This presentation is part of the Energy Solutions Center's Industrial Representative Training Program

For more information contact:

Energy Solutions Center Inc.
400 N. Capitol St., NW 4th Floor
Washington, DC 20001
202-824-7150

ESC
Energy Solutions Center

Track: Industrial

Unit #3: Semiconductors

An overview of the high tech semiconductor industry

Clifton Hazen, Clifton.Hazen@nwnatural.com, on behalf of Energy Solutions Center

ESC
Energy Solutions Center

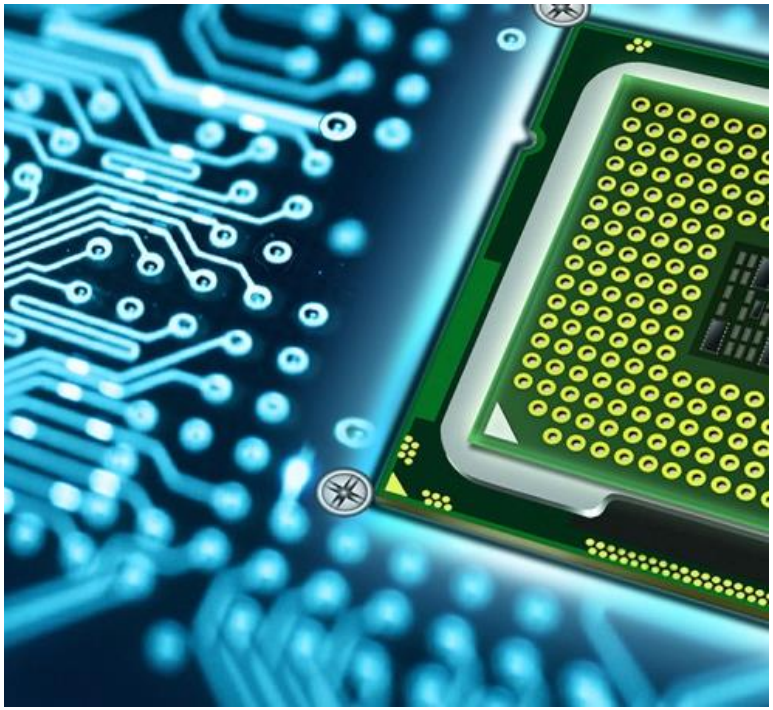
Presentation Outline

Market Overview

Trends + Market Analysis

Natural Gas Technologies

Resources + Case Studies



Semiconductor

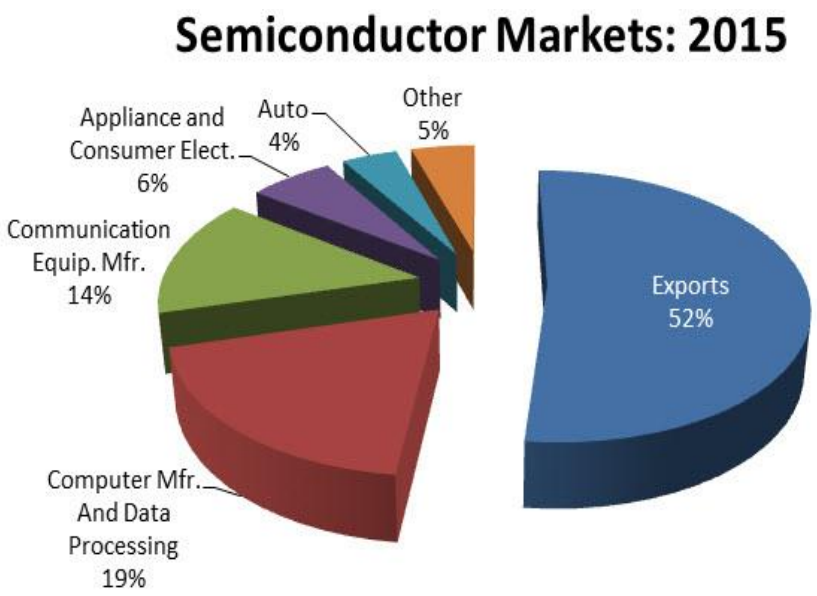
Market Overview

Semiconductors

- **Industry makes semiconductor diodes and stacks**, including rectifiers, integrated microcircuits, transistors, solar cells, and light-sending and -emitting devices.
- **Four main product categories:** 1) memory 2) microprocessors 3) commodity integrated circuit 4) complex SOS (system on a chip)
- **Success = being smaller, faster, cheaper.** The more transistors, the faster it is.

