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Electronic assembly challenges

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TOC

SOME BASICS

Reliability versus quality

Nowadays too often both terms are considered or used as synonymous

However these are two different disciplines even if they are related to each other

Today common accepted definitions are:

« Quality is conformance to customer expectation »

Supported by specifications, QA activities/tools
Involves everyone related to the product (design, manufacturing, purchase office, etc)

« Reliability is quality over time »

Supported by design, project management, quality assurance
Involves design team and project management

SOME BASICS

Failure in electronics: quality, the usual suspect

Provided that most of the failures (approx. 90%) in electronics are due to solder joint defects, quality is regulary seen as the primary suspect

However, even if proper quality management helps increasing yield, it is often the combination of several of the following factors

Design

Outsourcing practices

Assembly practices by the sub-contractor

Parts procurement

Assembled board handling

Also, it is important to understand that quality will never increase reliability that was built in the design

SOME BASICS

Assembly: the quality and reliability revelator

In the majority of the cases, except special dedicated cases, electronic assembly is the lowest added value process for the product with respect to design and/or part procurement costs

At the same time, assembly is the process where all the previous quality efforts can very quickly be vanished

This can induce unnacceptable delays and costs that can eventually completely kill a project, even before a single production board is tested

No need to say that extreme care must be taken when selecting the assembly company

SOME BASICS

Parts, PCB and material manufacturers: wrong common belief

The highest scored wrong common belief justifying an unpredicted result occuring due to incompatible practices is:

« They should have known this was not compatible, they all work in the electronics business »

No, even if everybody works in the electronics business, don't assume that every actor understands the activities of others, it is very rarely the case

The project team must be the one that understands electronic manufacturing/assembly constraints and gives directions to all involved parties

UNRELIABILITY AT CERN

Unreliability top scorers: TE-MPE-EM experience

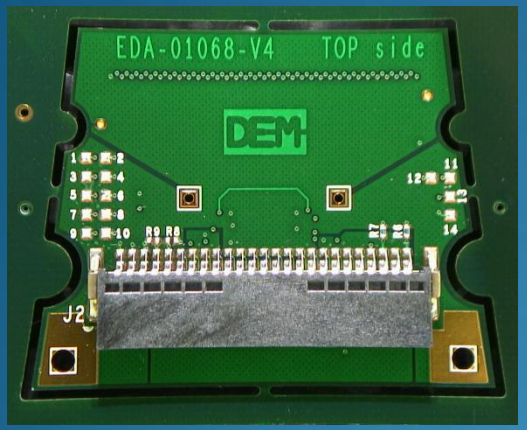
1° Poor outsourcing practices:
- Lack of or unadapted technical documentation
- Wrong company selection

2° Poor design practices:
- Lack of manufacturing/assembly constraints knowledge
- Material incompatibility or lack of material contraints knowledge
- Lack of reliability principles understanding/knowledge

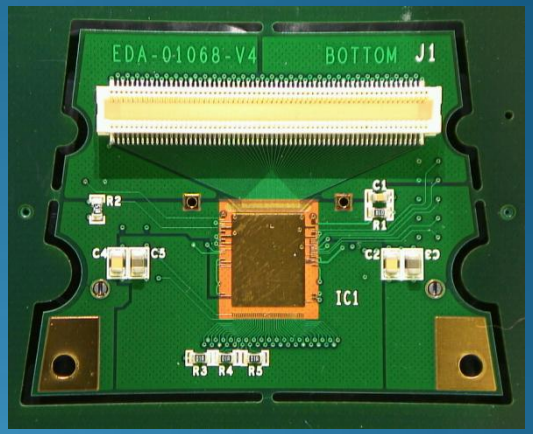
3° Parts procurement:
- Poor parts packaging, storing and handling practices
- Couterfeit parts

UNRELIABILITY AT CERN

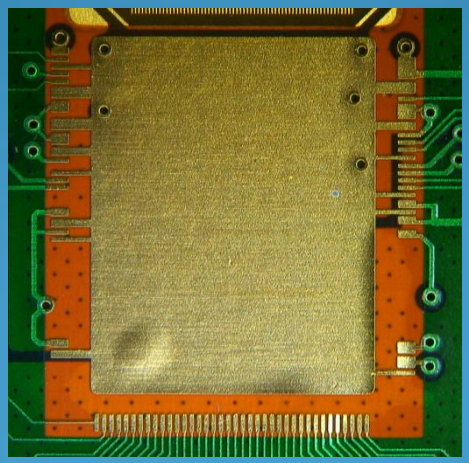
Practical case: poor outsourcing practices



Does this board look like rocket science?



