Test Floor Management Software

Automated Correlation
Wafer Management and Processing

White Paper

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DELPHI ELECTRONICS & SAFETY

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ELECTROGLAS, INC.
Who is Delphi?

- Delphi is a world leader in mobile electronics and transportation components and systems technology

- Multi-national Delphi
  - Conducts its business operations through various subsidiaries and has headquarters in Troy, Mich., USA, Paris, Tokyo and São Paulo, Brazil.

- Delphi’s two business sectors
  - Dynamics, Propulsion, Thermal, and Interior Sector
  - Electrical, Electronics, and Safety Sector

- Delphi has approximately 185,000 employees and operates 171 wholly owned manufacturing sites, 42 joint ventures, 53 customer centers and sales offices and 33 technical centers in 40 countries.

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### Delphi Electronics & Safety

#### Breadth of Product

<table>
<thead>
<tr>
<th>Body</th>
<th>Security Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body Electronics</td>
<td>Vehicle</td>
</tr>
<tr>
<td>Climate Controllers</td>
<td>Content</td>
</tr>
<tr>
<td>Head-up Displays</td>
<td></td>
</tr>
<tr>
<td>Instrument Clusters</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Powertrain</th>
<th>Power Modules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standalone &amp; Engine Management System</td>
<td>Semiconductors</td>
</tr>
<tr>
<td>Controllers</td>
<td>Software</td>
</tr>
<tr>
<td>Engine</td>
<td></td>
</tr>
<tr>
<td>Machine and Heavy Duty</td>
<td></td>
</tr>
<tr>
<td>Powertrain</td>
<td></td>
</tr>
<tr>
<td>Transmission</td>
<td></td>
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<table>
<thead>
<tr>
<th>Safety</th>
<th>Forewarn Collision Warning Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airbags</td>
<td>Smart Cruise Control</td>
</tr>
<tr>
<td>Frontal, Side, Curtain</td>
<td>Back-up Aid</td>
</tr>
<tr>
<td>Inflators, Cushions, Covers</td>
<td>Side Alert</td>
</tr>
<tr>
<td>Antilock Brake Control</td>
<td>Restraint Systems Electronics</td>
</tr>
<tr>
<td>Belt Tension Sensor</td>
<td>Crash Sensing</td>
</tr>
<tr>
<td>Seat Belts</td>
<td>Occupant Sensing</td>
</tr>
<tr>
<td>Steering Wheels</td>
<td>Steering Electronic Control</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Integrated Media Systems</th>
<th>Hands-free Connectivity</th>
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<tbody>
<tr>
<td>Acoustic Systems</td>
<td>Navigation Systems</td>
</tr>
<tr>
<td>Advanced Digital Audio</td>
<td>Premium Audio Systems</td>
</tr>
<tr>
<td>Playback Devices</td>
<td>Rear Seat Entertainment Systems</td>
</tr>
<tr>
<td>Satellite Receivers</td>
<td>Receivers</td>
</tr>
<tr>
<td>Digital Receivers</td>
<td>Satellite Data Services and Communication</td>
</tr>
<tr>
<td>Amplifiers</td>
<td>Truck PC</td>
</tr>
<tr>
<td>Fuba Advanced Antenna Systems</td>
<td>Wireless Networking</td>
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</tbody>
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Delphi Electronics and Safety Delphi Microelectronics Center

Key Semiconductor Technologies

Dept 8436 - Wafer Test, Saw and Sort

- 150 Products
  - CMOS, Bipolar, Smart Power, IGBT, Micro Machine, and Sensors
  - Flip Chip and Pad Devices
- 87 Test Cells
  - Teradyne A5xx, A3xx, J9xx, J750, Eagle 300 - Sentry - SZ M3020 - LTX 77, CP80, Synchro HT, Fusion HT, HF, CX
  - EG2001, EG4090 and TEL P8XL, WDF, WDP Probers
  - Offline Ink
- Test 1,000,000 Die Per Day
  - 3 Shifts, 5 Days/Week Operation
- Automatic Visual Inspect, Saw, and Sort
- Packaging and Final Test – DIP, QUAD PAK, SOIC, BGA…

Current Correlation Wafer Process

- Typical Correlation wafer uses:
  - Prior to Device / Product or hardware changeovers
  - After Corrective or Preventive Maintenance
  - Verify / validate test cell integrity anytime yield or test results are in question
• Current practice is to run an entire wafer to verify the test system setup based on the repeated yield of the correlation wafer.
  
  - Performed manually by an operator with simple pass/fail criteria. We use the good count +/-5% to determine a min and max number of good die.
  
  - The correlation wafer passes if the number of good die on subsequent runs falls within the min and max values.
  
  - This process is simple for the operator but it does not systematically indicate if the test system is performing optimally.

