Agenda

- What is a 300mm Wafer Fab?
- Why are they Buildings for Advanced Technology?
- Contamination Issues
- Cleanroom Environment
- Current Technology
- Where we are going from here?
300mm Fabs

- Survey of 300mm Fab Technology
- 1000 operating fabs worldwide
  - very few are 300mm
- Operating data very scarce
- No Single design solution

What is a 300mm Wafer Fab?

- Latest generation fabrication plant for producing microchips
- 300mm diameter wafers (12 inch)
- Replaces previous 200mm generation

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What is a 300mm Wafer Fab?

- Huge production factories
  - up to 40,000 WSM
  - 500 process steps per wafer
- Cleanroom typically
  - 100,000–150,000 sq. ft.
  - 1,000,000 total sq. ft.
- High yield - >90%

They Are Big

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What is a 300mm Wafer Fab?

- New Fab today
  $2.0 - $2.5 billion
- 80%-85% is cost of tools
  balance is the building
- Recover these costs in 3 years

Wafer Fab Cost
($millions)

[Bar chart showing wafer fab cost over the years]

Not For The Faint of Heart

Design - Construction - Tools

Time to First Wafer Start

- 200 mm - 1995
- 300 mm - 2003

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If They’re so Expensive – Why Build Them?

- Annual Revenue = $Billions
- Wafer is 2.25 times bigger
- 2.5 times as many chips per wafer

Cost per wafer is higher but...
- Cost per Chip is substantially less
- Economy of Scale vs. 200mm

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Today’s Microelectronics are crossing the threshold into Nanoelectronics
- Currently at the 130nm technology node
- Next year will bring 90nm process
- 65nm node is being proven in labs
- 300mm wafers are the first generation to make this transition.

IBM Claims World’s Smallest Silicon Transistor
- Online staff -- Electronic News, 12/9/2002

IBM Corporation today said it has created a working 6nm silicon transistor, making it the smallest one of its type in existence.
Why Is This Important?

- The technology that is being applied to this generation of IC.
- How does this technology effect the cleanroom environment?

Cleanroom Specifications

- Filter ceiling – 100% coverage w/ gel seal grid
- Airflow – 60-90 fpm
- Temperature – 72 +/- 0.5 F critical areas
  - 72 +/- 2 F non-critical areas
- Humidity – 50% +/- 2%RH critical areas
  - 50% +/- 5%RH non-critical areas
- Pressurization – 0.05” WG wrt corridor
- Class 0.1 as-built condition
- Class 1 operating

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This presentation material can be used without the direct consent of the author.
Cleanroom Zone Isolation

- HVAC isolation between process zones

For Example:

<table>
<thead>
<tr>
<th>Photolithography</th>
<th>CVD / Diffusion</th>
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<tr>
<td>CMP / Wet Etch</td>
<td>Exotic Metals</td>
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</table>

Support

Types of Contamination

- Temperature instability
- Humidity instability
- Vibration
- Static discharge
- EMI / RFI

We will focus on Airborne contamination

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Types of Contamination

- Particulates
- Bacteria
- Metallic Ions – sodium, potassium, chloride
- Airborne Molecular Contamination
  - Acid vapor
  - Water vapor
  - Hydrocarbons
  - Other gas

Effects of Contamination

- Yield reduction – killer particles
- Early device failure
  - Uncontrolled doping
  - Modified electrical properties
- Degradation of fabrication equipment
  - Stepper optics hazing

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Sources of Contamination

- Gases
- DI Water
- Chemicals
- Box Carriers & Wafers
- Production People
- Gloves & Garments
- Wipes

Measuring Contamination

- The goal is to build Cleanrooms to limit manufacturing defects and other impacts
- Standards define the cleanliness of the cleanroom
- In the Old Days, Things were simple

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Federal Standard 209B - 1976

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## Measuring Contamination

### Federal Standard 209E

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### Measuring Contamination

**Federal Standard 209E**

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**How Did We Get Here?**

- **Cleanroom Classification**: Traditional cleanroom classification based on particle counts.
- **Technology Generation**: Evolution of technology with decreasing particle sizes and increasing data rates.

**Cleanroom Evolution**:
- 1980: 100 mm
- 1984: 100 mm
- 1987: 125 mm
- 1990: 150 mm
- 1993: 200 mm
- 1995: 200 mm
- 1998: 200 mm
- 2002: 300 mm

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### Measuring Contamination

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#### International Standard

- Replaced Federal Standard 209E (Nov. 2001)
- Added classifications

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What Has This Meant For The Cleanroom?

We’ve declared war on contamination

Fighting Contamination

- High efficiency PTFE filters (99.9995% or better)
- Non-outgassing, easily cleanable materials
- Chemically treated carbon filters for AMC
- Static dissipative floors
- Room pressurization
- Cleanroom Certification
- Cleanroom protocols & Gowning

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Sources of Contamination

Class 10 Cleanroom
- Environ 25%
- People 10%
- Process 25%
- Tools 40%

Class 1 Cleanroom
- Environ 10%
- People 5%
- Process 60%
- Tools 25%

Cleanroom Trends
- Contamination control
- Tighter temp control
- Process cooling water for heat removal
- AMC filters
- High efficiency dc motors on FFUs
- High efficiency vane axial fans
- Wafer Isolation Technology

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Isolation Technology

- Cleanroom
- Mini-environment

Year:
- 1989
- 1992
- 1995
- 1998
- 2001
- 2004
- 2007
- 2010

Class:
- Class 10
- Class 1
- Class 0.1
- Class 0.01

Wafer Isolation

- Enabling technology below 90nm
- Wafer is never exposed to the fab cleanroom environment
- Front Opening Unified Pod
- FOUP
- Next generation will offer inert gas purge

Asyst FOUP

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**Wafer Isolation**

- SMIF Load Port
- Interface between FOUP and Tool

**Integrated Mini-environment**

- Contain individual tools
- Fan Filter Units
- Better than class 1 environment

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Material Handling Systems

Wafer Isolation

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Cleanroom Trends

- Wafer Isolation helps resolve issues with:
  Particulate Contamination
  Temperature control
  Airborne Molecular Contamination

- If the wafer never sees the cleanroom –
  Why have one?

Where are we Going?

International Technology Roadmap for Semiconductors

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<tr>
<th>Technology Generation</th>
<th>Cleanroom Classification</th>
<th>Cleanroom Evolution</th>
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- 2003
- 2004
- 2005
- 2006
- 2007
- 2010

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Cleanroom Implications

- Extreme Wafer Isolation – Inert Environment
- Reduced classification
  - Reduced airflow
  - Reduced capital cost of building
  - Reduced gowning requirement
  - Reduced operating costs for cleanroom

- Heat Removal is a problem
  Limits airflow reduction

The Transition

- Expensive, Complex Cleanroom
- Expensive Complex Production Tool

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### What’s Next?

### Would You Believe 450 mm?

**International Technology Roadmap for Semiconductors**

<table>
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**Cleanroom Evolution**

- 300 mm
- 450 mm

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Thank You

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