10 Largest Semiconductor Companies (Jan. 2016)

1. Intel
2. Samsung Electronic
3. SK Hynix
4. Qualcomm
5. Micron Technology
6. Texas Instruments
7. Toshiba
8. Broadcom
9. STMicroelectronics
10. Infineon Technologies



ESC Energy Solutions Center

Semiconductors

Trends + Market Analysis

Trends

Traditionally: semiconductors companies controlled production process.

Today:

- Production is delegated more to foundry companies, specialized designers and chip testers.
- Chip production is collaborative.
- Concerns over ever-increasing R&D costs and cost of owning a fab resulted in fabless-foundry model.
- Companies that both design and manufacture are called IDMs (integrated device manufacturers).

Trends

- IDM model creating technology challenges designers and manufacturers.
- Complexity requires researchers and manufacturers to be in same physical location for real-time problem solving.
- IDMs are opening up foundry operations to fab-less firms.
- Fab-less firms are buying existing foundries, instead of building them.
- Existing foundries are building dedicated fab modules specific to each customer.

Importance of Water and Energy

Water is critical to manufacturing: Creating an integrated circuit on a 300 mm wafer requires about 2,200 gallons of water, of which 1,500 gallons is ultra-pure.

- Industry spends about $1 billion annually on water and wastewater.
- A fab may use 2-4 million gallons of ultra-pure water every day, equivalent to water use of a city with 40,000-50,000 residents.

Water use intimately linked to energy use:

- For every dollar spent on utility-supplied water, $20 is spent on making it ultra-pure, and $10 is spent to treat discharge.
- Most energy used is electric, though natural gas is also used.

Natural gas use:

- Gas-fired boilers make steam and hot water for process (heats multiple wafers) and environmental control.
- Combined heat and power (CHP) and HVAC for facilities.

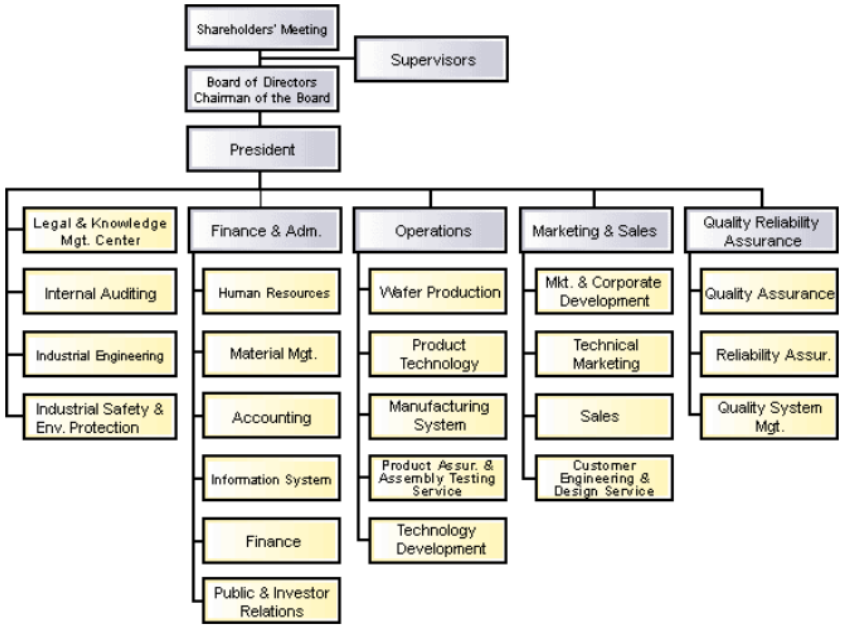
Decision Making and Org Structure

Decision making is collaborative with multiple levels of approval.

- Field-level engineer may recommend type of equipment, which is reviewed by engineering/production.
- Then recommendation sent to planning and finance.
- Final approval by senior management.