- Double-sided SMD
- 1 CoB (chip on board)
- 2 connectors
- 12 resistors/capacitors



- 600+ boards
- 50% yield due to PCB delamination

UNRELIABILITY AT CERN

Practical case: poor outsourcing practices

Project description:

PCB assembly combining standard SMD and CoB

> 600 pieces to be assembled by an external company

PCB stackup using mixed materials (FR4 internal, Polyimide external)

Quality issue: PCB delamination due to moisture absorption by the base material

Solution: bake the boards prior to soldering processes

Sequence of events:

- A pilot validation production of few pieces was requested by the project team
- Inspection of the pilot production showed delamination on PCBs
- Analysis showed it was due to lack of baking of the PCBs prior to soldering processes
- Company agreed to bake the PCBs prior to soldering processes
- A new pilot production was built not showing any defects
- The production run, when delivered, exhibited the same yield and quality issue as on first pilot production

UNRELIABILITY AT CERN

Practical case: poor outsourcing practices

So… What happened?

The company, as planned, baked the boards prior to soldering

Unfortunately, they soldered the first side one day and soldered the second side the day after

The time between PCB baking and the second soldering process was long enough to allow a complete moisture absorbtion by the PCB

How come that the company did not realize a second baking was required?

First, obviously the company does not understand material moisture absorption processes

and

The project team assumed « the company have the understanding and knowledge of PCB materials, and thus will handle the boards properly once warned about the special stackup and guidelines are given »

UNRELIABILITY AT CERN

Practical case: poor outsourcing practices

So… Then?

Of course, the failed boards (50%) had to be trashed and unacceptable delays and added costs entered the project

The company refused refunding of PCBs and parts considering they were not properly informed about the required special handling

Epilogue

The situation then generated a lot of discussions back and forth between CERN and the subcontractor

The discussion with the subcontractor could have been shortened if the proper specification would have been part of the order

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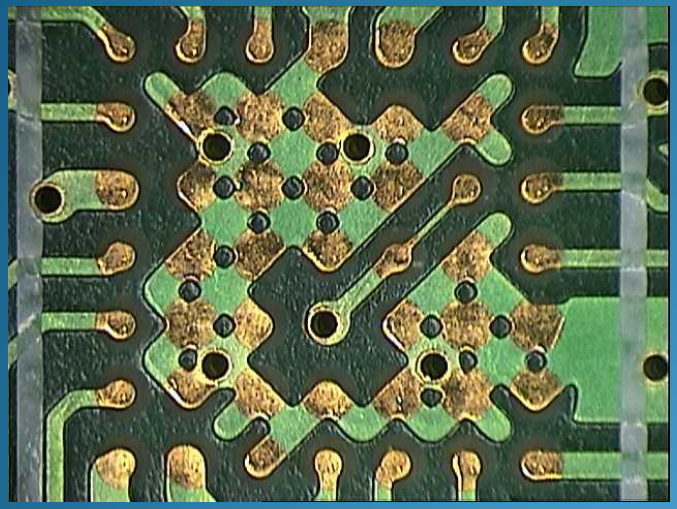
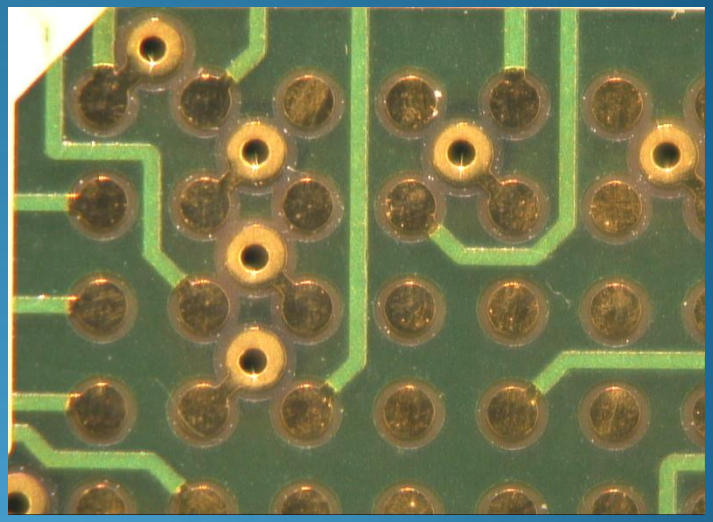
Poor design practices: some examples

