How To Peel Ultra Thin Dies From Wafer Tape

Stefan Behler, Besi Switzerland AG
stefan.behler@besi.com

Introduction:
- 4 key properties
- Multidisc Die Ejector
- FEA Model

1. Wafer foil bulk peel force
2. Wafer foil edge peel force
3. Bending stress: ejector types, FEA simulations, comparison
4. Die strength: overview, examples
Four Key Properties

- handling thin dies with carrier foils is still state of the art
- typical die bonder data sheet specification: «min. die thickness 20 μm»
- this specification is too simple!

Multidisc Die Ejector
Multidisc Die Ejector: Disc Move

Multidisc Die Ejector: Die Peeling Simulation

pre-defined geometries, pseudo-dynamic
8um peel/step (47steps)
disc height 300um
color code: bending stress
z-axis 4X
1. run simulation for static geometry
2. convert stress at peel front to peel energy $G$ (D = adhesive thickness, $E =$ adhesive modulus)
   
   $G = \frac{< \sigma > D}{2E}$

3. convert peel energy to peel speed
Four Key Properties

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1. Wafer foil bulk
2. Wafer edge peel force
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1. Wafer foil «bulk» peel force | data sheets

<table>
<thead>
<tr>
<th>Label</th>
<th>Foil Type</th>
<th>Peel speed [mm/s]</th>
<th>Peel energy [J/m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Lintec LE4728 UV</td>
<td>5.0</td>
<td>2.0</td>
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<tr>
<td>B</td>
<td>Hitachi HR Series UV</td>
<td>1.0</td>
<td>0.43</td>
</tr>
<tr>
<td>C</td>
<td>Ablestik ATB-100US1 UV</td>
<td>1.7</td>
<td>5.2</td>
</tr>
<tr>
<td>D</td>
<td>Nitto EM-310J-P UV</td>
<td>5.0</td>
<td>4.8</td>
</tr>
<tr>
<td>- Nitto SWT-20P+ non-UV</td>
<td>5.0</td>
<td>70.0</td>
<td></td>
</tr>
</tbody>
</table>

\[
\text{peel energy} = \frac{F}{b}(1 - \cos \phi)
\]

* approximates trend in data from Saiki et al., Tokyo Institute of Technology
2. Wafer foil «edge» peel force

- adhesion at die edge (point load)
- typical range 0.1 ... 1.5 N
- must be < 0.3 N for thin dies
- value depends on dicing method
- can be reduced by step cut, DBG, ...

example: step cut

![Image of a measurement tool](image1)

![Diagram of wafer foil peel force](image2)

2. Wafer foil «edge» peel force

- single cut shows 2x higher edge peel force due to local heating by blade
- Hitachi HR-9070-GT1

![Graph of peel force vs. UV dosage](image3)

(A) single cut
(B) DBG, DAF laser cut

![Image showing single cut and DBG cuts](image4)
3. Bending Stress | Ejector types

- Multi Stage
- Multi Disc
- Multi Needle

3. Bending Stress | 2D FEA models

- Multi Stage
- Multi Disc
- Multi Needle
3. Bending Stress | Multi Stage

- 40 um
- Total time: 700 ms
- Up speed: 1 mm/s
- Stage width: 2 mm

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3. Bending Stress | Multi Disc

- 40 um
- Total time: 200 ms
- Down speed: 3.8 mm/s
- Disc width: 0.8 mm

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3. Bending Stress | Multi Needle

20 um
needle diameter 0.7 mm
needle distance 3 mm
(dynamic simulation not possible in 2D)

3. Bending Stress | Peel propagation

Multi Stage
20 um die can not be peeled

Multi Disc
3. Bending stress | Comparison

- thinner die → more bending stress
- tensile stress on surface (compressive stress only for multi needle)
- smallest bending stress by multi disc
- with assumption/settings in this model, 20um dies cannot be picked with multi stage

4. Die strength

- material property, (almost) independent of thickness
- measured by bending test

three main regions of different strength:
- surface (active structure)
- backside (grinding, polishing...)
- edges (dicing)

die strength [MPa] measured by 3-point bending
4. Die strength | example

- wafer preparation & strength measurement by IMEC
- IMEC’s standard 5x50 µm via-middle TSV
- die size 10x10x0.05 mm | stealth dicing

Ultra-Thin Chips - A New Paradigm in Si Technology [BURKHART] 2012
4. Die strength | overview

<table>
<thead>
<tr>
<th>wafer processing</th>
<th>CDS [MPa]</th>
</tr>
</thead>
<tbody>
<tr>
<td>conventional backgrind, #320</td>
<td>80</td>
</tr>
<tr>
<td>conventional backgrind, #2000</td>
<td>800</td>
</tr>
<tr>
<td>DBG, CMP</td>
<td>1'000 – 15'000</td>
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<tr>
<td>DBG, CMP, thickness 100 um</td>
<td>440</td>
</tr>
<tr>
<td>DBG, CMP, thickness 30 um</td>
<td>1'433</td>
</tr>
<tr>
<td>DBG, blank 20 um</td>
<td>1000</td>
</tr>
<tr>
<td>DBG, metal tracks and bondpads</td>
<td>800</td>
</tr>
<tr>
<td>Stealth dicing, with TSV’s</td>
<td>930</td>
</tr>
</tbody>
</table>

- backgrinding grit size effect
- size effect
- structure effect

- large variation, 2 orders of magnitude!

4. Die strength vs. bending stress

- typical ranges are very close
- risk of die cracking
- «min. die thickness 20 μm»  
  → this specification is too simple!

- max bending stress
- characteristic die strength
- var. processing methods
  - 40 um
  - 20 um
Summary

• Introduction of the key properties
• Wafer foil bulk & edge peel force
• Bending stress: ejector types, FEA model, comparison
• Die strength: overview

Acknowledgements

• Thanks to Shotaro Kato and co-workers (Hitachi Chemical) for providing test wafers
• Thanks to W. Teng, A. Podpod (IMEC, Belgium) for providing strength data for TSV dies