Thin Die Technology – Agenda

- Introduction
- Beneficial Machine Architecture
- Pick Process & Process Control
- Application Tools and Optimization Process
- SW Features for High End Apps
- Yield Assurance
- Conclusion / Roadmap
Key Driver for Thin Die Handling Technology:

Die Thickness Trend

Production (high end MCP)
Qualification / Demo

DAF / FOW Thickness Trend

Film over Wire
Mother Die DAF
Daughter Die DAF
Successfully Processed Thin Die App’s on iStack

3 Layer Stack (MD – DD – Controller) Thickness 15µm Die / 5µm DAF

10 Layer Shingle Stack Thickness 15µm Die / 5µm DAF
K&S Thin Die Technology Overview

- Thin Die (Needle-less) Ejector & Pick Mode
- Dedicated Vacuum Supply

- Special ‘Seal Lip’ Tool
- Multi-Step
- Smooth Tool Lift-off
- Expert Diagnostics
- Step-wise Pick

Standard & Multi Needle (Magnetic) Die Ejector

Thin & Small Die (Needle-less) Ejector & Pick Mode
K&S Thin Die Pick Technology
- Machine Architecture
Equipment Architecture

Key Benefits for Thin Die Handling:

- **Process Performance & Flexibility**
  Optimized pick & place tooling design

- **Highest Throughput**
  Long pick times for high-end DAF/FOW app’s are “hidden” behind bond process through parallel die handling

- **Process Stability**
  “Cold” pick process while bonding at high temperatures
Separated PTP architecture allows for optimized pick & place processes!

- **Pick Tool** – Many big holes = Strong pick
  - Multi-hole tools optimized for pick yield

- **Transfer Tool** – High Accuracy
  - Transfer tool designed for highly accurate handover process
  - Vacuum holes location optimized to prevent “potato chip effect” on thin die for reliable vision
  - Tool has “self cleaning” effect and lowest surface energy – optimized for WBL/FOW handling

- **Place Tool** – No Voids
  - Tool optimized to eliminates voiding
K&S Thin Die Technology – Pick Process & Process Control
Thin Die Picking Method Piston Ejector

1. **Tool Impact**
   - Vacuum Level
   - Impact Speed
   - Pick Force

2. **Initial Peeling**
   - Separation Distance
   - Separation Speed
   - Multi-Step Separation configurable

3. **Retraction – Final Peeling**
   - Pick Force
   - Retract Distance
   - Retract Speed
   - Multi-Step Retraction configurable

4. **Die Pick-up**
   - Smooth Tool Lift-off configurable
Thin Die Picking Method Slider Ejector

1. **Tool Impact**
   - Vacuum Level
   - Impact Speed
   - Pick Force

2. **Initial Peeling**
   - Eject Height
   - Eject Speed
   - Slider Speed
   - Slide Distance
   - Multi Step configurable

3. **Final Peeling**
   - Sliding Distance
   - Slide Speed
   - Multi Step configurable

4. **Die Pick-up**
   - Smooth Tool Lift-off configurable
(Thin) Die Handling Process Control

*iStack’s Tool Impact, Force & Position Control for Minimum Stress on the Die:*

**Tool Impact Control:**
- Tool impacts at user adjustable constant velocity
- Tool impacts are automatically detected and adjusted during *each* machine cycle

**Force Control:**
- Force is generated by linear motors (spring-less) with auto calibrated current loops
- Highest force repeatability through closed loop current control

**Position Control:**
- Dies are positioned and handed over between tools within 1.5µm (sigma), implying zero shear stress during pick and handover
- Drifts are eliminated through “Dynamic Calibration” during production
K&S Thin Die Technology – Application Tools and Optimization
Thin Die Ejector Optimization

*Die Ejector Design Optimization using Finite Element Analysis based on:*

- minimizing tensile (center and neighbor) die stress near/along the die edges
- maximizing peel stress along the die edges
Excellent agreement between FEA model and Pick Test (7.8x10.8mm Die, 25µm thin)

