IQ
Ingenious Quality

CamSemi

Return on investment through reliability evaluation

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Overview

Company Introductions

Approaches to product qualification testing

Types of testing and what they may tell you

Questions to ask your subcontractors during selection and what to look for in their qualification reports

CamSemi experience with potential assembly subcontractors

What else you should do to secure a good quality supplier

Conclusions

Company Introductions

CamSemi

- Started in 2002 as a fabless start-up in Cambridge UK
- Two founders from Cambridge University Engineering Department
- Focus is efficient mains power conversion and lighting products for high volume consumer markets
- Portfolio of patented, proprietary technologies and topologies including intelligent control architectures, RDFC and PowerBrane
- In full production since mid 2007 with over 14M units shipped
- ISO9001 and ISO14001 certified
- Offices in Cambridge, Taiwan and Shenzhen





Company Introductions

Ingenious Quality Ltd

- Founded in 2005
- Focus is consultancy serving semiconductor and high technology sector
- Services
  - Quality Management
    - Customer quality – RMA/FA and specification negotiation
    - Internal audit, customer communications – Change control
    - Document management
    - Attainment of certification to ISO9001 standards
  - Environmental Management
    - Status review against environmental legislation
    - Attainment of certification to ISO14001 standards
  - Operations, Facilities and Engineering management
    - Package engineering
    - Subcontractor management and purchase agreement negotiation
    - Subcontractor audit
    - Data management
  - Health & Safety Management
    - How to stay out of prison!

Approaches to qualification

1. **Rely totally on wafer fab. and assembly house data**
   - ✓ Quick
   - ✓ Low cost

   - ✗ Does not tell you about the quality or reliability of ***your*** product
   - ✗ May not satisfy your customers
   - ✗ May not satisfy legal requirements
   - ✗ Low confidence from stakeholders

Approaches to qualification

2. Do your own analysis/testing

- ✓ Higher confidence in your design implementation
- ✓ Safeguards investment – lowers business risk
- ✓ Lower likelihood of surprises during production ramp
- ✓ Can ensure compliance with some legal requirements
- ✓ Helps to pipe-clean the electrical test HW/SW and speed production ramp

- ✗ Takes longer and may slow product ramp
- ✗ May be costly depending on your choice of tests and suppliers

Types of testing/analysis

Silicon/Design

- Design analysis and review for current capacity versus silicon and package vendor rules (electromigration and wire bond capacity)
  - Fusing or premature wear-out
- Over-voltage review versus silicon vendor rules and wafer level reliability data (hot carrier effects and time dependent dielectric breakdown)
  - Premature wear out
- Thermal analysis of power dissipation in application environment
  - High Infant mortality rate
  - High Intrinsic failure rate
  - Premature wear out
- ESD and Latch-up immunity
  - Checks physical instantiation of protection cells and their operation
- High Temperature Operating Life (burn-in)
  - Infant mortality rate
  - Intrinsic failure rate

Types of testing/analysis

Package/Assembly

- Moisture sensitivity level classification
  - Ability to withstand normal board assembly processes without introducing yield issues or reliability hazards
- Thermal Cycling
  - Package integrity and reliability in service life
  - Compatibility of Bill Of Materials
- Unbiased Highly Accelerated Stress Test (UHAST) (replaces Autoclave)
  - Chemical purity of BOM and assembly process
- Temperature Humidity with Bias (THB or HAST)
  - Chemical purity of BOM and assembly process

Types of testing/analysis

Chemical/Environmental

- Flammability
  - Usually available from supplier or their mould compound supplier
  - Proof of customer compliance
- RoHS
  - Proof of legal/customer compliance
- REACH (SVHC)
  - Proof of legal/customer compliance
- Customer Specific environmental tests (e.g. Sony Green Partner compliance)
  - Proof of customer compliance

Supplier selection

Request

- Ability to meet all your expected customer environmental requirements
- Moisture Sensitivity level of your chosen package with a comparable die size
- The proposed bill of materials (BOM) to be used for your product
- Assembly design rules/constraints
- The relevant qualification reports

Check

- The *detailed* bill of materials used in the qualification and if it matches your proposed BOM
- Wafer fab and passivation type, mould compound, die size, die attach, wire bond type, leadframe type/substrate type and manufacturer, plating/ball finish

CamSemi experience

Initial product qualified without issues using a well known assembly vendor in Malaysia (M1)

- Completed first time with no issues

Cost reduction programme initially selected several candidates in China and attempted to qualify two (C1 and C2)

- Both abandoned

Additional candidates selected - Philippines (P1) & Malaysia (M2)

- One completed successfully, one underway

Moisture Sensitivity Class

Current JEDEC/IPC joint standard for MSL testing

- JSTD020D-01(March 2008) Moisture/Reflow Sensitivity Classification for Non-hermetic Solid State Surface Mount Devices

