Test
Technology
Symposium

Qualification Test definition
based on application and product mission

Kees Revenberg
Co-founder / MD

MASER ENGINEERING

Content

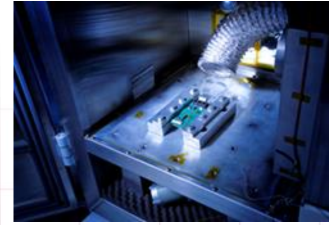
- Introduction
- Application profile and mission review
- Qualification programs and standards
- Electrical Test of components
  - ATE tests
  - Non-ATE tests
    - Passives & Actives
    - Power & High Voltage Electronics
    - MEMS & Electro-Optical
  - ESD & Latch-Up
- Summary

MASER Engineering

MASER Engineering, founded in 1993, is an independent engineering service company operating in the semiconductor and electronic systems industry.

Reliability Test scope

- Design and Manufacturing of R/T boards and mechanical test fixtures
- Electrical Test: DC + optical parametric | Structural | ATE | more
- ESD & Latch-Up test: HBM | MM | CDM | TLP | system
- Environmental test: HTOL | THB | HAST | TCY | MSL | PTC | more
- Mechanical test: Vibration | Shock | Centrifuge | Bending | Pull/Shear | more



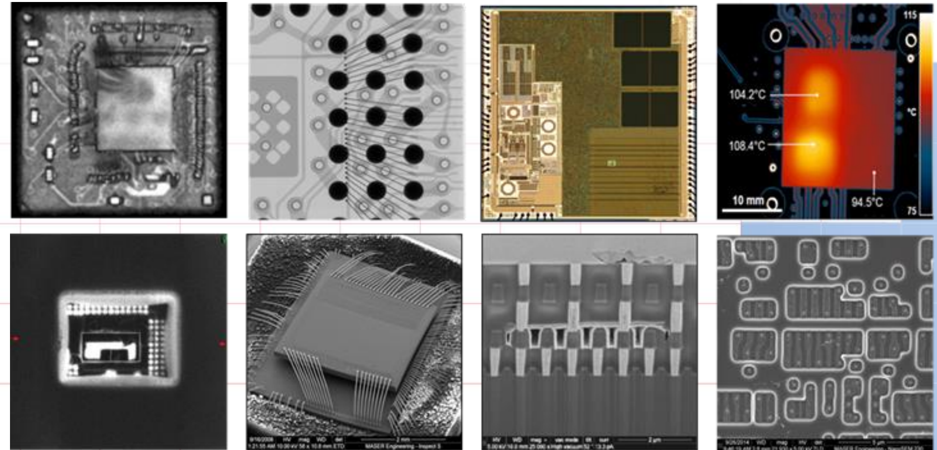
MASER ENGINEERING

MASER Engineering

MASER Engineering has >55 employees working in 3000m^2 office and laboratory in Enschede, The Netherlands. ISO9001 certified & ISO17025 accreditation L388.

Failure Analysis scope

- Non Destructive Analysis: E-test | 2D-XRAY | 3D-XRAY | SAM | LIT | EOTPR
- Sample Preparation: mechanical grinding & polishing | plasma | FIB
- Fault Localization: LIT | EMMI | OBIRCH | LVx | C-AFM
- Imaging & Material Analysis: Optical | SEM | TEM | FIB | AFM | SIMS/Auger*
- First Silicon Circuit Edit service > 28nm, Front and Backside, CAD driven



© MASER Engineering

MASER ENGINEERING

Application profile and mission

- Definition of application area statement
  - Functional description
  - Parametric limitations
  - Environmental conditions
  - Mechanical constraints
- Mission
  - Failure Mode Effect & Criticality Assessment
  - Customer or Market requirement definition
  - Mission definition to address robustness, safety and reliability

Application profile and mission

- Uncertainties
  - Customer behaviour → mis-use and handling faults
  - Unexpected harsh environments → indoor / outdoor
  - Excessive electrical power conditions → insufficient ESD/LU protection
  - Device applications beyond scope → overstress

