Analysis of probe C.C.C. according to temperature and evaluation method

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June 4-7, 2017
Overview

• Background
• Evaluation method
• Evaluation results
• Analysis of evaluation results
• Automated measurement system
• Conclusion
• Acknowledgements
Background

• **Diversification of application field of semiconductor chips**
  – Wafer test under harsh environmental condition is required
  – Probe card that ensures sufficient characteristics under high temperature is necessary

• **Analytical research on the probe characteristics are required**
  – Evaluation method (ISMI, MAC)
  – The temp. dependence of probe C.C.C
    → Verifying effect of materials & design
    → Guide to predicting high temp. C.C.C.
    and selecting probe

**T-CCC Formulation**

- New CCC formula including temp. variation: T-CCC
- T-CCC parameters:
  - Resistivity, function of temperature (ρ)
  - Probe length (L)
  - Temperature (T)
  - Area (A)
  - Simplified multiplier (δ')

Where $k$, $h$ are considered as constant due to:
- Thermal conductivity ($k$) is unchanged in 25°C to 100°C
- The coefficient of convection ($h$) is negligible.

$$CCC = \beta' \frac{A}{L} \sqrt{\frac{1}{\rho(T)}}$$
Background

• Development of precision probe analyzer
  – Can evaluate various probe characteristics at elevated temperature
    → C.C.C., force, plastic deformation, Cres., durability, etc.,
  – High accuracy sensing
    → Temp., force, resistance, current
  – Fully automated equipment
    → Test time efficiency
    → Reliable testing and data acquisition
Evaluation method

• Type of probes
  – Type A: MEMS cantilever (Ni alloy)
  – Type B: φ50µm cobra (Pd alloy)

• Evaluation parameters
  – Probe force
  – ISMI C.C.C., MAC at various temp. (25°C ~ 150°C)
  – Equipment: newly developed probe analyzer
Evaluation results

“A” & “B” type probe evaluation results (probe force)

- Type “A” : MEMS cantilever design
- The graph shows a linear trend.

<table>
<thead>
<tr>
<th>Type</th>
<th>Force</th>
<th>Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>“A”</td>
<td>2.25gf (@OD75)</td>
<td>25°C</td>
</tr>
<tr>
<td>“B”</td>
<td>3.52gf (@OD75)</td>
<td>25°C</td>
</tr>
</tbody>
</table>

- Type “B” : Wire vertical (cobra)
- As O/D increase, slope of force curve is decreased
- The graph slope is smaller than “A” type
Evaluation results

“A” type probe evaluation results (ISMI C.C.C.)

- C.C.C.: 896mA, Temp.: 25°C
- C.C.C.: 696mA, Temp.: 85°C
- C.C.C.: 421mA, Temp.: 125°C
- C.C.C.: 345mA, Temp.: 150°C
Evaluation results

“B” type probe evaluation results (ISMI C.C.C.)

Probe force upon applied current

- C.C.C. : 617mA
  - Temp. : 25°C
- C.C.C. : 604mA
  - Temp. : 55°C
- C.C.C. : 555mA
  - Temp. : 85°C
Evaluation results

“A” & “B” type probe evaluation results (MAC)

Type : “A”
MAC: 281mA
Temp. : 25°C

Type : “A”
MAC: 191mA
Temp. : 85°C

Type : “B”
MAC: 465mA
Temp. : 25°C

Type : “B”
MAC: 377mA
Temp. : 85°C
Analysis of evaluation results

ISMI C.C.C. & MAC according to temperature

<table>
<thead>
<tr>
<th>Temp.</th>
<th>“A” type</th>
<th>“B” type</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>896</td>
<td>617</td>
</tr>
<tr>
<td>55</td>
<td>(780)</td>
<td>604</td>
</tr>
<tr>
<td>85</td>
<td>696</td>
<td>555</td>
</tr>
<tr>
<td>125</td>
<td>421</td>
<td>(522)</td>
</tr>
<tr>
<td>150</td>
<td>345</td>
<td>(489)</td>
</tr>
</tbody>
</table>

- Evaluation result is correlated with above formula (error ≤ 5%)
- (data) is calculated value by the formula
- C.C.C. depends on probe material & design and decreases with the increase in temperature.

<table>
<thead>
<tr>
<th>Temp.</th>
<th>“A” type</th>
<th>“B” type</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>281</td>
<td>465</td>
</tr>
<tr>
<td>55</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>85</td>
<td>191</td>
<td>377</td>
</tr>
<tr>
<td>125</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>150</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

- No correlation with the ISMI C.C.C. result.
- MAC also decreases when the temperature rises
- MAC is insensitive to probe design compared with ISMI C.C.C.
  → MAC slope upon temp. of A and B are similar
Analysis of evaluation results

ISMI C.C.C. vs. MAC for a range of temp.

<table>
<thead>
<tr>
<th>Type</th>
<th>Temp. [℃]</th>
<th>ISMI [mA]</th>
<th>MAC [mA]</th>
<th>MAC/ISMI x100 [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;A&quot;</td>
<td>25</td>
<td>896</td>
<td>281</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>85</td>
<td>696</td>
<td>191</td>
<td>29</td>
</tr>
<tr>
<td>&quot;B&quot;</td>
<td>25</td>
<td>617</td>
<td>465</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>85</td>
<td>555</td>
<td>377</td>
<td>68</td>
</tr>
</tbody>
</table>

- In case of "A" type, MAC value dropped sharply compared with "B" type.
- Probe design & fixation methods are more dominant factor than material.
- Vertical structure is more advantageous in evaluation than horizontal (cantilever) structure.
  → Vertical probe is easy to release heat by guide plate.
Automated measurement system

Precision probe test solution

• Precise force measurement
  Resolution : 0.01g

• PID temperature control
  RT, HT test available (Max. 180°C, target Temp. ±0.3°C)

• 4-wire resistance measurement

• X, Y, Z stage control

• Vision Alignment
  3 camera system(Top, Side, CCTV)
Automated measurement system

① Source meter & load cell control
② Top camera & load cell
③ Temperature control
④ Stage, heater, temperature sensor
⑤ Side camera, CCTV camera
Automated measurement system

① Objective lens window  
② CCTV window  
③ Stage control window  
④ Stage state window  
⑤ Position/recipe set-up window  
⑥ Pin map display window  
⑦ Manual run window  
⑧ Stage heater control window
Automated measurement system

• **Objective lens (x10)**
  – X & Y-axis positioning

• **Objective lens (x4)**
  – Contact tip & probe first contact

• **CCTV**
  – Observation from various angle

[Images of measurement system components, including a probe tip and contact tip.]
Automated measurement system

- Probe position set-up
- Probe recipe set-up
Automated measurement system

- **First contact (Z-axis auto detect)**
  - Contact tip moving
  - Movement per step and the detection gram can be set depending on the probe type.
  - After the 3rd step, 1μm retraction point is recognized as first contact point.
Automated measurement system

Data graph (example)

- Probe force

- C.C.C. (ISMI)
Conclusion

C.C.C. Evaluation & Analysis

- C.C.C. formula of previous presentation is well matched to the experimental result (ISMI).
- Temperature dependence of ISMI C.C.C. & MAC
  - Probe design & fixation methods are more dominant factor than material.
  - For the MAC method, the value is insensitive to probe geometry compared with ISMI C.C.C.

Automated measurement system

- Reliability of measurement result ↑
- Various measurement items can be set by each probe at one time
Acknowledgements

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