Flow:

- electrical test
- optical/acoustic microscopy
- bake
- moisture soak
- 3x reflow
- optical microscopy
- electrical test
- acoustic microscopy

Moisture Sensitivity Class

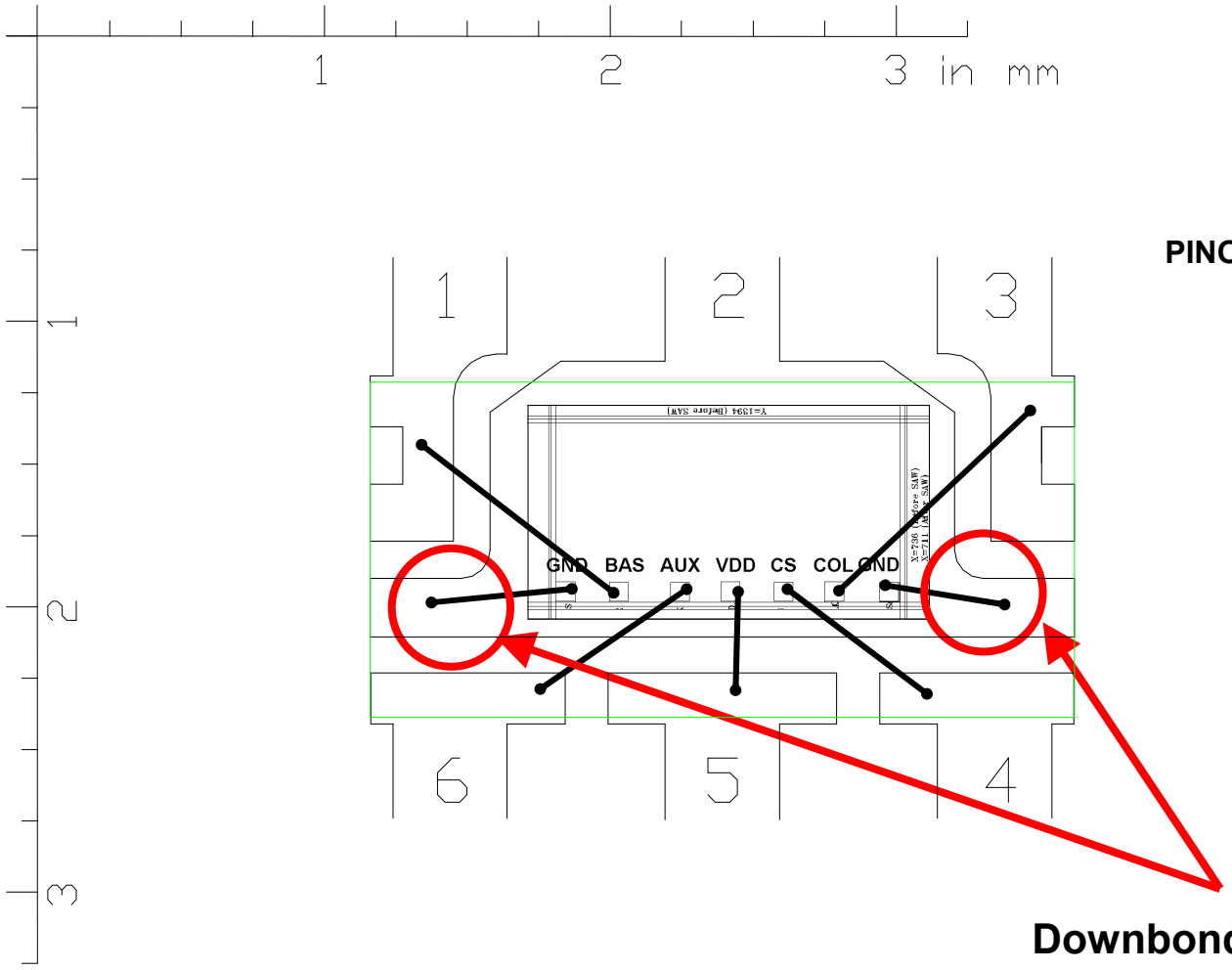
JSTD020 failure criteria are very detailed and include:

- Electrical failure
- External cracks
- Internal cracks in some locations
- Coplanarity changes

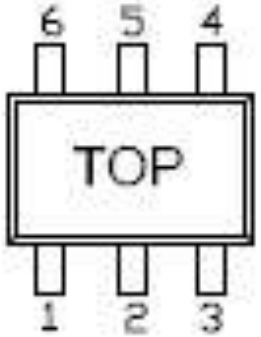
If delamination is seen, then for metal leadframe packages

