Kwaliteit kwantificatie
en
Kwaliteitverhoging door test

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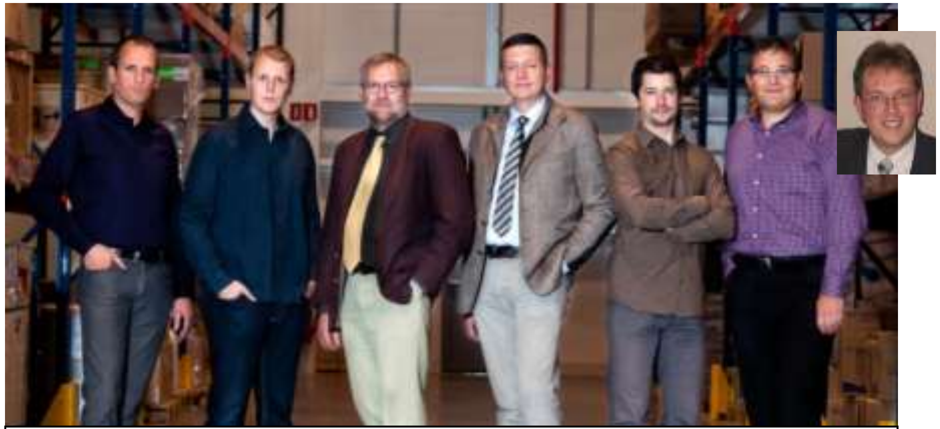
Center for Electronics Design & Manufacturing



Imec's Center EDM team

>70 years industry

>35 years research

experience in electronics

We bridge the gap between research and industry

EDM

Better electronics

at

reduced cost

through

science based design & production methods

ELECTRONICS & AUTOMATION

Inhoud

- Gekwantificeerde kwaliteit van PBA
- Kost van “minder kwaliteit”
- Impact van assemblage test
- Defect en test coverage modellen

Herkent u dit?

We zijn wel wat duurder maar onze **kwaliteit** is zoveel beter!

Kwaliteit is beter?

Minder uitval bij opstart!

Betere performantie

ROBUUSTER!

Langere levensduur!

Getest!

IPC class 3

CEE gecertificeerd

MIL gekwalificeerd!

Mooier!

Metaal ipv plastic

Gereinigd!

Geschroefd ipv gelijmd

Metaalfinish ipv verf

Minder builen en blutsen!

GREEN PRODUCT!

Laag energieverbruik!

RoHS

Vintage design

En wat u nog meer onder de noemer kwaliteit kan plaatsen…

Elektronica

Top Quality!

50% lower assembly cost!

Gekwantificeerde kwaliteit

Quantified Quality:

- The **Quantified Quality *Q*** of a part/product is the probability of having **no defect**.
- A **defect** is any property that does not meet expectations.

Gekwantificeerde kwaliteit

Quality calculation

- Determine the Defect Opportunities DO
- Determine no-defect probability Q_i per DO
- A defect-free PBA mandates that none of the Defect Opportunities is defective.
- The probability Q of a defect-free PBA:

$$Q = \prod_{i=1}^{DO} Q_i$$

Gekwantificeerde kwaliteit

$$Q = \prod_{i=1}^{DO} Q_i$$

Properties:

- *Q*=Yield (first pass – after test)
- Zero Hour Defect Rate (ZHDR) = 1-*Q*
- *Q* decreases with:
  - Increasing number of DO (complexity)
  - Increasing assembly failure rate: $Q_i = 1 - DPMO_i.10^{-6}$
- *Q* improves by introducing test and repair.

Gekwanticeerde kwaliteit

Added value of Quantified Quality concept:

- **Quality** becomes measurable and quantifiable. One can assign **an objective value** to it.
- **Test** - perceived as an overhead cost - transforms into an quality improving therefore **a value adding process**.
- Predictabillity of quality. Basis for **Design-for-Quality**.
- Basis for **a common quantified quality language** in the supply chain.

Gekwantificeerde kwaliteit

In real life there is no such thing as

“Zero Defect Manufacturing”

***Be realistic**:*

Deal with manufacturing failure risks

Kost van "mindere kwaliteit"

Top quality!

- Q=99.5%
- BOM=€450
- Assembly=€50
- Price=€550

50% lower assembly cost!

