Risk analysis on IC in Schneider Electric

Presented by: Claire Garden / EME lab / Schneider Electric
Summary

1. Schneider Electric / EME laboratory
2. Mission Profile: Customer expectation
3. Risk analysis on IC
4. Difficulties / Concerns
Schneider Electric, the global specialist in energy management and automation

€25 billion
FY 2014 revenues

~5%
of revenues devoted to R&D

~170,000
people in 100+ countries

Diversified end markets – FY 2014 revenues¹

<table>
<thead>
<tr>
<th></th>
<th>Non-residential &amp; Residential Buildings</th>
<th>Data Centers &amp; Networks</th>
<th>Industrial &amp; Machines</th>
<th>Utilities &amp; Infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent</td>
<td>33%</td>
<td>14%</td>
<td>27%</td>
<td>26%</td>
</tr>
</tbody>
</table>

Balanced geographies – FY 2014 revenues¹

<table>
<thead>
<tr>
<th>Region</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>25%</td>
</tr>
<tr>
<td>Western Europe</td>
<td>28%</td>
</tr>
<tr>
<td>Asia Pacific</td>
<td>28%</td>
</tr>
<tr>
<td>Rest of World</td>
<td>19%</td>
</tr>
</tbody>
</table>
Energy is the base of life.

We ensure energy is on by making it

• Safe
• Reliable
• Efficient
• Connected
• Sustainable
At Schneider Electric, we combine Energy Management, Automation and Software serving 4 markets, i.e. 70% of the world energy consumption. Source: IEA Explore 2015
Life is On with Schneider Electric Building Solutions:
From grid to floor space, we ensure safety, comfort, reliability, efficiency and sustainability
Life is On with Schneider Datacenter Solutions:
From rack to cyber space, we optimize performance, speed and cost
Life is On with Schneider Electric Smart City Solutions:
From downtown to suburb, we deliver urban efficiency today

- **Smart Water**
  - Plant & Network Energy Performance
  - Water Distribution Optimization & Loss Mgt
  - Stormwater management and Urban Flooding
  - Irrigation Management

- **Smart Energy**
  - Smart Grid Asset Management, Smart Generation, Demand Side Management, Utility Services
  - Renewables Integration & Micro Grid
  - District Heating/Cooling Management
  - Gas Distribution Management
  - Shore Connection

- **Smart Buildings & Homes**
  - Multiple Disparate Buildings Management
  - High Performance Buildings
  - Flexible Buildings
  - Efficient Homes

- **Smart Mobility**
  - EV Charging Infrastructure & Supervision Services
  - Traffic Management
  - Tunnel Management
  - Tolling Management
  - Railway Management
  - Airport Solutions

- **Smart Public Services**
  - Public Safety: Video Surveillance
  - Smart Street Lighting Management

- **Smart Data Center**
  - Efficient Data Centers
  - Prefabricated Data Centers
  - Infrastructure Enabled Management Services

- **Smart Integration**
  - City-wide Platforms
  - Energy & Sustainability Resource Management
  - Urban Efficiency Platform
  - District Energy Management Information System

- **Cross-domain Application**
  - Weather
  - GIS
  -Asset Management

- **City Strategy Services**
  - Sustainability Services
  - Smart Cities Advisory Services
  - Energy Performance Contracting
Our capabilities allow us to deliver tangible results for customers, wherever they might be.
Electronics and Materials Expertise Lab. (EME)

Provide technological expertise support to all Schneider Electric Businesses for product quality mastery

- Qualification
- Failure analysis
- Consulting

In the field of

- Electronics
- Materials
- Metals
- Assembly
EME lab in few figures

19 experts
550 m² lab
5 M€ equipment
+
a wide external laboratory network

750 analyses performed / year
7500 expertise reports accessible in our iExpert database

2013: ventilation by domain
(except progress plan)

Components 40%
Assemblies 21%
Metals 18%
Plastics 21%
Mission Profile: Customer Expectation
Varieties of environmental constraints in our final customers applications require high reliability & requirements levels where failures cannot be tolerated!

Electronics to be safe, reliable, connected, green, in our customer environment during the expected lifetime.....
Our Customers expect the “legendary reliability of Schneider Electric products “!

For each life phase of the product, the mission profile …

1. describes the environmental conditions of the product and its components
2. describes the usage conditions
3. fixes the expected time duration and cycles numbers

Manufacturing:
- component storage,
- assembling,
- sub-assembly storage

Shipping:
- distribution center,
- distributor,
- final customer

Storage:
- Installation / Commissioning
- Operation
- Maintenance
Product Mission Profile Example

**Storage**

<table>
<thead>
<tr>
<th>Temperature (close to the component)</th>
<th>Humidity (close to the component)</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>30°C</td>
<td>80%RH</td>
<td>6 months</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature (close to the component)</th>
<th>Humidity (close to the component)</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>90°C</td>
<td>7%</td>
<td>61320 h</td>
</tr>
<tr>
<td>105°C</td>
<td>5%</td>
<td>26280h</td>
</tr>
</tbody>
</table>

**Operation**

<table>
<thead>
<tr>
<th>Temperature (close to the component)</th>
<th>Humidity (close to the component)</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>50°C</td>
<td>15%</td>
<td>157680h</td>
</tr>
<tr>
<td>60°C</td>
<td>10%</td>
<td>8760h</td>
</tr>
</tbody>
</table>

Standard components market gets lower level requirements than Schneider industrial products.
Risk analysis on IC
Risk analysis

Quality and Reliability data from the component manufacturer are compared to the need of the project (mission profile), in order to identify the risks related to the technology and its use in the final product.