- No delamination allowed on the active side of the die.
- No delamination allowed on any wire bonding surface including the downbond area
- Etc …

C247xPX2 bonding diagram



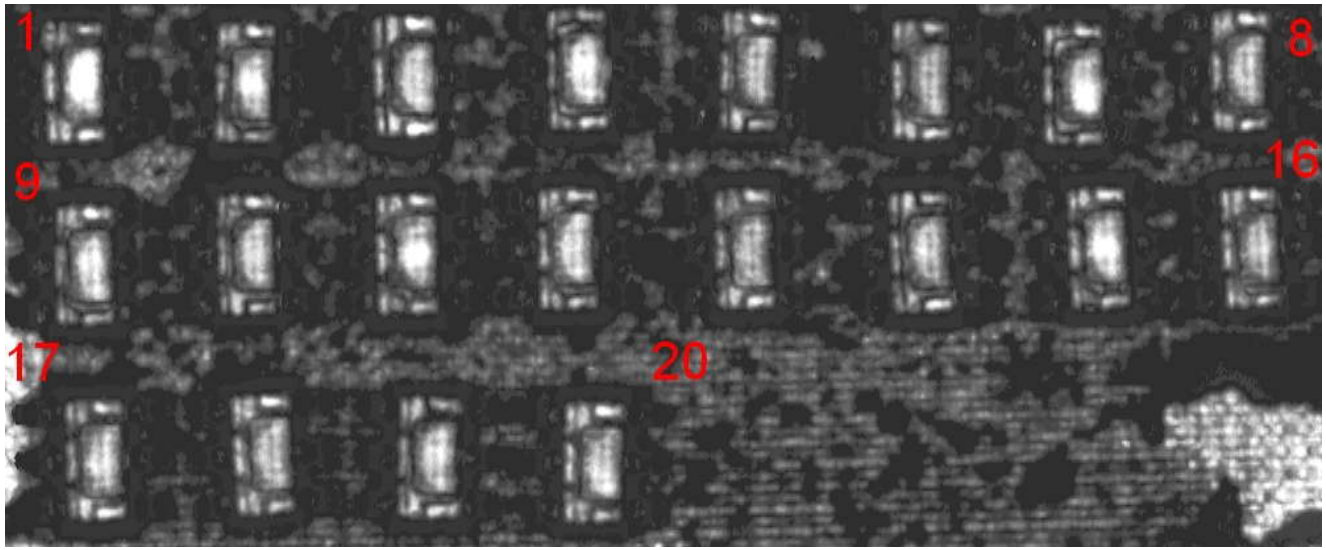
PINOUT AFTER FORMING DIE DOWN



Downbonds to die paddle

Baseline for supplier M1

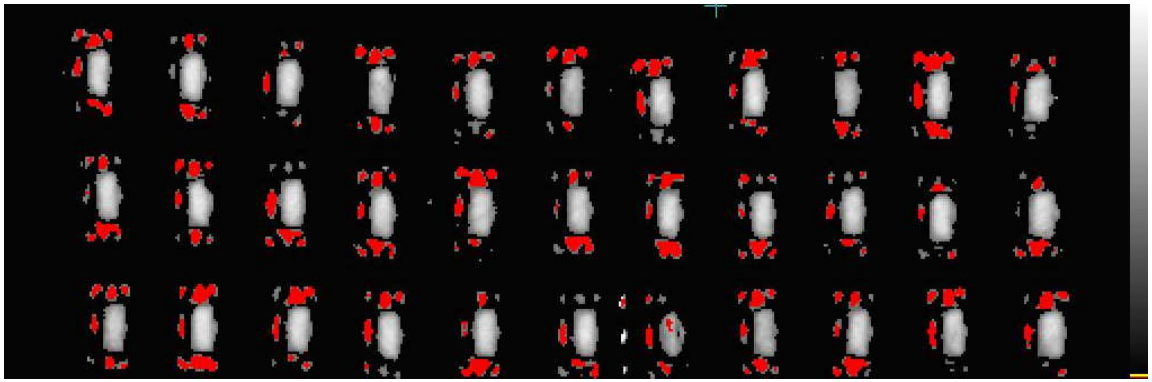
After MSL1 preconditioning, die to paddle interface