- Risk assessment in the FMECA review

Qualification programs & standards

- Qualification program development
- Application or Customer driven
- Standards for industrial (JEDEC) or automotive (AEC-Q100)
- Standards for military (MILSTD-883) and space (ESCC)
- Customer driven requirements
  - Aerospace: Boeing & Airbus
  - Automotive: Ford/Volvo, GM, Volkswagen → AEC-Q100
- Legal restrictions: CE, ROHS, REACH, UN, UL

JEDEC JESD47K – august 2018

- Stress-Test-Driven Qualification of IC's
- IC and Package sections

Table 5-1 — Device qualification tests

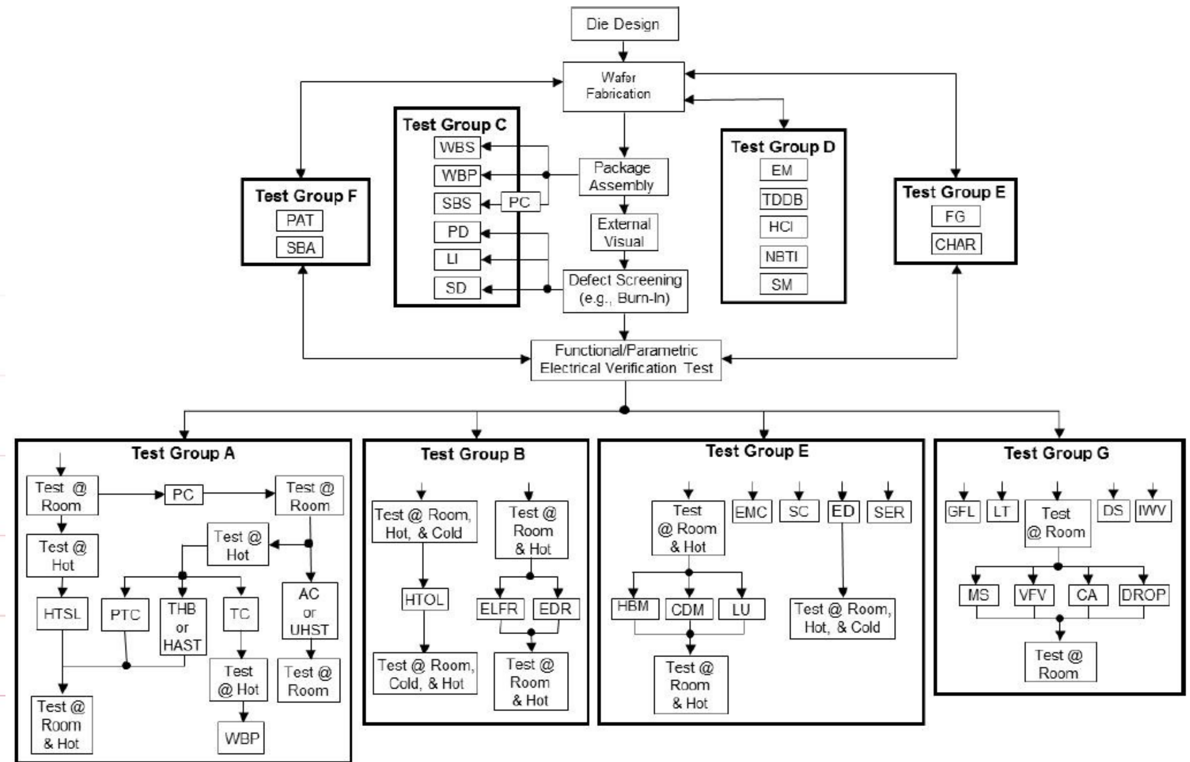
Stress	Ref.	Abbv.	Conditions	Requirements	
				# Lots / SS per lot	Duration/Accept
High Temperature Operating Life	JESD22-A108, JESD85	HTOL	$T_J \geq 125$ °C $V_{cc} \geq V_{cc}$ max	3 Lots/77 units	1000 hrs/ 0 Fail
Early Life Failure Rate	JESD22-A108, JESD74	ELFR	$T_J \geq 125$ °C $V_{cc} \geq V_{cc}$ max	See ELFR Table	$48 \leq t \leq 168$ hrs
Low Temperature Operating Life	JESD22-A108	LTOL	$T_J \leq 50$ °C $V_{cc} \geq V_{cc}$ max	1 Lot/32 units	1000 hrs/0 Fail
High Temperature Storage Life	JESD22-A103	HTSL	$T_A \geq 150$ °C	3 Lots/25 units	1000 hrs/0 Fail
Latch-Up	JESD78	LU	Class I or Class II	1 Lot/3 units	0 Fail
Electrical Parameter Assessment	JESD86	ED	Datasheet	3 Lots/10 units	T_A per datasheet
Human Body Model ESD	JS-001	ESD-HBM	$T_A = 25$ °C	3 units	Classification
Charged Device Model ESD	JS-002	ESD-CDM	$T_A = 25$ °C	3 units	Classification
Accelerated Soft Error Testing OR System Soft Error Testing	JESD89-2 and JESD89-3 OR JESD89-1	ASER SSER	$T_A = 25$ °C	3 units OR Minimum of 1E+06 Device Hrs or 10 fails.	Classification