1st step: Gathering component data by CIR
2nd step: Analysis and calculation
3rd step: Risk assessment plan
Risk analysis

1\textsuperscript{st} step

- Gathering all the data concerning the component: A CIR is sent to the supplier

- Check obsolescence or shrink status of the component,
- Technological node used,
- Wafer plant names and locations,
- Assembly plants/subcontractors names and locations
- All test results (wafer, die and package levels)
Risk analysis

2nd step

- Analysis of the CIR form
Risk analysis

Reliability tests results at wafer level

- Hot Carrier Injection (HCI)
- Time Dependent Dielectric Breakdown (TDDB)
- Electromigration (EM)
- Negative Bias Thermal Instability (NBTI)

Source: Semiconductor Device Reliability Verification (SONY)
Risk analysis

Reliability tests results at device level

High Temperature Operating Life (HTOL)

Latch Up (LU) at max. operating temperature

Electro-Static Discharge (ESD)

Source: [http://vlsiuniverse.blogspot.fr/2013/03/latchup-condition-in-cmos-devices.html](http://vlsiuniverse.blogspot.fr/2013/03/latchup-condition-in-cmos-devices.html)

Failure Signature of electrical overstress on power MOSFETs
Risk analysis

Reliability tests results at die level (applying to non volatile memories and IC’s with flash or non volatile memories embedded)

Non-volatile Memory Uncycled High Temperature Data Retention (UCHTDR)

Non-volatile Memory Cycling Endurance (NVCE)

Non-volatile Memory Post Cycling High Temperature Data Retention (PCHTDR)
**Risk analysis**

**Reliability tests results at package level**

- High Temperature Storage (HTS)
- Temperature Humidity Bias (THB) or Highly Accelerated Stress test (HAST)
- Thermal Cycling (TC)
- Bond Pull Strength (BPS)
- Bond Shear (BS)
- Solderability (SD)
- Tin whisker’s tests excepted to BGA package

**Qualification tests applying only to BGA packages:**

- Solder Ball Shear (SBS)
- Thermal warpage characterization test

Risk analysis

2nd step

• Check if all the tests have been performed in accordance with JEDEC Standards (or AEC-Q100): JESD47I / JEP122G / JEP001A
Risk analysis

2nd step

- Use acceleration factors and JEDEC models in order to validate the coverage of the mission profile by the reliability tests performed by the supplier

\[
AF = e \frac{E_a}{k} \left( \frac{1}{T_{use}} - \frac{1}{T_{Test}} \right)
\]

**Arrhenius**

\[
AF = \left( \frac{J_{use}}{J_{test}} \right)^{-n} \times e^{ \frac{E_a}{k} \left( \frac{1}{T_{use}} - \frac{1}{T_{Test}} \right) }
\]

**Black Model**

\[
AF = \left( \frac{RH_{Test}}{RH_{use}} \right)^m
\]

**Hallberg-Peck Model**

Source: Semiconductor Device Reliability Verification (SONY)
## Risk analysis

### 3rd step

- Identify the risks
- Propose a risk assessment plan

<table>
<thead>
<tr>
<th>Risk n°</th>
<th>Description of risk</th>
<th>Risk Assessment Proposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Risk of poor quality of assembly of BGA package on electronic boards for ASET assembly site: The supplier did not provide the SBS, SD and warpage tests</td>
<td>Ask the supplier to provide SBS, SD and warpage test results.</td>
</tr>
<tr>
<td>2</td>
<td>Risk of poor quality of assembly of BGA package on electronic boards for CML assembly site: BGA thermal warpage characterization test results are missing.</td>
<td>Ask the supplier to provide BGA thermal warpage characterization results.</td>
</tr>
</tbody>
</table>
Risk analysis

Gap coverage following risk analysis

- Reliability tests missing: ask the supplier to provide the missing test
  ➔ Example: missing HTS test

- Reliability tests not covering the mission profile: ask the supplier to perform the test with the conditions to cover the mission profile or perform the test in our laboratory
  ➔ Example: data retention test

- Technological analyses (verification of the process quality, wafer fab unknown, new technology...
Difficulties / Concerns
Difficulties / Concerns

• Difficulties in getting the relevant data from supplier (especially for wear out test results) as companies buy only small quantities of components.

• Difficulties in getting the activation energy value for certain test (data retention, HCl…)
  ➔ “Secret” values for component companies (can reveal the maturity of the process…)

• Models used are getting obsolete (combination of failures mechanisms….) and in some points the JEDEC has reached its limit.

• Use multisource to avoid obsolescence: merging of several companies reduce the choice of component supplier (NXP/Freescale, Cypress/Spansion….)
THANK YOU.
Questions?