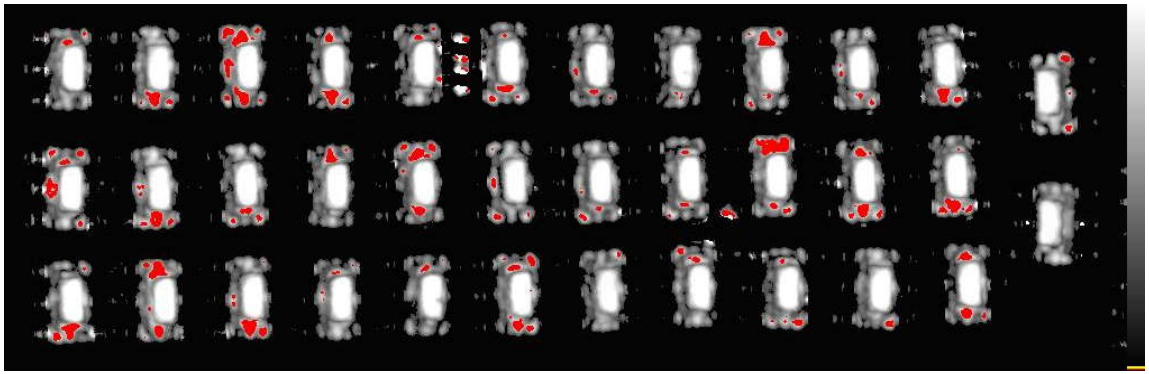
Results for supplier C1

All results after MSL1 preconditioning, die to paddle interface

Standard offering



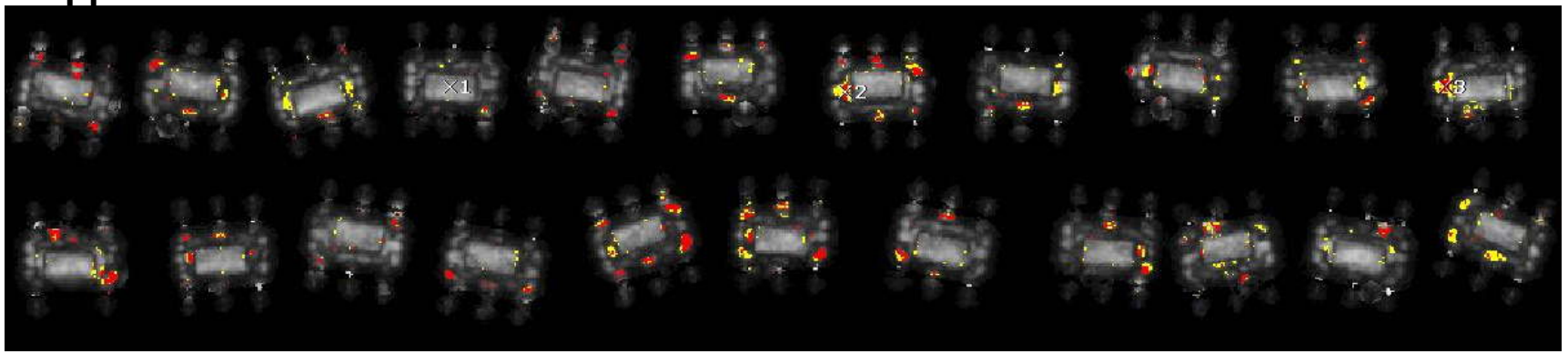
After “optimisation”



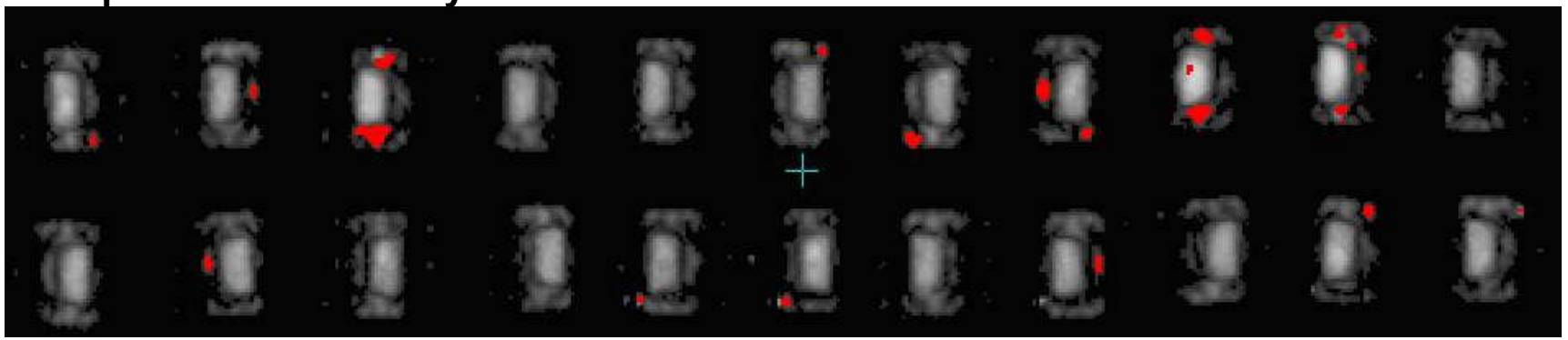
More results for supplier C1

After further BOM and process optimisation

Supplier CSAM



Independent Laboratory CSAM



All results after MSL1 preconditioning

Supplier C1 conclusions

Although used by several well known large semiconductor companies we found:

