Intelligent On-line AMC Monitoring Technical Conclude in Fab

Presenter Name: May Chang
Presenter Title: Technical Director
Date: 2019/7/5
Fundamental Introduction
# Difficult Challenges for Yield Enhancement

## 2015-2020 (ITRS Roadmap for semiconductors 2.0 2015 edition)

<table>
<thead>
<tr>
<th>Difficult Challenges 2015-2020</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detection of multiple killer defects and the signal-to-noise ratio</td>
<td>It is a challenge to detect multiple killer defects and to differentiate them simultaneously at high capture rates, low cost of ownership and high throughput. Furthermore, it is difficult to identify yield relevant defects under a vast amount of nuisance and false defects.</td>
</tr>
<tr>
<td>Process stability vs. absolute contamination level</td>
<td>This includes the correlation to yield test structures, methods and data that are needed for correlating defects caused by wafer environment and handling to yield. This requires determination of control limits for gases, chemicals, air, precursors, ultrapure water and substrate surface cleanliness.</td>
</tr>
<tr>
<td>Next generation inspection &amp; on-line defect characterization and analysis</td>
<td>As bright field detection in the farfield loses its ability to discriminate defects of interest, it has become necessary to explore new alternative technologies that can meet inspection requirements beyond 13 nm node. Several techniques should be given consideration as potential candidates for inspection: high speed scanning probe microscopy, near-field scanning optical microscopy, interferometry, scanning capacitance microscopy and e-beam. This assessment should include each technique’s ultimate resolution, throughput and potential interactions with samples (contamination, or degree of mechanical damage) as key success criteria.</td>
</tr>
<tr>
<td>Next generation lithography</td>
<td>Manufacturing faces several choices of lithography technologies in the long term, which all pose different challenges with regard to yield enhancement, defect and contamination control.</td>
</tr>
</tbody>
</table>
AMC Identification & Impact on Wafers

Detection limit $< 1$ppbv $\rightarrow < 0.1$ppbv

- Corrosion
  - Pad corrosion
  - Aluminium corrosion
  - Cu thin film flake
  - Defectivity on deep UV (DUV) and Mid UV resist
  - T-topping
  - Critical dimensions shift

- Sources of Contamination
  - Airborne Molecular Contaminant
  - Volatile Organic Contaminants
  - Chemical Contamination
  - Absorbed Molecules
  - Metal Ion
  - Non-volatile Residue
  - Cations / Anions
  - Particles
  - Film thickness and property change
  - Dielectric breakdown voltage
  - Si-C bonding formed
  - Electrical properties failure
  - Condensable $\rightarrow$ non-condensable

- Detection limit $< 1$ppbv $\rightarrow < 0.1$ppbv

* SEMI F21-95
  - VOCs (1996, J. electrochemistry society)

(B.J. Wu et al., 2010)

(2000, IEEE Transactions on semiconductor engineering)

(D. Ruede, 2001)

(2000, IEEE Transactions on semiconductor engineering)
AMC Identification & Impact on Wafers

Detection limit requirement $< 1 \text{ppbv} \rightarrow < 0.1 \text{ppbv}$

- Corrosion
  - Pad corrosion
  - Aluminium corrosion
  - Cu thin film flake
  - Defectivity on deep UV (DUV) and Mid UV (MUV) resist

- T-topping
  - Critical dimensions shift
  - Particles

- Dielectric breakdown voltage
  - Film thickness and property changed
  - Dielectric breakdown voltage
  - Si-C bonding formed

- Electrical properties failure

Condensable $\rightarrow$ non-condensable
# ITRS 2015-Technology Requirements Roadmap for Wafer Environmental Contamination (AMC)

<table>
<thead>
<tr>
<th>Year of Production</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>2025</th>
<th>2026</th>
<th>2027</th>
<th>2028</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRAM ½ Pitch (nm) (contacted)</td>
<td>17</td>
<td>15</td>
<td>14</td>
<td>13</td>
<td>12</td>
<td>11</td>
<td>10</td>
<td>9.2</td>
<td>8.4</td>
<td>7.7</td>
</tr>
<tr>
<td>Lithography: Point of entry to track &amp; inspection tools; temporary reticle pod storage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Inorganic Acids</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
</tr>
<tr>
<td>Total Bases</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
</tr>
<tr>
<td>Condensable organics</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>Gate/Furnace area wafer environment cleanroom FOUP ambient/tool ambient</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total metals (E+10 atoms/cm²/week)</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Dopants (E+10 atoms/cm²/week; front end of line only)</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Volatile Organics</td>
<td>20,000</td>
<td>20,000</td>
<td>20,000</td>
<td>20,000</td>
<td>20,000</td>
<td>20,000</td>
<td>20,000</td>
<td>20,000</td>
<td>20,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Exposed Copper Wafer Process Environment (Cleanroom ambient, Tool inside)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Inorganic Acids</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Total Bases</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
<td>2,000</td>
</tr>
<tr>
<td>Total Organic Acids</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Exposed Copper Wafer Environment (FOUP inside)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HF</td>
<td>5,000</td>
<td>5,000</td>
<td>5,000</td>
<td>5,000</td>
<td>5,000</td>
<td>5,000</td>
<td>5,000</td>
<td>5,000</td>
<td>5,000</td>
<td>5,000</td>
</tr>
<tr>
<td>HCl</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Total Organic Acids</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