Table 5-3 — Qualification tests for components in nonhermetic packages

Stress	Ref.	Abbv	Conditions	Requirements	
				# Lots / SS per lot	Duration /Accept
MSL Preconditioning Must be performed prior to: THB, HAST,TC, AC, & UHAST	JESD22 - A113	PC	Per appropriate MSL level per J-STD-020		Electrical Test (optional)
High Temperature Storage[1]	JESD22-A103 & A113	HTSL	150 °C + Preconditioning if Required	3 Lots / 25 units	1000 hrs / 0 Fail
Temperature[2] Humidity bias (standard 85/85)	JESD22-A101	THB	85 °C, 85 % RH, V_{cc} max	3 Lots / 25 units	1000 hrs / 0 Fail
Temperature[2, 3] Humidity Bias (Highly Accelerated Temperature and Humidity Stress)	JESD22-A110	HAST	130 °C / 110 °C, 85 % RH, V_{cc} max	3 Lots / 25 units	96/264 hours or equivalent per package construction / 0 Fail
Temperature Cycling	JESD22-A104	TC	B[4] -55 °C to +125 °C G[4] -40 °C to +125 °C C[4] -65 °C to +150 °C K[4] 0 °C to +125 °C J[4] 0 °C to +100 °C	3 Lots / 25 units	700 cycles / 0 Fail 850 cycles / 0 Fail 500 cycles / 0 Fail 1500 cycles / 0 Fail 2300 cycles / 0 Fail
Unbiased Temperature/Humidity (Unbiased HAST[3])	JESD22-A118	UHAST	130 °C / 85% RH 110 °C / 85% RH	3 Lots / 25 units	96 hrs / 0 Fail 264 hrs / 0 Fail
Unbiased Temperature/Humidity (Autoclave[5])	JESD22-A102	AC	121 °C / 100% RH	3 Lots / 25 units	96 hrs / 0 Fail **Not Recommended**
Solder Ball Shear	JESD22-B117	SBS	Characterization	30 balls / 5 units	
Bond Pull Strength[7]	M2011	BPS	Characterization, Pre Encapsulation	1 Lot / 30 bonds / 5 units	Ppk≥1.66 or Cpk≥1.33 (note 6)
Bond Shear[7]	JESD22-B116	BS	Characterization, Pre Encapsulation	1 Lot / 30 bonds / 5 units	Ppk≥1.66 or Cpk≥1.33 (note 6)
Solderability	M2003 J-STD-002	SD	Characterization	3 lots / 22 leads	0 Fail
Tin Whisker Acceptance	JESD22-A121 through rqmts of JESD201	WSR	Characterization per JESD201	See JESD201	See JESD201, Based on Appropriate Classification