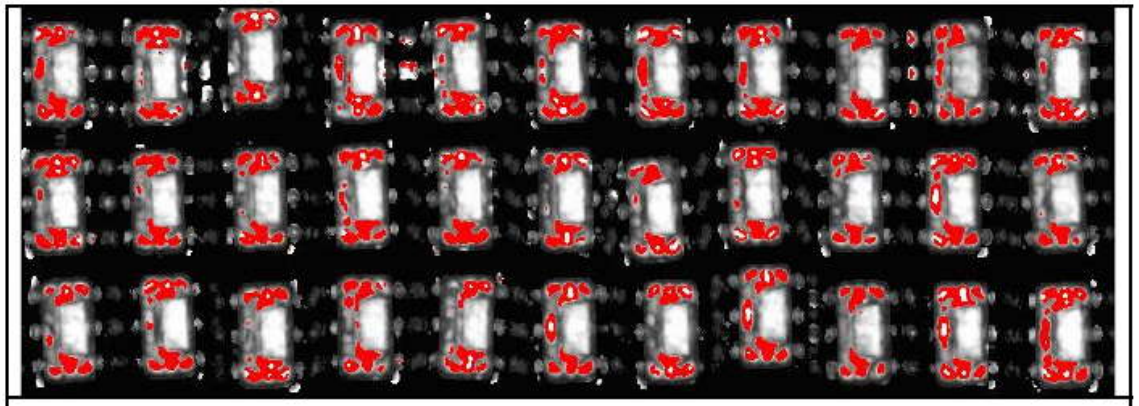
1. Both their and our independent labs. confirmed significant delamination on both lead fingers and die paddle both before and after MSL exposure
2. Electrical failures (opens) were also sporadically seen before and after MSL exposure
3. Several optimisation experiments over more than 1.5 years could not provide an acceptable result
4. Running the same experiment twice gave vastly differing results
5. We never got a supplier qualification report that backed their claim that they could achieve MSL1 with a RoHS compliant BOM
6. We were doing the process engineering for them!