Org structure built around product function and market (function-based groups)

Vanguard semiconductor organizational chart



Semiconductor

Natural Gas Technologies

Natural Gas Technologies

1. Boilers, steam, hot water
2. HVAC equipment
3. Combined Heat and Power (CHP)
4. Humidification

Boilers, Steam, Hot Water

Hot water used for HVAC heating and water supplies.

Ultra-pure steam used for manufacturing.

- Oxidation and annealing
- Purity affects quality of oxide layer or annealed surface

Move to larger wafers, higher throughputs increase water-vapor flow requirements.

HVAC

- Large office spaces and general manufacturing areas
- Clean room application requires high accuracy and reliability; often a separate dedicated environmental control system
- Clean room HVAC = more air supply, airflow patterns, high-efficiency filters, room pressurization

Gas-fired make-up air vents

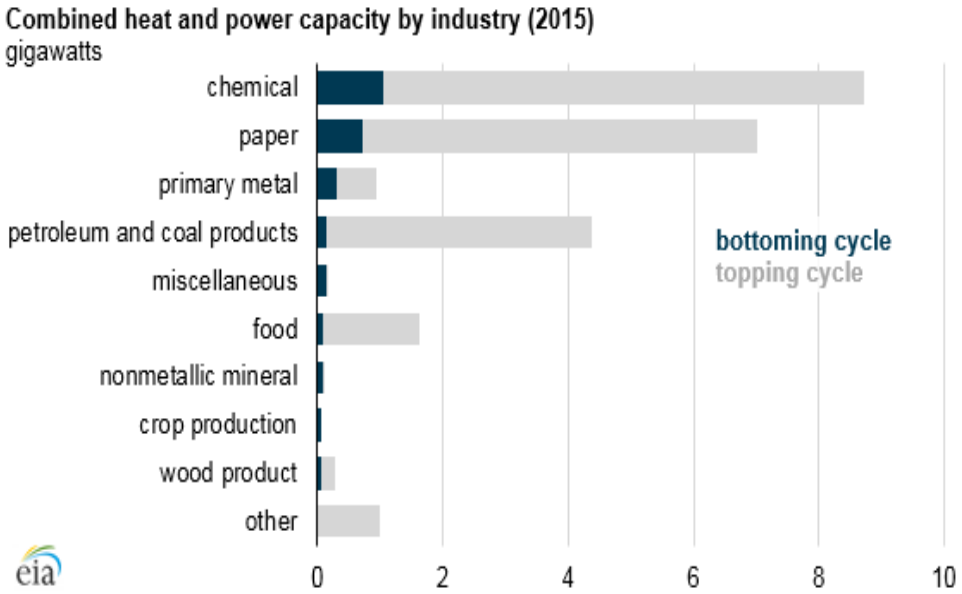
CHP

Not widely accepted

Reduces overall energy intensity

- Topping cycles: produces power first, then heat
- Bottoming cycles: Produces heat first, then power

Recommendation: Consider using CHP to develop micro-grids



CHP capacity by industry

Humidification

High purity and very pure water required

- DI/RO water (deionized, reverse osmosis)

Water purity degrades upon contact with atmosphere and certain materials

Should be in closed system with only chemically stable materials

DriSteem gas-steam humidifier

Semiconductors

Resources + Case Studies

Resources

The following associations are recommended:

- Semiconductor Industry Association: semiconductors.org
- China Semiconductor Industry Association: csia.net.cn
- GSA: GSAglobal.org
- India Semiconductor Association: isaonline.org
- Microelectronics Packaging Test Engineering Council: meptec.org
- Semi: semi.org
- Semisrael: semisrael.com
- Semiconportal: semiconportal.com

Case Studies

- Commissioning to Meet Space Qualification Criteria vs. Energy Consumption Optimization Focused Commissioning
- Making Energy Intensive HVAC Processes More Sustainable via Low Temperature Heat Recovery
- Gas-to-steam Humidifier Saves 64% on Utility Bills
- Museum Maintains Proper Humidification Levels, Uses On-site Gas with Gas-to-steam Humidifier

A DriSteem GTS humidifier at Region of Waterloo Water Testing Laboratory

Thank you …

This presentation is part of the Energy Solutions Center's Industrial Representative Training Program

For more information contact:

Energy Solutions Center Inc.
400 N. Capitol St., NW 4th Floor
Washington, DC 20001
202-824-7150

ESC
Energy Solutions Center