Current Correlation Process Concerns

• Correlation result integrity
  
  - What if we get more good die than the max number?
  
  - Are we now calling bad die good?
  
  - What does it mean if we get less good die than the min?

• Correlation wafer integrity and lifespan
  
  - A correlation wafer can be run 5, 10, 20 times before it is “worn out” or scraped
  
  - Often, one cannot tell if a failure is due to some part of the test system or due to the correlation wafer integrity

• Throughput cost
  
  - Test times range between 15 min and 3.5 hours per wafer
    ▪ 600 to 10,000 die per wafer

• Correlation wafer cost
  
  - Typically correlation wafers are scraped which impacts revenue

How Can The Process Be Improved?

• Implement automate statistical correlation wafer result analysis to improve correlation integrity
  
  - Rule based bin analysis
  
  - Good die remain good and bad die remain bad

• Enhance correlation wafer integrity and lifespan
  
  - Control the number of die tested with each correlation run
  
  - Control the number of touchdowns per die

• Reduce Cost
  
  - Improve throughput
    ▪ Not necessary to probe the entire correlation wafer for a valid assessment of the test cell setup
    ▪ Reduce test time used in correlation process
- Reduce Correlation Wafer Cost
  - Extend the life of correlation wafers
  - Controlled use of the wafers enables them to be sold as product for revenue

What is Correlation Wafer Manager (CWM)

- CWM uses automated map management and rule based SPC to automate the correlation wafer process and provides substantial cost savings with increased production throughput
- CWM Features:
  - Identifies correlation wafer(s) from previously probed production wafers in the automated map manager
  - Manages correlation wafer usage
  - Creates correlation follow maps for the prober enabling the testing of a subset of the die on the correlation wafer
  - Analyzes the correlation results based on rules created for each product, or default rules
  - Messages the prober with correlation results
  - Provides simple solution for production with automated analysis and sends the prober a message indicating passage or failure, with failure details

How CWM Functions

- The Core Technology
  - Web-based
  - Automated map manager
  - Two-way prober communication
  - Statistical and graphical reporting engine provides SPC
- CWM Setup
  - Correlation wafer is selected
  - Correlation rules setup
  - Product recipe created for prober
How Many Die To Test?

- There are many variables in determining the correlation sample size. We assumed around 90% yield for the device and that Alpha would be 0.1 (90% confidence) and Beta would be 0.2 (risk of missing something significant). Based on that we looked at the comparison of two proportions and got the following:

  1% shift 1,000 die  
  2% shift 275 die  
  3% shift 125 die  
  4% shift 75 die  
  5% shift **50 die**  
  6% shift 40 die  
  7% shift 30 die  
  8% shift 25 die  
  9% shift 20 die

- The actual number is going to vary based on the individual device maturity and yield trend. Based on this testing 50 die will find a 5% shift while it will take over 100 to find a 3% shift. Looking for 1-2% shifts impacts the cost effectiveness and best utilized with immature devices.
Correlation Rules Setup

**Correlation Rules Manager**

Source(s): 19478 CORE.txt

PSA78 CORR.txt

[Correlation Rules: Add New]

If Bin is -1, the Bin Group is used. Bin Groups can contain wildcard. "Min # to Test" is the minimum number of die of this bin/group to test. "Min % Match" is the minimum allowed % of die of this bin remaining this bin. "Max % Transition" is the maximum allowed % of die not of this bin to change to this bin.

<table>
<thead>
<tr>
<th>Bin</th>
<th>Bin Group</th>
<th>Min # To Test</th>
<th>Min % Match</th>
<th>Max % Transition</th>
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<tbody>
<tr>
<td>Edit Delete 1</td>
<td>*</td>
<td>25</td>
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<td>100</td>
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</table>

Web Interface for CWM Rule Setup

CWM Map Examples

- Initial correlation wafer
- (4) Individual correlation regions of the wafer used for correlation
CWM Prober Message Example = Fail

![CWM Prober Message Example](image)

The Correlation “Failed” the Bin 1 Transition Rule

Benefits

- **Correlation Analysis Integrity**
  - Implement automate statistical correlation wafer result analysis to improve correlation integrity
    - Rule based bin analysis
    - Good die remain good and bad die remain bad.
    - Removed operator analysis portion (pass/fail) (subjective), making it a statistical rule based decision made by CWM
    - CWM is integrated one device at a time with the flexibility to easily change number of die to test, number of times to probe a wafer section and pass/fail criteria.

- **Correlation Wafer Management**
  - CWM provides a record of correlation wafer inventory and usage
  - Enhanced correlation wafer integrity and lifespan
    - Control the number of die tested with each correlation run
    - Control the number of touchdowns per die

- **Reduced Cost**
  - Improve throughput
  - Extend the life of correlation wafers