Results for supplier C2

All results after MSL1 preconditioning, die to paddle interface

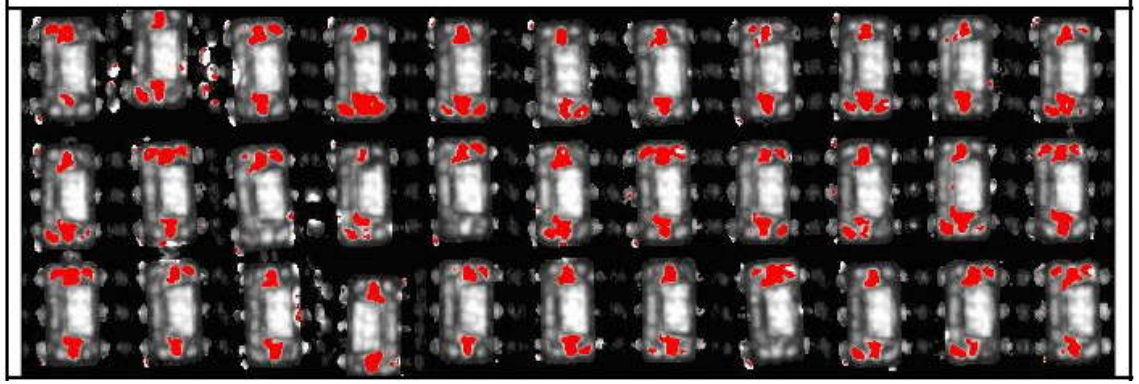
C2 Standard offering

BOM a



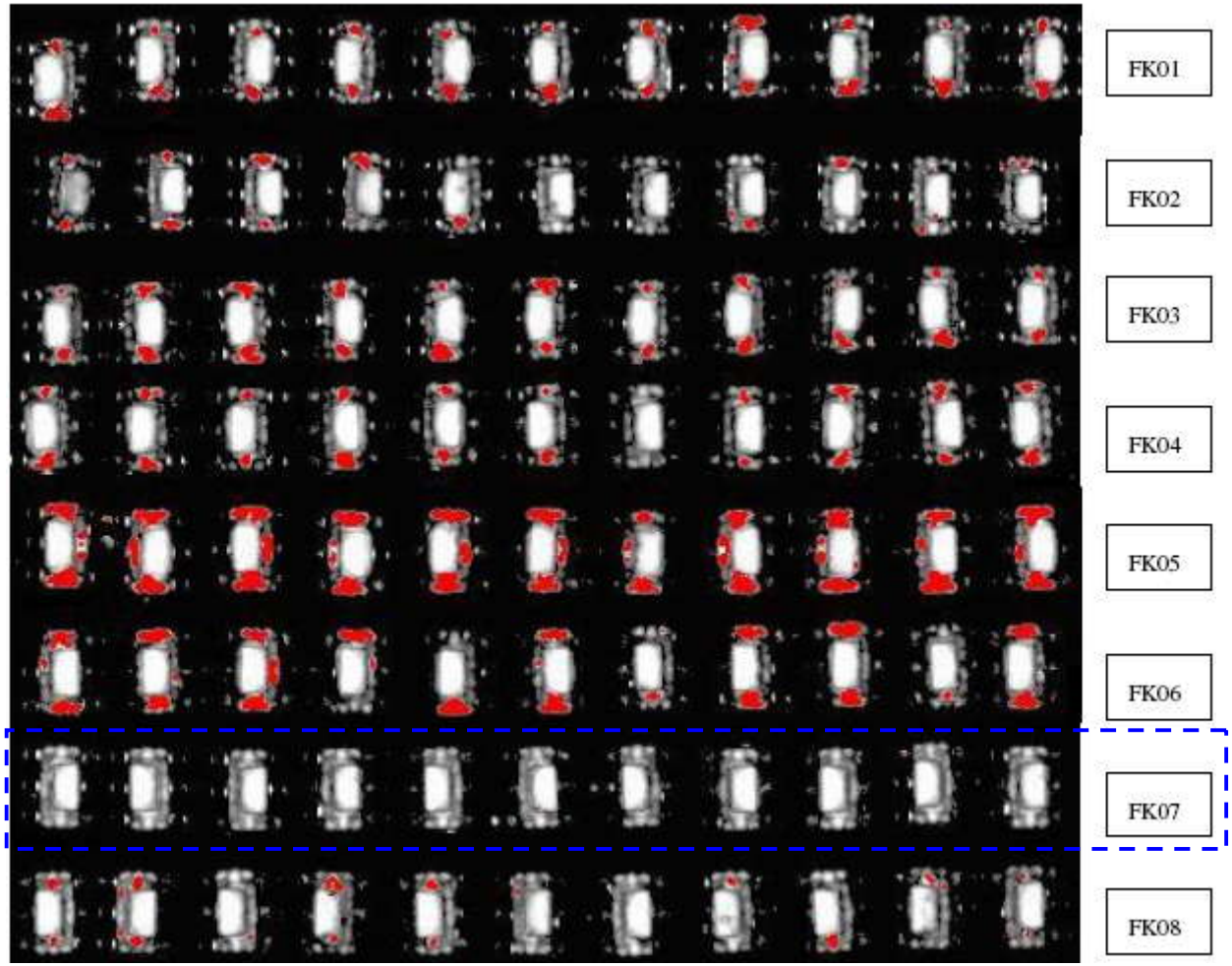
C2 Standard offering

BOM b



Conclusion: Worse starting point than supplier C1 so no more work done