BGA design classics



Every ball shall have an individual pad with the same shape, except on certain occasions for reliability improvement



Vias close to BGA pads shall be tented to avoid solder wicking inside it and thus ensure homogene solder volume in joints

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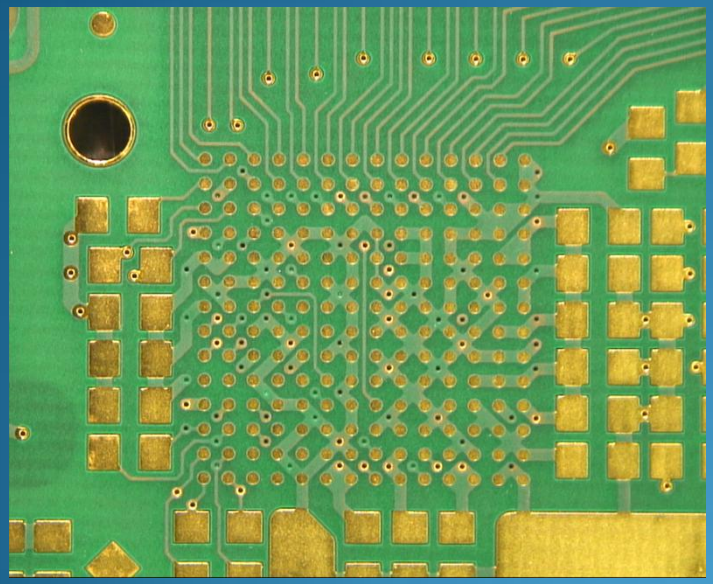
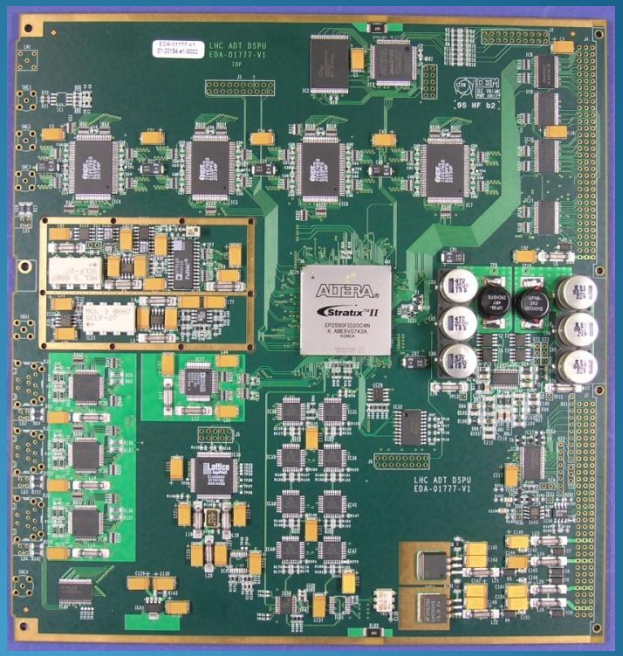
Poor design practices: some examples

BGA design classics



Mechanical attachement like screws shall be put away from BGA parts to avoid unnecessary load on solder joints



BGA parts should not be put in the middle of the board as it is where the max deflection will occur

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Poor parts handling/packaging: some examples