**Unit:** pptv
Guideline of On-line AMC Monitoring Technology in Fab.
NF On-line AMC Monitoring System Configuration

- Check point experience
- Automatic sampling
- VOCs & MA/MB determination
- Intelligent self-check and auto-alarm
- Upload report to customer cloud system

Contamination Free Sampling tube

Full Integration of Sampling, Analysis, Reporting to CIM
Full Automation & Intelligent Mechanism

**NF On-line MA/MB System_C350**
- Automatically eluent preparing
- Automatically calibration curve
- UPW Standby
- Calibration Curve Build-up
- Self check
- Lock Spot
- Sampling
- Sample Solution
- Sample Direct Analysis
- Spec / Criteria OOW OOC OOS
- Intelligent Judgement
- Zero false alarm
- Automatically Reporting

**NF On-line VOCs System_NFA-1007 Advanced**
- Automatically calibration curve
- UPW Standby
- Calibration Curve Build-up
- Self check
- Lock Spot
- Samples
- Sample Direct Analysis
- Spec / Criteria OOW OOC OOS
- Intelligent Judgement
- Zero false alarm
- Automatically Reporting
High Detection Ability & Capacity
On-line MA/MB System_NFA-C350

Real Time & High Data Throughput

**Data Output cycle time Illustration**

<table>
<thead>
<tr>
<th>A-1 Impinger</th>
<th>Sampling</th>
<th>Sample Pre-concentration</th>
<th>Analysis</th>
<th>Standby</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 min</td>
<td>5~10 min</td>
<td>10~15 min</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

15 ~ 25 min

<table>
<thead>
<tr>
<th>B-1 Impinger</th>
<th>Sampling</th>
<th>Sample Pre-concentration</th>
<th>Analysis</th>
<th>Standby</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

15 ~ 25 min

<table>
<thead>
<tr>
<th>A-2 Impinger</th>
<th>Sampling</th>
<th>Sample Pre-concentration</th>
<th>Analysis</th>
<th>Standby</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

15 ~ 25 min

<table>
<thead>
<tr>
<th>B-2 Impinger</th>
<th>Sampling</th>
<th>Sample Pre-concentration</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Sampling volume: 70-90L

**NFA-C350 Stability**

- Fluoride: 130%
- Chloride: 120%
- Nitrite: 115%
- Bromide: 115%
- Nitrate: 110%
- Phosphate: 105%
- Sulfate: 100%
- Sodium: 95%
- Ammonia: 90%
- Magnesium: 85%
- Potassium: 80%
- Calcium: 70%

* Criteria: 1ppb QC recovery < 15%

**DL of NFA-C350**

- <0.1 ppbv

**Sampling Module**

**Detector Module**

**Smart interface report**
High Detection Ability & Capacity
On-line VOCs System NFA-1007 Advanced

MDL = 2.998 x S (2.998 – confidence level for 8 repeat runs / S - RSD*C)
Reference: NIEA-PA107

Real Time & High Data Throughput

Data Output cycle time Illustration

Real air sample in Fab

Analysis 0.06ppb more than 8 cycles, RSD <10%
AMC Big Data Integration
Web Data Reporting Platform
Intelligent On-line Monitoring System Conclusions
NFA On-line System Benefit & Support for Customers

- Full automation and Intelligent system
  - Self-checking & recovery mechanism
  - Zero false alarm & lock spot function
- High capacity & reliable system
  - Reliable analysis results including precision & accuracy & low level conc. detection ability
  - Real time & high data throughput with web-database
- Unique total solution provider
  - Cross Fab matching knowhow including on-line & off-line for baseline consistent
  - On-site service / Fab AMC monitoring technical integration

Installed base statistic

- On-line VOCs System
- NFA-ALIS
- Off-line VOCs System
- On-line MA/MB System

Locations:
- Hsinchu Science Park
- Central Science Park
- Tainan Science Park
- China Shanghai
- China Nanjing
- China Wuhan
- China Wuxi
NFA Intelligent Monitoring System Application

Check point experience
Automatic sampling
VOCs & MA/MB determination
Ultra trace metal / SNP determination
Intelligent self-check and auto-alarm
Upload report to customer cloud system

AMC Monitoring
Chemical Monitoring

NFA-C350 NFA-1007Ad NFA-1007m NFA-ALIS NFA-1007w
NFA-i108s IS-T10R NFA-i108p
New-Fast always thinks to provide total analysis solution for your need

Thanks for your attention~