Results for supplier P1 DOE



All results after MSL1 preconditioning, die to paddle interface

Different lots represent different BOM and process parameters

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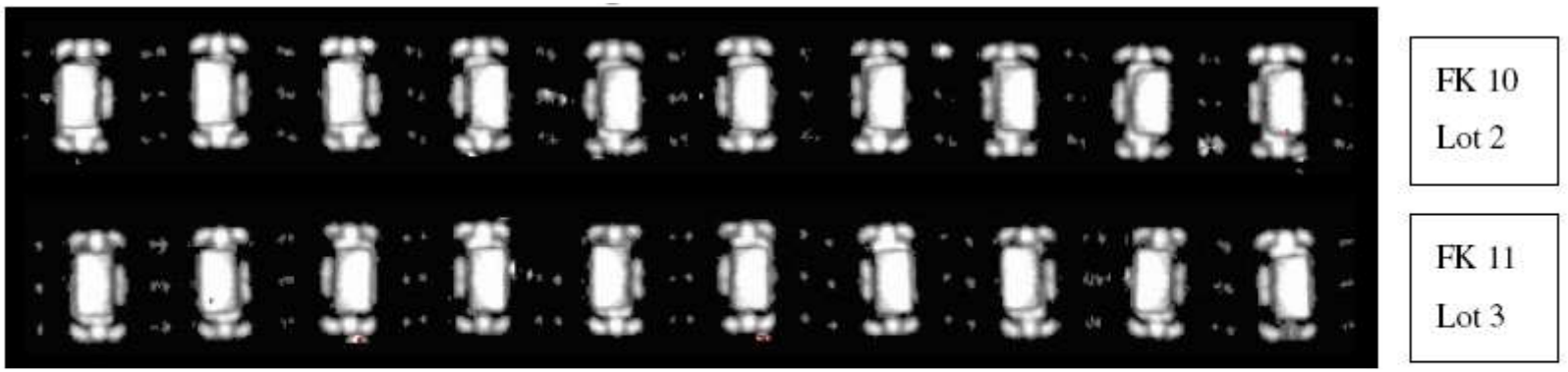
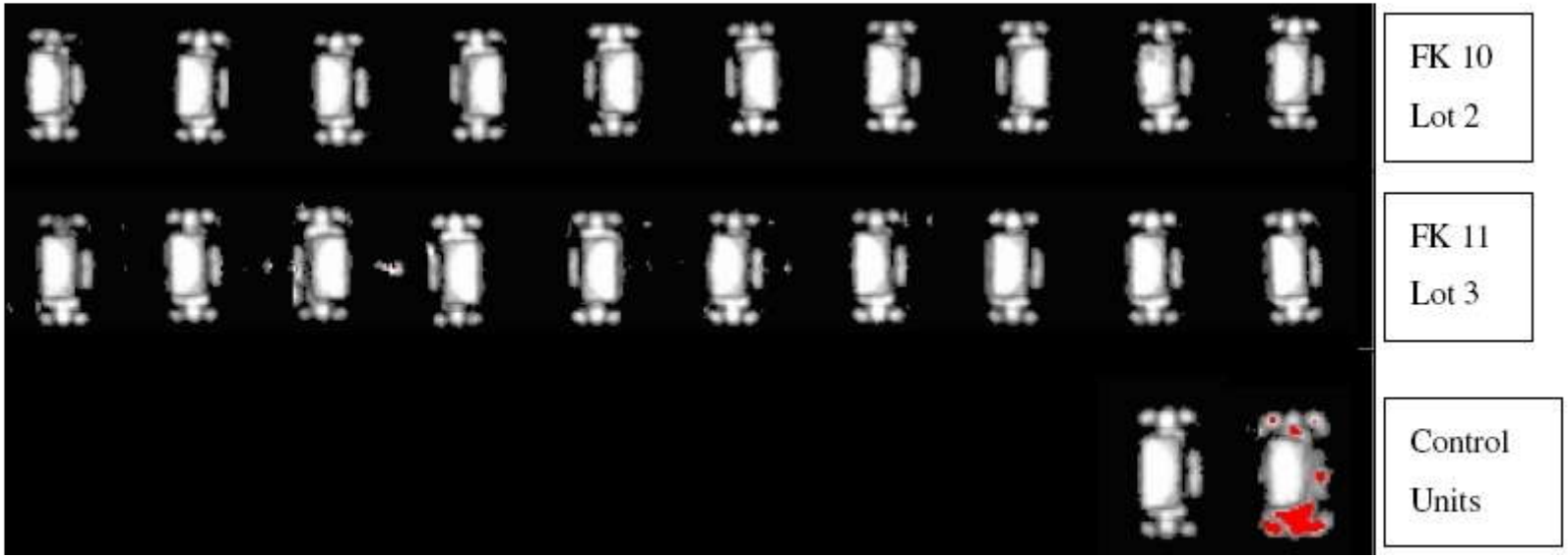
Chosen for more study