Some parts for an outsourced production…

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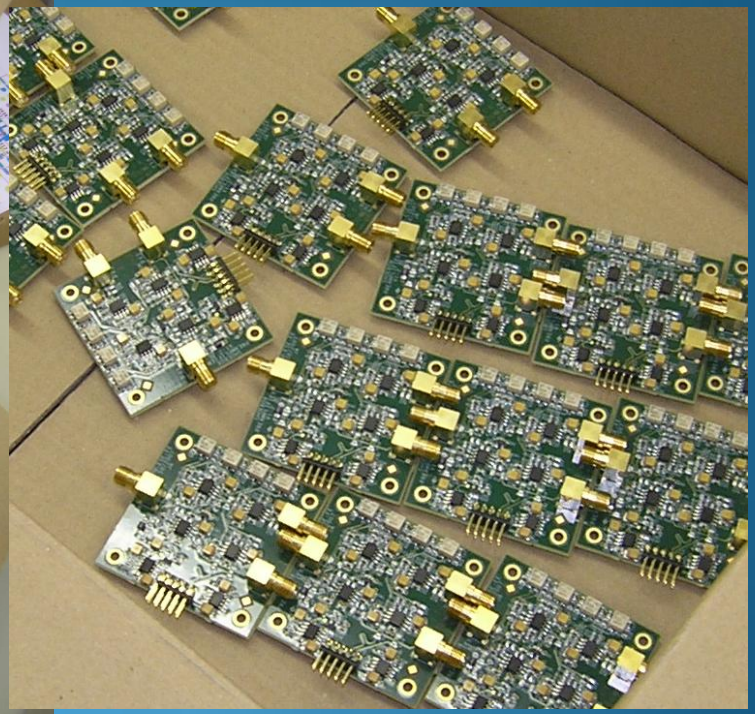
Poor parts handling/packaging: some examples

Some boards for modification or repair operations…



HOW TO IMPROVE

Design base line: IPC/JEDEC standards

Regarding design, the very first reference to look at is IPC/JEDEC standards

IPC is nowaday the first ressource for industry regarding standards applicable to electronics DfM (design for manufacturing)

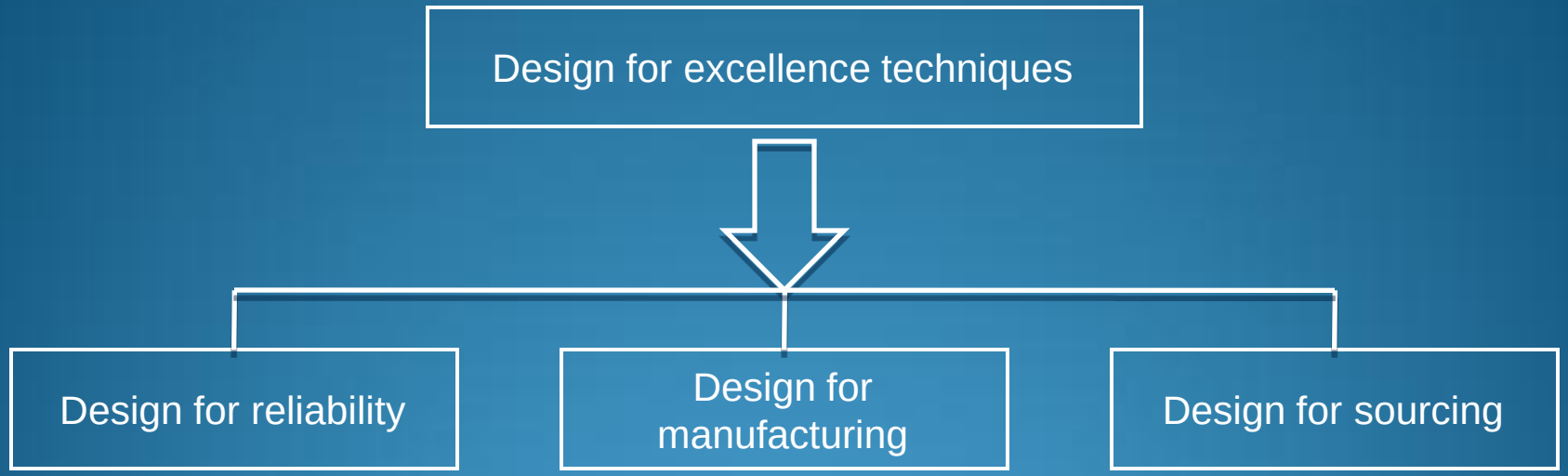
Applicable standards are numerous, here are some examples (see IPC website for details, ipc.org):