AEC-Q100H – september 2014

- Industry council
- No car manufacturers
- Failure Mechanism based Stress Test Qualification for IC's
- Grade 0 – Grade 4 → -40C to +150C/ +125C/+105C/+85C
- Reference: JEDEC and specific tests methods

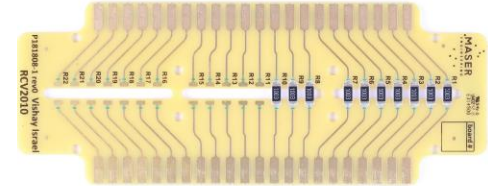


Electrical Test of components

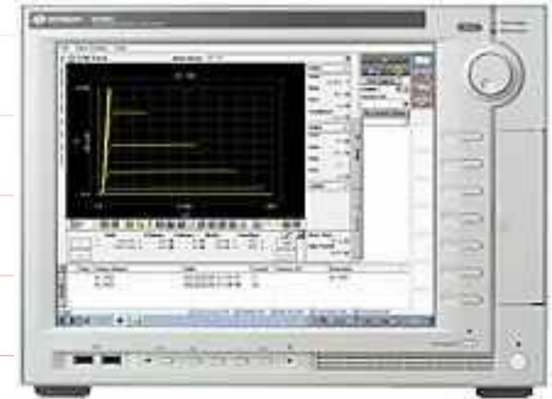
- ATE test
  - Volume production E-test tools for memory, digital, mixed-signal and RF
  - Wafer level and Device level automated handler systems
  - Production test program with characterisation and F/A confirmation mode
- Non-ATE tests
  - Passive and Active devices
  - MEMS and Optical
  - Power and High Voltage
- ESD & Latch-Up test
  - Device level tests
  - System level tests

Non-ATE tests

- Passives & Actives
  - Impedance measurements → DC to GHz
  - Parametric Measurement Units → fA to kA, uV to kV
  - Dynamic parameters with special measurement setup → switching timing

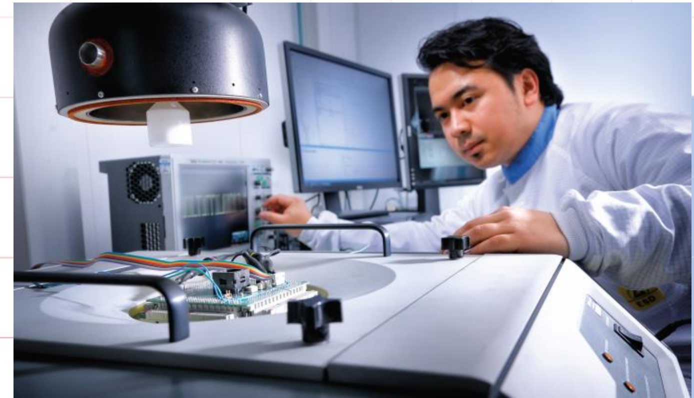


- Power & High Voltage Electronics
  - High current / High voltage handling
  - Power switching and Thermal run-away issues
  - Cooling and Safety of Testing



Non-ATE tests

- MEMS & Electro-Optical
  - Additional non-electrical stimuli or measurements
  - Mechanical, Chemical, Optical and Electrical parameters
- ESD & Latch-Up
  - Test protection circuits for manual, machine or electrical handling
  - Component level ESD test
    - Human Body Model → JS-001
    - Charged Device Model → JS-002
    - Human Metal Model → pending standard
  - System level ESD test
  - Latch Up test
    - Process sensitivity for current injection



MASER ENGINEERING

Summary

- Qualification program should be addressing application scope
- Intense review of potential application environment
- Reference to industry standards give multi testlab access
- Combined application of E-test and E&M stress conditions
- Optimized qualification programs give better and cost effective outcome in time and results

Thank you for your attention!

Any Questions?