Supplier P1 lots 2 and 3

Before MSL 1 preconditioning, die to paddle interface



After MSL 1 preconditioning, die to paddle interface

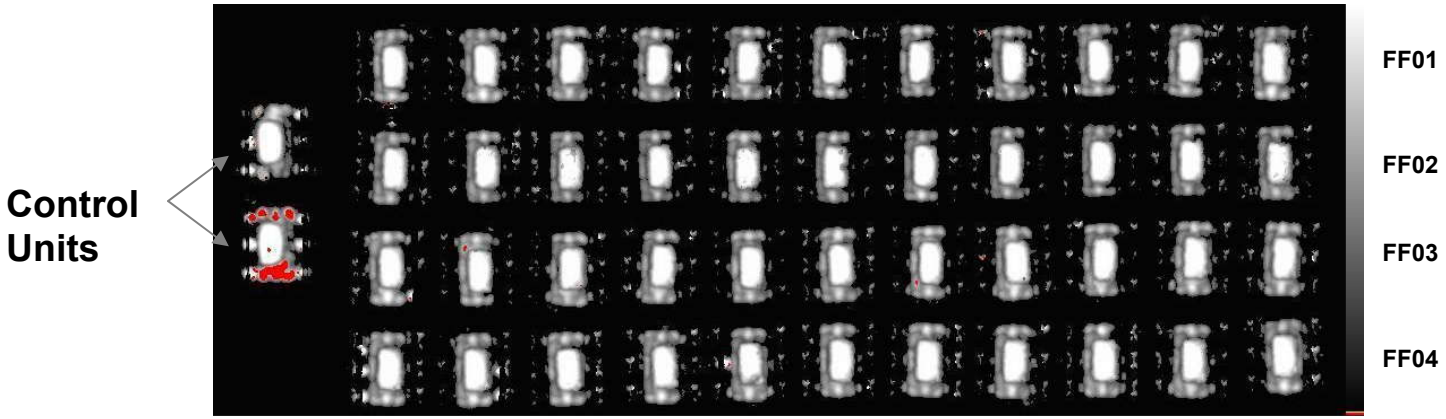


Conclusions for supplier P1

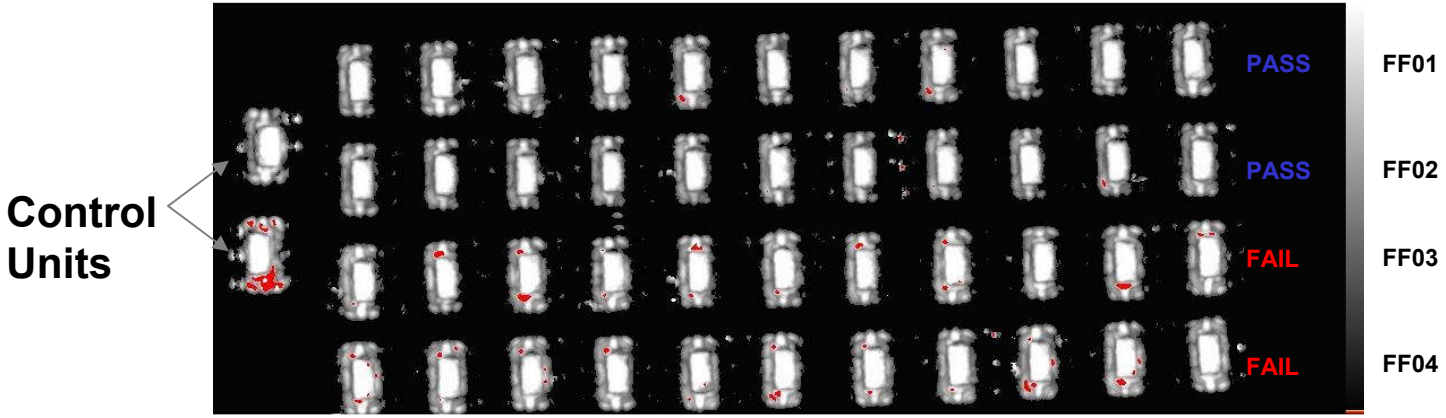
1. After initial design of experiments, no electrical or delamination failures seen
2. Subsequently all units passed qualification stress testing on three independent lots (THB, Autoclave, Temp Cycle, post stress decapsulated optical inspection)

Results for supplier M2 DOE

Before MSL 1 preconditioning, die to paddle interface



After MSL 1 preconditioning, die to paddle interface



Results for supplier M2

1. After initial design of experiments, no electrical or delamination failures seen
2. Subsequently two more lots were able to repeat the result
3. Lot 1 passed qualification stress testing on three independent lots (THB, Autoclave, Temp Cycle, post stress decapsulated optical inspection)
4. Lots 2 and 3 underway with stress testing

Subcontractor control

Once you have determined the correct supplier(s) for you

- Document and agree the BOM and key process parameters
- Document and agree the process flows for assembly, test, pack and ship
- Agree what key process parameters are to be reported on a regular basis
- Continue to periodically monitor their performance with simple stress tests (ask them to use your product in their reliability monitor programme)
- Ask supplier to put you on their PCIN list so you know of any proposed changes
- Don’t forget that most customers will want to be informed of changes of supplier via a PCIN/PCN
- Continue to perform or commission independent audits of your subcontractors so you have confidence that they are doing what you agreed

Overall Conclusions

1. **Some level of explicit qualification testing will be asked for by your customer at some stage so plan for this at the beginning**

   In increasing cost order:

   1. RoHS and REACH analysis
   2. ESD/LU immunity
   3. MSL performance
   4. Temp cycle and UHAST
   5. HTOL
   6. THB

2. **Detailed analysis of supplier qualification reports is low cost and pays off**
3. **It is unlikely that the *exact* BOM used on your product will have been used by the assembly subcontractor in their qual.**
4. **MSL testing can be a low cost screen to predict performance in subsequent reliability stress testing**

Overall Conclusions

5. Just because the “Big Boys” use them doesn’t mean they make reliable product
6. Even if you and your supplier use a “generous” interpretation of JEDEC specifications, your customer (or their customer) may not!
7. Small companies usually cannot survive a product recall
8. Suppliers in other countries are prepared to compete with China on cost
9. Often you get what you pay for!

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Thank you

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