- Q=98%
- BOM= €425
- Assembly= €25
- Price= €525

Kost van “mindere kwaliteit”

Volume
10000/year

Non-quality cost: €2500 per failure at customer

Q=99.8%	Cost: M€5 NQ-cost: 2500 x 0.5%x 10000=**K€ 125**
	Sales: M€5.5 Margin: **K€ 375** or **€37.5/PBA**
Q=98 %	Cost: M€4.5 NQ-cost: 2500 x 2% x 10000=**K€ 500**
	Sales: M€5.25 Margin: **M€ 2.5** or **€25/PBA**

Kost van “mindere kwaliteit”

Volume
10000/year

Non-quality cost: €5000 per failure at customer

Q=99.8% Cost: M€5.0 NQ-cost: 5000 x 0.5%x 10000=**K€ 250**
Sales: M€5.5 Margin: **K€ 250** or **€25/PBA**

Q=98 % Cost: M€4.5 NQ-cost: 5000 x 2% x 10000=**M€ 1**
Sales: M€5.25 Margin: **-K€ 250** or **-€25/PBA**

Assemblage test

Inspection methods

MVI

AOI

2D Xray

3D Xray

Electrical test methods

Flying probe

Boundary scan

In-Circuit Test

Assemblage test

Improving quality Q of PBA by detecting failing defect opportunities followed by repair.

- First pass quality $\{Q_i\}_{\mathrm{DO}}$: First pass PBA Q_{FP}
- Test and repair of $\{Q_i\}_{\text{testable DO}}$: $\{Q_i\text{=}1\}_{\text{testable DO}}$

$$Q_{\text{tested}} = \prod_{i=1}^{DO} Q_i^{\text{tested}} \;\; > \;\; Q_{\text{first pass}} = \prod_{i=1}^{DO} Q_i^{\text{first pass}}$$

$$\text{where } Q_i^{\text{tested}} = 1 \text{ if test coverage } TC(i) = 1 \text{ else } Q_i^{\text{tested}} \geq Q_i^{\text{first pass}}$$

Kwaliteit na test

Test access TA_{DT} – Test efficiency TE_{DT} per DO

Test coverage TC_{DT}: $TC_{DT} = TA_{DT} \times TE_{DT}$

Test slip TS_{DT}: $TS_{DT} = 1 - TC_{DT}$

DO quality after test:

$$^{a}NQ_{DT} = TS_{DT}^{t} \times NQ_{DT}$$

$$^{a}NQ_{DT} = \prod_{t=1}^{T} TS_{DT}^{t} \times NQ_{DT}$$

PBA quality after test:

$$^{a}Q_{PBA} = \prod_{DT=1}^{DO} {}^{a}Q_{DT}$$

$$^{a}Q_{PBA} = {}^{0}Q_{PBA} + QTC \cdot {}^{0}NQ_{PBA}$$

Test strategie

- No test provides 100% test coverage
- Defect identification capability depends on test.
  From simple/low-cost to difficult/expensive:
  Structural test: AOI - MDA/ICT/flying probe - Boundary Scan
  Functional test
- Good practice: start with the test that provides the lowest cost trouble-shoot.
- An effective test strategy requires proper DPMO estimation, correct test coverage and PBA quality *Q* quantification.

Assemblage test

Impact of test

- **Interpretation 1**:
  Reduction of failure probability 1-Q → 0 (perfect repair)
- Interpretation 2:
  Elimination of a Defect Opportuniteit

NOT (!):

Reduction with fraction *TC* of the number of defects in a group of defects D. (TC: test coverage)

Kwaliteit en test analyse

DO
=
20000

Top quality!

- Q=99.5%
- DPMO=1/100000
- AOI QTC=40%
- ICT QTC=50%
- FT QTC=90%

50% lower assembly cost!

