component.

Deposition



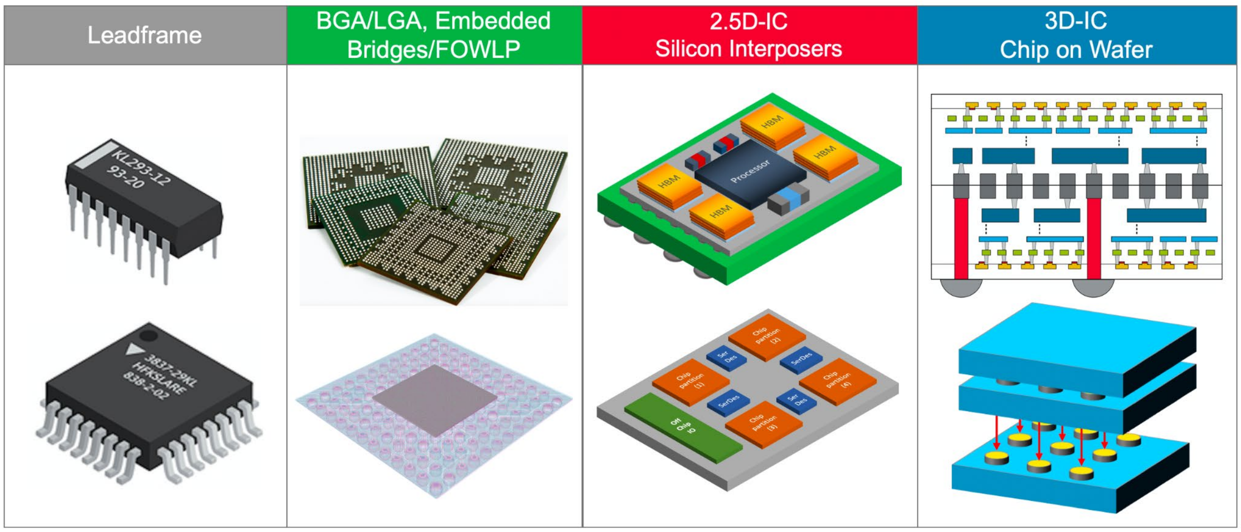
Silicon deposition is a process used in semiconductor manufacturing to apply thin layers of material to a silicon wafer. The process can be achieved using a variety of techniques, such as chemical vapor deposition or physical vapor deposition, and typically involves exposing the wafer to a vapor or gas containing the desired material. The deposited material can be either conductive or insulating and can be used to create the various electronic components of a semiconductor device.

Testing



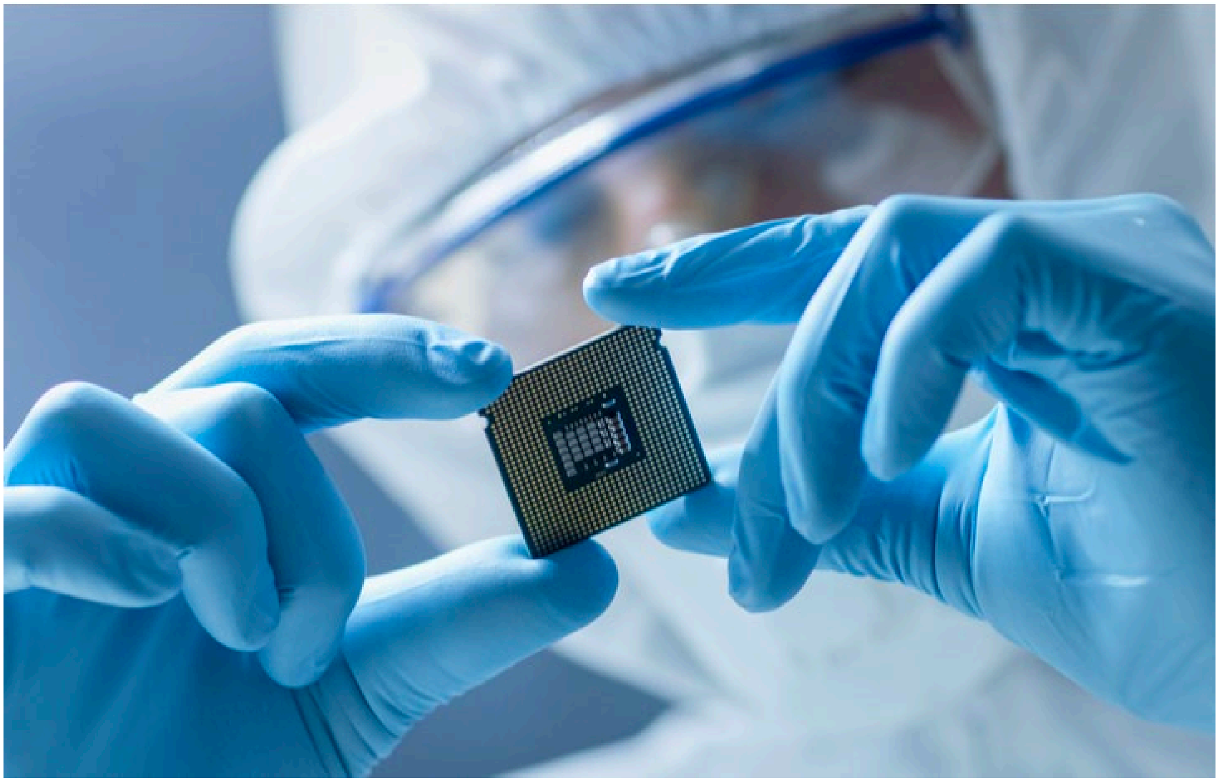
Silicon wafer testing is a critical step in semiconductor manufacturing used to ensure the quality and functionality of the semiconductor components produced. The testing process typically involves subjecting the wafers to various electrical and physical tests to determine their performance and identify any defects or anomalies. The results of the testing are used to determine which wafers and chips meet the required specifications and can be packaged for use in electronic devices, and which ones need to be discarded.

