Considerations for effective high temperature operation life (HTOL) implementation

Track G:
Verification, Simulation, and Testing

Ducat - Deny Hanan
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My name is Deny Hanan, and I am co-founder of Ducat.

I have ~25 years experience in semiconductor Q&R engineering and management.
What is HTOL?

High Temperature Operating Life (HTOL) is a reliability test applied to Integrated Circuits (IC) to determine their intrinsic reliability. It stresses the IC at an elevated temperature, high voltage and dynamic operation for a predefined period of time for triggering potential failure modes and assess IC lifetime.
HTOL evolution

I.C Dynamic (Mid 80’s)  D.C
I.C Static (Early 70’s)  D.C
I.C tested (Current)    D.C
I.C Monitored (Early 00’s)  D.C
For effective HTOL stress test, the following parameters shall be considered:

1. Digital Toggling Factor,
2. Analog Modules Operation,
3. I/O Ring Activity,
4. Monitor Design,
5. Ambient Temperature (Ta),
6. Junction Temperature (Tj),
7. Voltage Stress (Vstrs),
8. Acceleration Factor (AF),
9. Test Duration (t),
10. Sample Size (SS)

- Toggle as many as possible
- Activate all modules
- Operate all I/Os
- Consider self heating
- Precise aging
- Max rating vs over stress
- Count all aging models
- Equivalent to lifetime
- The higher the better
HTOL Policy

Sample Selection

- Use (three) nonconsecutive production lots in order to represent manufacturing variability
- Samples shall be fabricated, handled, screened and assembled in the same manner that will be done in production

Sample preparation

- Test prior to stress and at predefined check points
- Test at max/min rating temp. & at room temp.
- Log all functional events and parametric results
HTOL Policy

Test duration

- Assuming 1000h trial, check points (usually) are after 48, 168, 500 and 1000 hours
- Different check points for different AF can be calculated
- Electrical testing shall be completed as soon as possible after removing the stress
- if samples cannot be tested soon after removal additional stress time shall be applied (24 hours for each 168 hours)
HTOL Policy

Merit numbers

- Qualification is an outcome of statistical sampling plan.
- An AUDIT TOOL to ensure that the output of a process meets the requirements. It simply accepts or rejects the tested lots.
- Consider AQL, LTPD, manufacturer’s risk, and customer’s risk for fitting qualification strategy.
- The commonly used sampling plan of 0 rejects out of 230 is equal to 3 rejects out of 668 samples assuming LTPD = 1 but with higher ‘pass’ probability.
Standard use in various industries

• Commercial Use

<table>
<thead>
<tr>
<th>Min Tuse</th>
<th>Max Tuse</th>
<th>Description</th>
<th>expected life time</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 °C</td>
<td>50 °C</td>
<td>desktop products</td>
<td>5 years</td>
</tr>
<tr>
<td>0 °C</td>
<td>70 °C</td>
<td>mobile products</td>
<td>4 years</td>
</tr>
</tbody>
</table>

• Automotive Use

<table>
<thead>
<tr>
<th>Min Tuse</th>
<th>Max Tuse</th>
<th>Description</th>
<th>expected life time</th>
</tr>
</thead>
<tbody>
<tr>
<td>-40 °C</td>
<td>105 ÷ 150 °C</td>
<td>under hood condition</td>
<td>10 ÷ 15 years</td>
</tr>
<tr>
<td>-40 °C</td>
<td>80 °C</td>
<td>passenger compartment condition</td>
<td>10 ÷ 15 years</td>
</tr>
<tr>
<td>0 °C</td>
<td>70 °C</td>
<td>passenger compartment condition</td>
<td>10 ÷ 15 years</td>
</tr>
</tbody>
</table>
Standard use in various industries

- Telecommunication Use
  (European Telecom)

  (US Telecom)

- Military Use
The ducat, a coin of value, was once the gold standard of trade in Europe.

True to its name, ducat is adding value, and introducing a new standard of Q&R services.

Thank You

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