**FEA Model:** Red WBL sticks on Tape, Blue WBL peeled from Tape

**Thru-Tape Photos:** Dark Grey WBL sticks on Tape, Light Grey WBL peeled from Tape
Thin Die FEA Model Validation

*Process Tests on Various Devices for Verification of FEA Results & Developments*

- **Test Device Information:**
  - Die Thickness: 15µm
  - DAF Tape: Hitachi FH9011
  - Die Sizes:
    - 17.15mm x 9.70mm
    - 16.90mm x 10.65mm
    - 10.80mm x 7.80mm
  - Pick Cycle time: 350ms

![Graph showing thin die picking performance on 15µm die](image)

<table>
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<tr>
<th>Ejector Type</th>
<th>Die Picked</th>
<th>Crack Yield</th>
<th>Pick Yield</th>
<th>Total Yield</th>
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**Seal Lip Pick Tool maintains vacuum between tool and thin die if the die deforms:**

- Strengthens grip and adds stiffness to the die
  - Increases pick-up yield
- Avoids stress due to pressure difference between atmospheric pressure and ejector vacuum
  - Reduces die bending

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**Flexible seal to cover the edges of die**

**FEA of tool with vacuum, showing lip seal compliance**

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**Prototype**

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**Standard Pick Tool**

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**Seal Lip Pick Tool**

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Confidential
Thin Die Technology – SW Features for High-End App’s
**Multi-Step Separation Process:**

- More flexibility to parametrize the separation process
- Better control of initial peel process for applications with high “edge tackiness”

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**Configuration of Multi-Step Separation**

(Fast) Initial peel process for low “edge tackiness”:

- $\Delta t = 2\text{ms}$

(Slow) Initial peel process for high “edge tackiness”:

- $\Delta t = 40\text{ms}$
- $\Delta t = 60\text{ms}$
- $\Delta t = 70\text{ms}$
**Smooth Pick Tool Lift-off @ End of Pick Process:**

- More flexibility to parametrize the pick tool lift-off motion
- Higher process reliability for extremely thin or high “edge tackiness” dies
**K&S Mixed Signal Scope for Process Setup:**

- K&S includes unique monitoring and diagnostics SW scope, tracking all
  - axes position, speed & acceleration set points & actual readings,
  - digital and analogue I/O’s
- Allows for detailed pick process analysis & optimization

**Example:**

Pick tool detects leaks between pick tool and die → Conclusions on effectiveness of peel process

- Initial peeling not started – leakage between tool and die during separation
- Initial peeling completed – no leakage between pick tool and die
Thin Die Technology – Yield Assurance
Yield Assurance

**Crack Inspection System**

**Transfer Camera:**
- Full Die image @ 30µm/pix
- Technically NOT possible to make Cracks visible with full field FOV sensor (MP limit)

**Hi-Resolution Microscope:**
- ≈ 0.6µm/pixel → very small FOV
- Hard to tell Edge from Cracks
- Needs multi-image scanning (time consuming = low UPH)

**K&S technique:**
- Full Die image at 60µm/pixel resolution
- Special illumination technique
- High resolution **NOT** required even for 1µm crack

Cracks appear as bright signals on dark background

“Crack Detection Module” Inspection after Die Pick-Up

**SEM image**

Red Lines indicate Cracks

1.7 / 4.4µm crack width

17.1mm

10.0mm

210µm

320µm

≈ 10mm
Thin Die Technology – Conclusion / Roadmap
Conclusion

- Production proven ‘Best in Class’ Thin Die Handling
- Demonstrated Unique Crack Detection Capability

Roadmap - Extension of Current Thin Die Technology to Advanced Packages

- Background
  - TSVs will create different stress distribution in thin die.
  - Thinner Die ⇒ easier Via manufacturability ⇒ smaller possible Via ∅ (aspect ratio Via depth/∅)
  - Pillars are not touchable. Changed Pickup Tool geometry ⇒ different stress distribution.

- We will enhance existing technology for thinnest possible TSV / Copper Pillar Die.
  - Verification on suitability of existing thin die technology is started
  - Reduce inner stress on TSV and Copper Pillar Dice with FEA models and validation.
  - Looking for partners to validate Technology on TSV and Copper Pillar Dice in production environment.
Question / Answers
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