EtherCAT on Semiconductor Wafer Fabrication Equipment

Applied Materials, Inc.
Applied Materials Background

• Applied Materials is the number one equipment supplier in the global semiconductor industry, spanning a wide variety of platform types.

• Applied Materials is also a leading equipment supplier in the Display and Solar industries.

• Due to the diverse nature of the company product offerings within the semiconductor space and beyond, control system requirements are also diverse.
  – All business units within the company must be taken into account.
  – Solutions must meet both current and future needs.

The challenge is to find a fieldbus protocol that can meet all of our requirements.
Semiconductor Platform Challenges

• An example - challenges for typical Semiconductor cluster tools:
  – Repeatability
    • Chamber-to-chamber matching, side-to-side matching (Twin Chambers)
  – Geometries on the wafer constantly decreasing leads to control precision requirements constantly increasing.
Deficiencies with existing protocols

- Existing fieldbus protocols did do not offer the required determinism or performance to enable our present and future control needs.

- Deficiencies with some of the current fieldbuses is use:
  - **Serial**
    - Costly. For RS-232, single point of use per port:
      - Exceptional cabling/harnessing required for large number of ports.
      - Gateways/cards required to enable all required ports
    - Individual software connection per slave
    - Low bandwidth… susceptibility to noise
    - Cycle time limitations – handshaking/retries must be accounted for, and each implementation can be different due to protocol used

- **DeviceNET**
  - Maximum 63 devices per network + master
  - Specialized master hardware required (costly, asynchronous)
  - Limited bandwidth (500K/s)
  - Cycle time variations and limitations
## Existing Fieldbus Comparison

- How EtherCAT compares to existing protocols:

<table>
<thead>
<tr>
<th>Metric</th>
<th>EtherCAT</th>
<th>DeviceNET</th>
<th>Serial (RS-232)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Bandwidth</td>
<td>100Mb</td>
<td>0.5Mb</td>
<td>Typical &lt;0.1Mb</td>
</tr>
<tr>
<td>Data Packet Size</td>
<td>1500 bytes</td>
<td>8 bytes</td>
<td>Protocol dependent</td>
</tr>
<tr>
<td>Node Limit</td>
<td>65535</td>
<td>63</td>
<td>1</td>
</tr>
<tr>
<td>Master H/W</td>
<td>NIC</td>
<td>Dedicated Scanner</td>
<td>1 port per device</td>
</tr>
<tr>
<td>Deterministic?</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Typical AMAT Bus Cycle Time</td>
<td>1ms</td>
<td>20ms</td>
<td>Device dependent, typically &gt; 20ms</td>
</tr>
<tr>
<td>Device Synchronization</td>
<td>&lt;100ns</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>CPU Utilization</td>
<td>Low (DMA transfers)</td>
<td>Variable – can be high</td>
<td>Variable – can be high</td>
</tr>
</tbody>
</table>
EtherCAT Benefits

• Taking advantage of EtherCAT
  – Closed-loop control - Due to EtherCAT’s performance advantages, closed-loop control can now be realized via software.
  – Semiconductor process chambers contain non-linear interdependencies controlled by a multitude of end-devices. EtherCAT capabilities open up coordinated control opportunities not possible with previous protocols.
Conclusion

• After careful analysis of multiple industrial protocols, EtherCAT emerged as the winner due to superior performance capabilities and open nature.

• Applied Materials fully supports EtherCAT and the EtherCAT Technology Group, encouraging our suppliers to utilize and benefit from the technology.