- IPC-2220 serie -> board design
- IPC-7531 -> land pattern design
- IPC-J-STD-001 -> soldering requirements
- etc

IMPORTANT NOTICE: those standards represents the MINIMUM requirements, some projects may require to adapt the standards in order to get the expected reliability

HOW TO IMPROVE

Apply known and proven techniques to project management



This is an internal process that cannot be outsourced and that must be sutained by project management, a designer cannot succeed alone on such initiatives, this is a team work

HOW TO IMPROVE

Apply known and proven techniques to project management

Design for excellence combines lots of different standards and tools like:

- IPC/JEDEC standards
- LEAN techniques (applied to supply chain)
- Design review additional stages (requesting external input from manufacturing and assembly engineers for example)
- etc

Where to find information about DfX:

- Several multi-days seminars are available in the world (IPC, SMTA, SMART)
- Some literature is available on the subject
- Consulting companies provide on-site seminars (one was organized at CERN in 2010)

HOW TO IMPROVE

An electronic engineer is not a layout engineer

One common mistake from project management is thinking that electronic design and layout design could be handled by the same person

It is not true. The electronic engineer deals with electronic functions/response times/signal integrity (electronics), while the layout engineer deals with manufacturability/assembly/testability (mechanical)

Both these designers should work hand in hand in order to succeed with the project

The experience in the assembly field teaches that there is little chance to have a person able to combine full experience and skill in both disciplines

In electronic design, don’t underestimate the things you don’t know and that you are not aware of not knowing it

HOW TO IMPROVE

Outsourcing: the big deal

As stated some slides above, outsourcing can vanish all your design efforts when not properly handled

The proper company shall be selected following proper auditing:

- Production capacity AND capability
- Process control
- Internal quality management
- Internal problem solving processes and availability of required experts
- etc

Finally the company should be given with dedicated specifications for assembly

Soldering electronic boards is not an easy deal and it requires a lot of proactive work and different knowledges in order to reach the required quality and succeed with todays constraints

HOW TO IMPROVE

Building « out of standards » electronics

The case of inner detector electronics requires a special comment

This electronics usually deal with very specific materials and parts due to the necessity to be as transparent as possible to particles observed

And of course, provided they are inside the detector, they must work for more than 15 years

No choice but one: involve the manufacturer and assembler in the very first stages of design as they will be the only ones who can help with yield on such specific needs

In addition, for those specific boards, reliability shall be demonstrated

HOW TO IMPROVE

Parts procurement: trusted vendors for production runs

One regular quality killer TE-MPE-EM faces when outsourcing products for our customers is part packaging and sourcing

For production runs, only trusted vendors shall be contacted when parts are required and packaging should be carefully handled to cope with production needs

Working with trusted vendors limits the risk of receiving conterfeit parts or poorly handled and packaged parts

General purpose electronic distributors as well as so-called brokers should be considered only when no other choices are available for parts procurement

CONCLUSION

Built-in reliability is key to success

If a project team wants to plan ahead in the development with regard to reliability, design should have the reliability « built-in »

In order to get there, the whole project team must support actions: design for reliability requires extra ressources during early design stages – however the related costs will allways be far less than problem fixing costs

Design for excellence (or reliability) requires know-how of course, but most importantly it requires field data collection, proper analysis and project organization-wide rules and methodologies – this requires some time to implement, it is not a straight forward process

Prior to become knowledge and techniques, reliability is an internal policy

CONCLUSION

Industry provides good things, but…

Sometimes industry proposes solutions that don't necessary follow the best rules for reliability, usually for financial reasons – leadless packages becoming the standard for IC packages is a pretty good example of this trend

Due to economical situation a lot of outsourcing companies have lost their experts in soldering techniques – in best cases, the process technician is still in place and in worst cases the line manager plays the double role

The above situation becomes critical when problem solving must be deployed as the required knowledge is not there anymore

The good news is that some of those experts are still available, they now propose consulting services to industry (with the related costs one can easily imagine)

THANK YOU FOR YOUR KIND ATTENTION

QUESTIONS?