Packaging



Silicon wafer packaging is the final step in the semiconductor manufacturing process, where the individual chips are separated and placed into their final packaging for use in electronic devices. The packaging process typically involves placing the chips onto a lead frame or substrate, which is then encapsulated in plastic or ceramic to protect the chips from the environment and provide electrical connections. The packaged chips can then be used to create a wide range of electronic devices, from computer processors to sensors and memory chips.

Chip Design



The job of a computer chip designer is to create the blueprint or design for a semiconductor device, such as a microprocessor, memory chip, or sensor. This involves using specialized software to design the layout of the components and the paths of the electrical connections on the chip. The designer must also consider factors such as power consumption, performance, and cost to create a design that meets the requirements of the intended application.

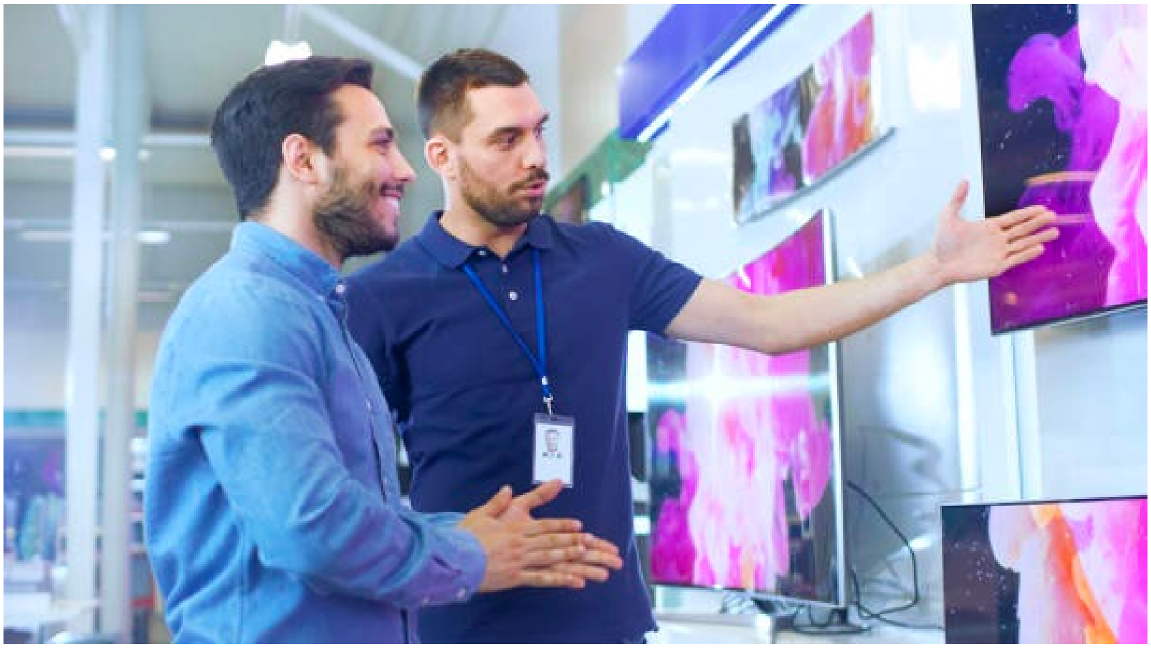
Phone Assembly

The process of assembling a smartphone involves integrating various components, such as the display, battery, camera, and circuit board, into a single device. The components are typically manufactured separately and then assembled using automated machinery and specialized tools, such as pick-and-place machines and soldering equipment. The assembled smartphones are then subjected to testing and quality control to ensure that they meet the required specifications before being packaged and shipped to customers.