- Q=98%
- DPMO=1/50000
- AOI QTC=40%
- FT QTC=88%

Kwaliteit en test analyse

DPMO=10ppm → $\boldsymbol{Q_{FP}}$**=81.9%**

ΔQ_{AOI}=7.2% *Δ*Q_{ICT}=5.5% *Δ*Q_{FT}=4.9%

→ **Q=99.5%**

DO = 20000

Quality improvement by test

DPMO=20ppm → $\boldsymbol{Q_{FP}}$**=67%**

ΔQ_{AOI}=16.5% *Δ*Q_{FT}=14.5%

→ ***Q=98%*** ***+ lots of repair&scrap!***

Defect model & test

Multiple tests

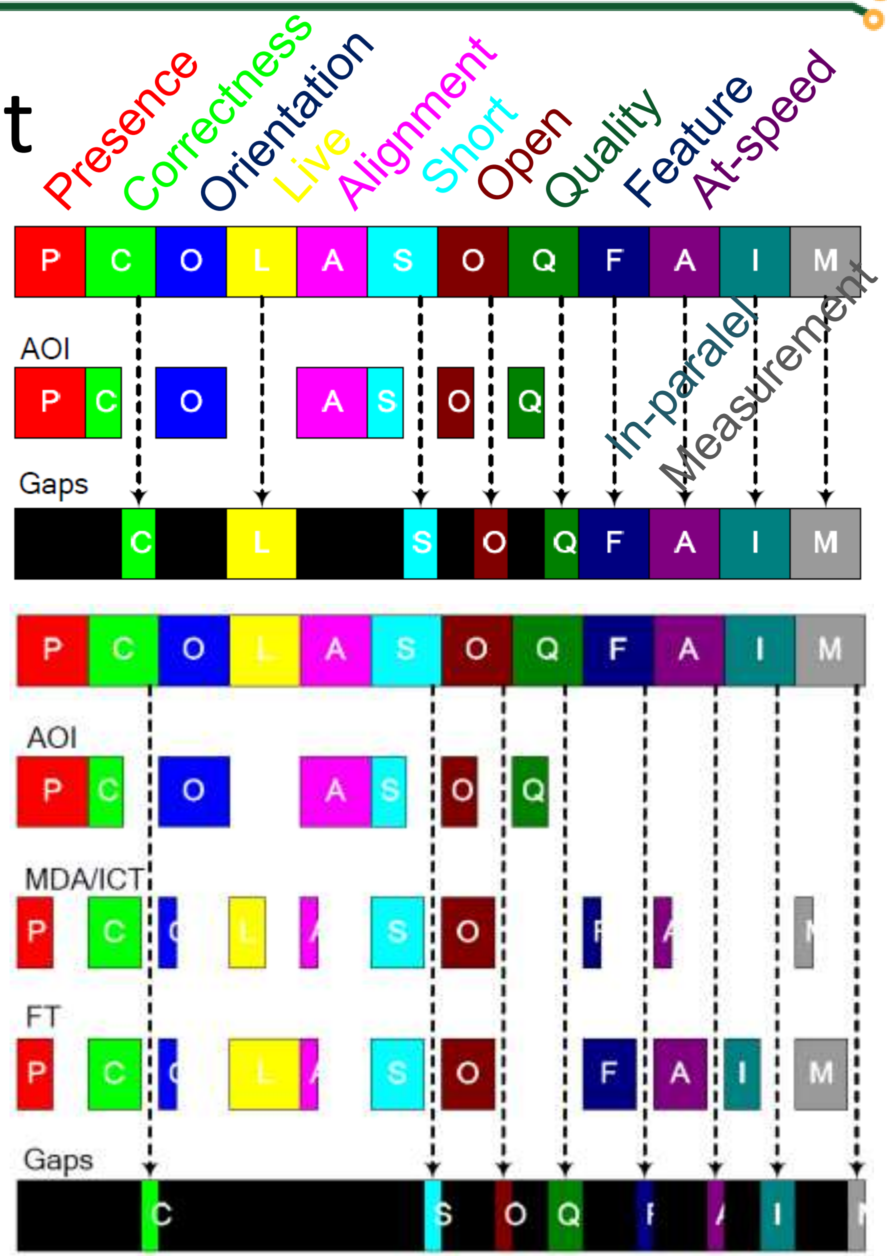
iNEMI

AOI: optical inspection
- Missing components
- Orientation of components

ICT: electrical
- Shorts - Opens
- Correctness component

Functional test:
- Shorts – Opens
- Correctness component
- **Defect component**

TEST STRATEGY
“Fill the gaps”



Defect model

Definition of defect categories: *wish list*

- Related to physical defects (≠electrical)
- “As simple as possible but not simplier”
- Linked to industry standards:
  - –Defect Opportunities of a PBA
    Component, placement, termination, PBA, PCB
  - –Defects Per Million opportunities = DPMO
- IPC-7912 insufficient detail.

