Major Considerations in 450 mm Wafer Handling

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## 450 mm Requirements and Challenges

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<th>Customer Requirements</th>
<th>Wafer Carrier Challenges</th>
<th>Equipment Challenges</th>
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<td>300 mm scale up</td>
<td>Heavy payload: 22 kg</td>
<td>Heavy payload handling</td>
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<tr>
<td>SEMI® Compliant</td>
<td>▪ SEMI E156 Compliant (FOUP)</td>
<td>▪ SEMI E154 compliant (FOUP loadport)</td>
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<td>▪ SEMI E158 Compliant (MAC)</td>
<td>▪ SEMI E162 compliant (MAC loadport)</td>
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<td>32 nm / 22 nm performance</td>
<td>▪ Very low moisture environment</td>
<td>▪ Interface to FOUP purge</td>
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<td>▪ UV light protection</td>
<td>▪ Opaque FOUP (black box)</td>
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<td>▪ Advanced static protection</td>
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<td>Equipment interoperability between shipping box and process carrier</td>
<td>Transparent equipment interoperability between FOUP and MAC</td>
<td>Equipment interoperable with FOUP and MAC</td>
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450 mm Requirements and Challenges

Microenvironment Level

- Wafer sag
- Wafer fragility
- Wafer positioning and support
- 22 nm and below micro-contamination control

Major Considerations in 450 mm Wafer Handling
Opening of less than 90° remain relatively constant in the amount of wafer sag. An opening of 85° – 120° would be a zone in which you achieve a good balance between sag performance and ability to manufacture the support structure.
Wafer Sag - Automation Interface with Wafer

The SEMI exclusion zone limits the area available to support the wafers within a carrier.
Wafer Fragility

- **Wafer orientation during transport**
  - Graphs below show the relative difference in wafer fragility based on horizontal and vertical wafer orientation

Wave-form screen shot of glass wafer before failure in flat-on-back (wafer vertical) orientation

Wave-form screen shot of glass and polysilicon wafer before failure in flat-on-KCplate (wafer horizontal) orientation

Due to the low fragility values of 450 mm wafers on a horizontal wafer impact the packaging will be a critical part of the overall wafer shipping system performance
Wafer Fragility - 300 mm Elastic Wafer (35G)

The above video shows the displacement of a 300 mm wafer during a 35G shock event.
The above video shows the displacement of a 450 mm wafer in an Entegris prototype during a 15G shock event.
The difference between successful wafer transport is less than 2 G’s during a shock event.

Defining this threshold is difficult as each wafer is slightly different due to variation in structure.

This type of testing enables a better definition of the critical wafer fragility boundary used for designing secondary packaging.

The above video shows the displacement of a 450 mm wafer in an Entegris prototype during a 17G shock event.
Wafer backstop location was examined to understand better its effects on wafer centering and retention forces.

The expected variability for wafer center is related to the location of the wafer backstops.

As the wafer backstop moves closer to the rear of the carrier, the force generated at the backstop decreases.
Wafer Positioning and Retention

Step 1
Door moves in

Step 2
Door contacts wafers

Step 3
Lifts and secures wafers into position
Key elements to control the wafer environment are carrier material properties, purging in select areas within the process and maintaining seal integrity.
22 nm and Below Micro-Contamination Control

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<th>TECHNICAL CHALLENGE</th>
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<td>CONTROL THE DEFORMATION SEEN IN THE SEAL AREA</td>
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FEA ANALYSIS OF MICROENVIRONMENT SHELL LOADED WITH 450 mm PAYLOAD REVEALS SCOPE OF THE CHALLENGE

Seal integrity is critical to maintaining a controlled environment

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<th>CONCEPT DEVELOPMENT</th>
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