Air-Delivered Freight

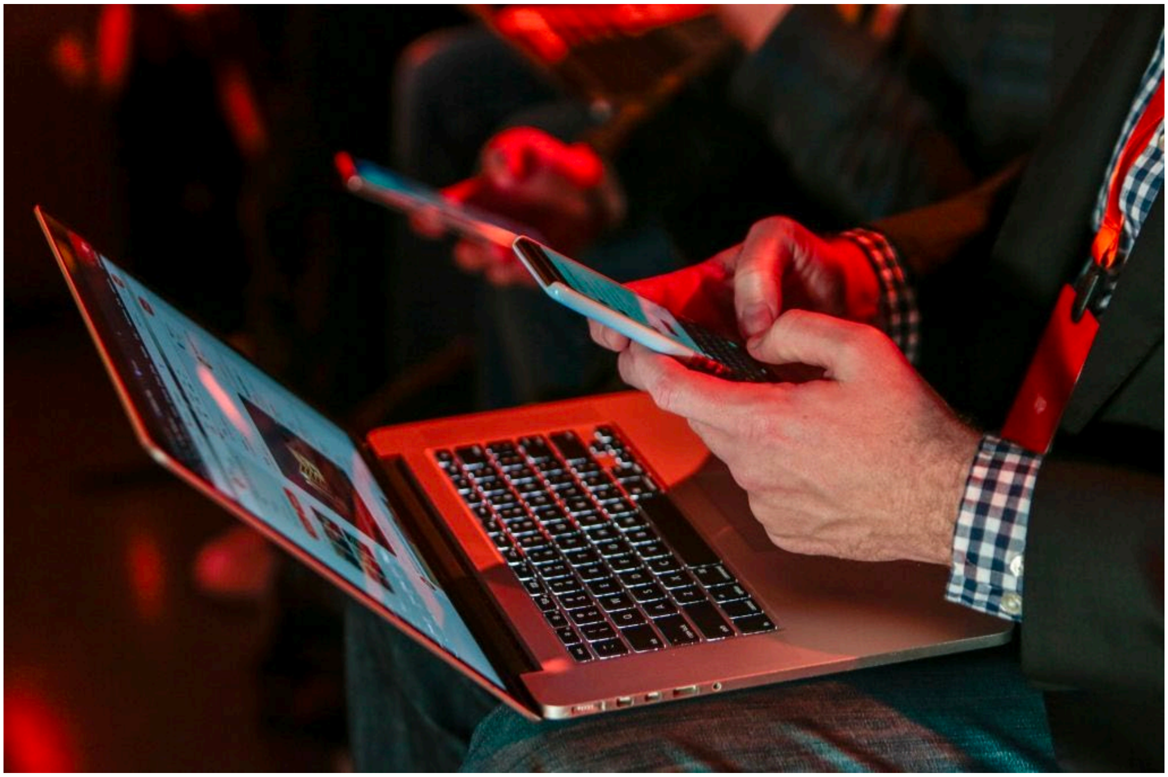
The job of an aircraft freighter pilot is to safely operate a cargo plane to transport goods and materials across domestic and international destinations. The pilot is responsible for pre-flight checks, such as fuel and weight distribution calculations, and must ensure that the cargo is properly loaded and secured in the aircraft. Without air freight, it would be difficult to transport semiconductor materials and components across long distances, which could slow down the manufacturing process and increase costs.

Electronics Sales



The job of an electronics salesman is to assist customers in selecting and purchasing electronic devices such as smartphones, laptops, and televisions. This involves understanding the features and specifications of different products, and being able to explain their benefits and drawbacks to customers. Electronics salesmen may work in retail stores, online marketplaces, or directly for manufacturers, and must be knowledgeable about the latest trends and technologies in the industry.

You: The End-User



The typical end-user of a computing device is someone who uses the device for personal or professional purposes, such as browsing the internet, using productivity software, or running specialized applications. End-users may have different levels of expertise and technical knowledge, ranging from casual users who only use basic functions to power users who require more advanced features and capabilities. The computing device may take various forms, such as a desktop computer, laptop, tablet, or smartphone, and the end-user's preferences and requirements will determine which type of device is most suitable for their needs.

Electronics Recycling

Semiconductor recycling is the process of recovering and reusing materials from end-of-life or discarded semiconductor devices, such as computer chips or electronic components. The recycling process typically involves sorting and disassembling the devices, extracting and purifying the reusable materials, and then reusing them to manufacture new semiconductor components or products. Semiconductor recycling is becoming increasingly important as a way to reduce electronic waste and promote sustainable manufacturing practices in the semiconductor industry.