IPC
ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES
IPC-7912A

Defect Model

EDM definitions

- As simple as possible
- FUNCTIONAL DEFECTS
- Acceptability defects IPC class 1-2-3
- Physical defects
- Independent of the failure cause
- Manufacturing not design defects

IPC Defect Category	PBA-item	Defect Opportunity DT	Definition
Component (DT_{PCB} = 3)	PCB	PCB DEFECT	PCB manufacturing defect
		DELAMINATION	Delamination of PCB during heat treatment
		VIA CRACKING	Via cracking during heat treatment
		class 1-2-3	IPC class 1-2-3 quality defect as defined by IPC-A-600 standard
Component (DT_C = 3)	BoM	PHYSICAL OUT-OF-SPEC	A component is functional but some aspect of its physical properties does not adhere to specification
		ELECTRICAL OUT-OF-SPEC	A component is functional but some aspect of its electrical properties does not adhere to specification
		FATAL DEFECT	A component is not functional due to electrical malfunction (including data programming error e.g. wrong PROM code)
		class 1-2-3	IPC class 1-2-3 quality defect as defined by IPC-A-610 standard
Placement (DT_P = 4)	BoM	MISSING	A component is missing.
		WRONGLY EQUIPPED	A wrong component was placed or a component was placed on a not-equipped location of the PBA design/layout
		MISORIENTED	Component placed with incorrect orientation w.r.t. pin 1
		MISPLACED	Component placed at incorrect position (e.g. with X-Y offset) or small orientation offset to the correct position resulting in electrical defect
		class 1-2-3	IPC class 1-2-3 quality defect as defined by IPC-A-610 standard
Termination (DT_T = 2)	BoM	OPEN	The electrical contact between the component terminal and a pad is interrupted.
		SHORT	Undesired electrical connection between a component terminal and other terminal(s) or other electrically conductive PBA features.
		class 1-2-3	IPC class 1-2-3 quality defect as defined by IPC-A-610 standard
Assembly (DT_{PBA} = 4)	PBA	MECHANICAL	PBA mechanical defect (not component related)
		INTERCONNECTION	PBA interconnection defect (not component related)
		CLEANING	PBA cleanliness issue
		CONFORMAL COATING	Conformal coating does not adhere to its specification (pinholes, not coated/overcoated areas)
		class 1-2-3	IPC class 1-2-3 quality defect as defined by IPC-A-610 standard

Defect Model

Unambiguous definitions are essential:

- Defect types
- Test access – Test efficiency – Test coverage.

Goal:

Objective, universally applicable and in-principle correct[1] approach to failure probability and test coverage calculations.

[1]test impact at DO – no calculation approximations

Defect Model

Electronic Design & Manufacturing

imec

Determine DO failure probability?

