Wafer Based Temperature Metrology

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Agenda

- Introduction
  - SA Wireless Wafer Products

- Wafer based metrology
  - Accuracy & Stability

- Key use cases for Etch, Thin Film processes
  - Characterize thermal stability of process tool
  - Correlation between wafer temperature and critical process parameters, CDs
  - Matching of wafer temperature and thermal budget
  - Diagnosis of process and process tools

- Summary
## Key Wireless Temperature Wafers

<table>
<thead>
<tr>
<th>Wireless Wafers</th>
<th>Spec.</th>
<th>Process</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ST</strong></td>
<td>20~24°C ±0.05°C; 0.03°C 65 Sensors; 775um</td>
<td>Scanner</td>
</tr>
<tr>
<td><strong>ET ET-SE</strong></td>
<td>20~140°C ±0.2°C; 0.25°C 65 Sensors (Edge Dense); 1.2mm</td>
<td>Dry Etch Implantation</td>
</tr>
<tr>
<td><strong>WT-LP</strong></td>
<td>15~140°C ±0.5°C; 0.5°C 65 Sensors, 775um</td>
<td>Wet Etch Clean</td>
</tr>
<tr>
<td><strong>Integrated Wafer</strong></td>
<td>20-145°C ±0.1°C; 0.1°C 65 Sensors; 1.3mm</td>
<td>Clean Track Room Atmosphere</td>
</tr>
<tr>
<td><strong>HT-350 XP</strong></td>
<td>25~350°C 21 Sensors ±1.0°C; ≤0.6°C Plasma Off &lt;6mm</td>
<td>Thin Film Strip</td>
</tr>
</tbody>
</table>

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**Metrology Tools**

An enabler, and/or part of a Process Solution.
SensArray Integral Wafer Technology

Proprietary Sensor Solutions >160 Patents

Notch
SensArray Wireless in-situ SensorWafer System

Measure and record in-situ wafer temperature up to 4Hz

- Create Mission using process recipe
- Launch Mission and record temperature on the wafer while in a chamber
- Download data from the BaseStation
- Analyze data using the SensArray system software
SensArray Core Value Proposition
Enhancing Process Equipment ROI Across the Fab

Tool Matching

Tool A Ch1
Tool A Ch2
Tool B Ch1
Tool B Ch2

Troubleshooting

Scanner Temp Profile
Temperature
Time

Overlay Shift
22.0°C
22.5°C

Process Characterization

WetTemp-LP
Process Condition A
Process Condition B

Multi Temp/Chamber Optimization

HighTemp-350
DEGAS COOL PVD-B COOL
Key Use Cases

- Equipment Engineers
  - Calibration/Qualification
  - Thermal Stability
  - Thermal Transient (Ramping)
  - WiW uniformity
  - C2C and T2T Matching
  - How accurate is?
  - How stable is?
  - How fast is?
  - How uniform is?
  - How much variation is?

- Process Engineers
  - Process Development
    - Effect of process knobs, i.e. temperature, power, chemistry, etc.
    - Allowable process window, i.e. range of temperature vs. process parametrics
  - Process Optimization & Integration
    - Duration between process steps
    - Thermal history
  - How sensitive is?
  - How optimal Temp & Duration are?
Etch Temp Use Cases in additional to ESC Cal

- Thermal Stability & Uniformity of Process Tool
- Thermal Sensitivity of Process

Wafer Based Temperature Metrology for Development & Optimization of Equipment & Process

Temperature change of 1°C leads to a Dense CD change of ~ 0.7 nm
Chamber Matching

STI Etch – High CD correlates to higher temp

CH D shows higher temperature resulting in higher CD
HighTemp-350 Multi-Chamber Thermal Profiling

- Provide temporal & spatial temperature information beyond the current 140°C limitation
- Insulate temperature-sensitive components from extreme heat during time-limited missions

Cluster-tool thermal characterization not available by any other means
High Temp 350XP for Thin Film

**Integration**

**Thermal Sensitivity**

**Transient**

**Thermal Stability**

High Temp-350 enables process tuning based on wafer temperature
For Tool – Tool (chamber-chamber) Matching

<table>
<thead>
<tr>
<th>Tools</th>
<th>A</th>
<th>B</th>
<th>Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degas</td>
<td><img src="image1" alt="Degas A" /></td>
<td><img src="image2" alt="Degas B" /></td>
<td>13.8</td>
</tr>
<tr>
<td>Mean</td>
<td>14.2</td>
<td>10.1</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>14.2</td>
<td>10.1</td>
<td>13.8</td>
</tr>
<tr>
<td>PVD</td>
<td><img src="image3" alt="PVD A" /></td>
<td><img src="image4" alt="PVD B" /></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>21.4</td>
<td>47.3</td>
<td>21.4</td>
</tr>
<tr>
<td>Range</td>
<td>33.9</td>
<td>47.3</td>
<td>21.4</td>
</tr>
</tbody>
</table>

- Both Chambers in Tool B are cooler than of Tool A
- Different cold spots between two degas chambers
- Larger temperature range in the PVD chamber of tool B than that of tool A
- **Longer duration in PVD of tool B over tool A**
  - Different thermal budget
Summary

- A metrology solution for characterizing and/or monitoring process tools
  - Thermal stability, uniformity, accuracy, matching, and throughput of all \( \leq 350^\circ C \)

- A metrology tool for process development & optimization
  - Effect of process knobs.
  - Thermal Sensitivity
  - Allowable process window
  - Duration of each and between process steps
  - Thermal budget