PBA DPMO models

Project : VIS-PROSPERITA

V1.2
November 2012

500.000.000 DO study

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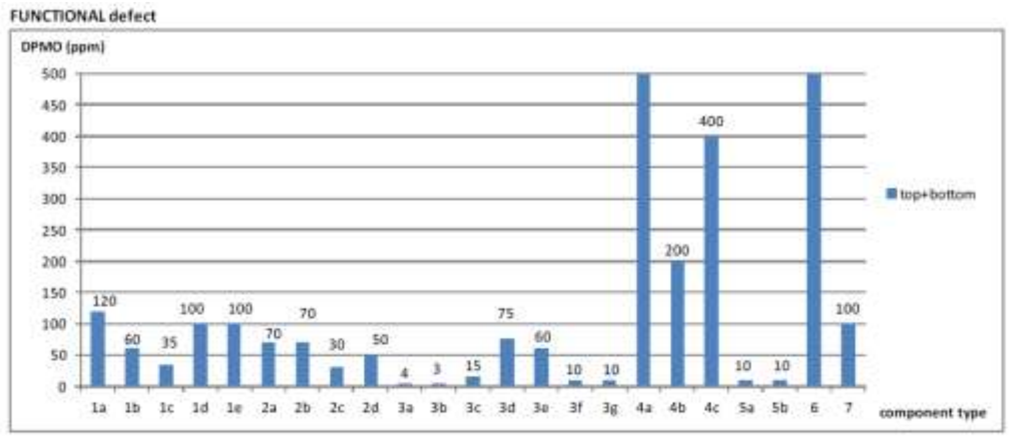
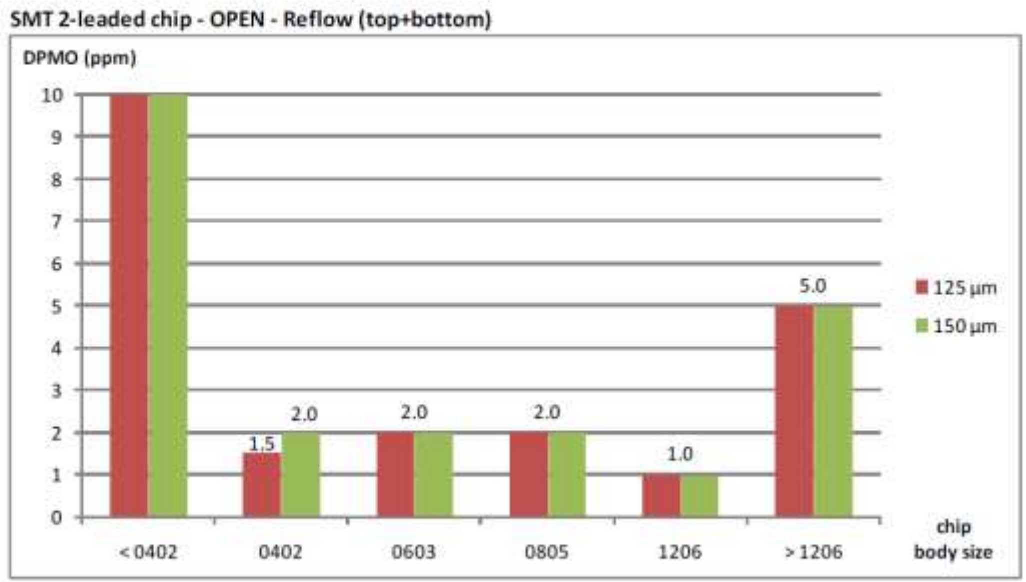
BOM based model





Test coverage model

IPC Category	Defect Type	Test Access	Test Efficiency
Termination (BOM)	**Open**	IF Terminal visible: TA = 1 ELSE: TA = 0	IF TH or leads Axial/Radial + 2 side inspection: TE = 0,5 ELSE: TE = 0
	Short	IF Terminal visible: TA = 1 ELSE: TA = 0	IF TH or Gullwing: TE = 1 ELSE: TE = 0
Placement (BOM)	**Missing**	TA = 1	TE = 1
	Wrongly equipped	TA = 1	Component has distinctive features such as label: TE = 0,95 ELSE: TE = 0,05
	Misoriented	TA = 1	Component has no orientation: TE = - Component has orientation mark: TE = 1 ELSE: TE = 0
	Misplaced	TA = 1	PCB provides position reference (e.g. silk screen): TE = 1 ELSE: TE = 0
Component (BOM)	**Physical Out-of-spec**	TA = 1	TE = 0,5
	Electrical Out-of-Spec	TA = 0	TE = -
	Fatal defect	TA = 0	TE = -
Component (PCB)	**Design**	TA = 0	TE = -
	PCB Defect	TA = 0	TE = -
	Delamination	TA = 0	TE = -
	Via cracking	TA = 0	TE = -
Assembly (PBA)	**Mechanical**	TA = 1	TE = 0
	Interconnection	TA = 1	TE = 0
	Cleaning	TA = 0	TE = -
	Conformal coating	TA = 1	TE = 0

AOI model
Algorithm based

- POS є {AT, CC, GA, FP, SO, CY, IP, FM}
- POS є {XD, LF} AND TC = 2 AND S є {R, F, H, E} AND Max(L,W) ≥ 1,6 mm

- POS є {XD,LF} AND TC = 2 AND S є {C,F,I,J,L,N,O,P,Q,R}
- POS є {AT,CC,GA,FP,SO,CY,IP,FM} OR (POS є {XD,LF} AND TC=2 AND S NOT є {C,F,I,J,L,N,O,P,Q,R}

- = SMD AND (POS є {CC,GA} OR (POS є {FP,SO,FM} AND TC ≥ 8 AND (TS ="N" OR TP є {D,T})))

BOM based test Coverage models: MVI, AOI, ICT, BS, functional test

PBA kwaliteit tool

Pred-X

Available now!

- Generic DfX supporting tool
- Can be used very early in design phase (concept)
- Quantified prediction of PBA DfX properties
- V1.0: Quality and test coverage prediction

Dank u voor uw aandacht

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