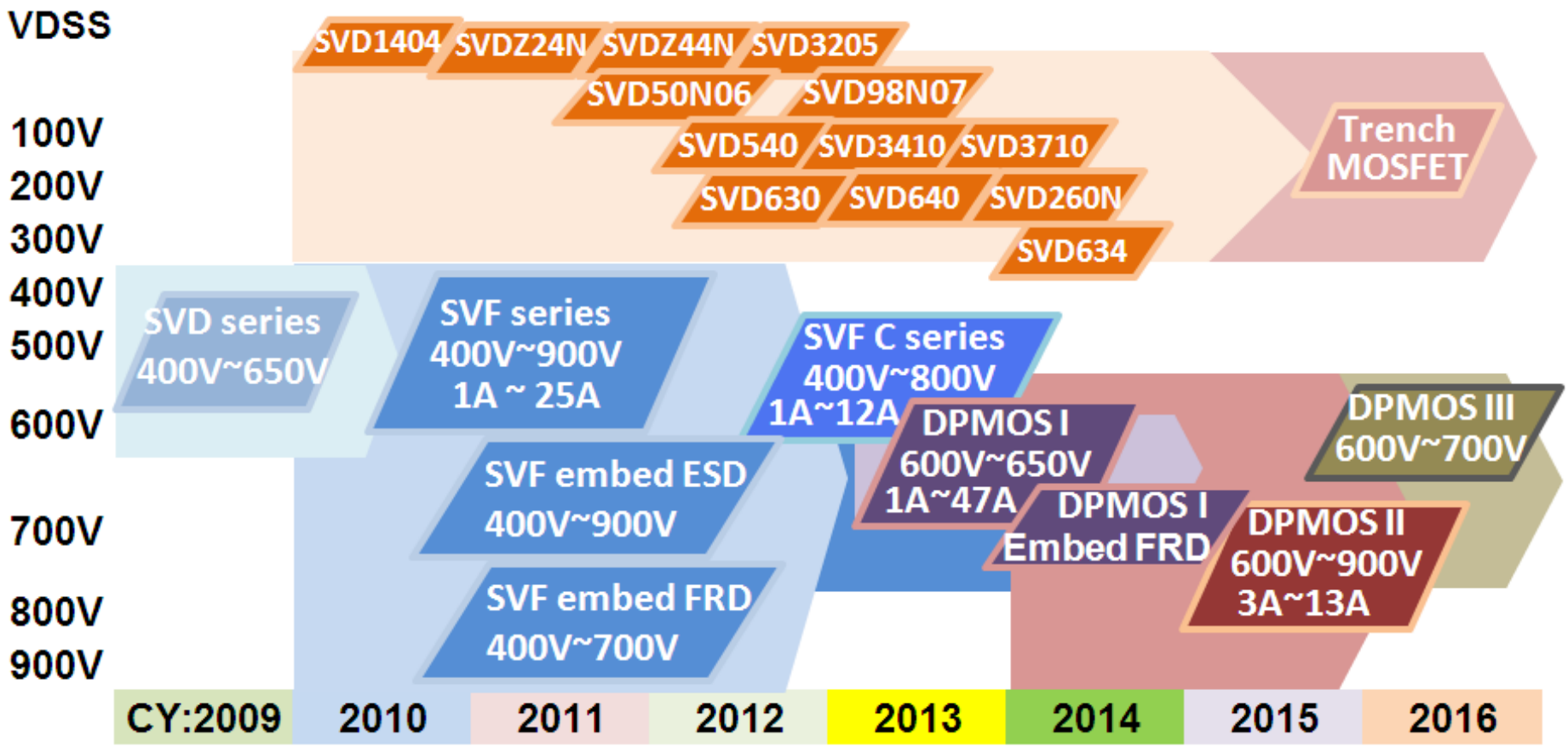
Silan High Performance Power Mosfet

2015.03

Silan Power MOSFET：The idea of development

Road Map of Silan Power MOSFET

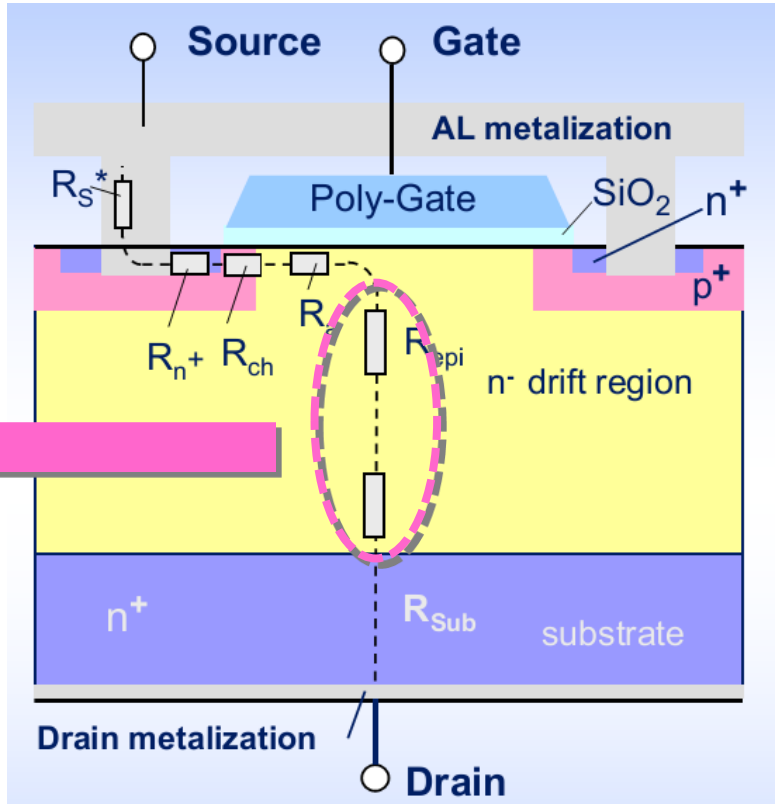


What is the key issue of high voltage Power MOSFET? Why it is a problem?

$R_{DS(on)}$ Analysis

$V_{DS} \approx 30V$		$V_{DS} \approx 600V$	
R_S*	7 %	R_S*	0.5%
R_{n+}	6 %	R_{n+}	0.5 %
R_{ch}	28 %	R_{ch}	1.5 %
R_a	23 %	R_a	0.5 %
R_{epi}	29 %	R_{epi}	96.5 %
R_{sub}	7 %	R_{sub}	0.5 %

R_S* = packaging



96.5% of Rds(on) for high voltage standard MOSFET determined by the epitaxial resistance

*** Rds(on) / Area ∝ $V_{(BR)DSS}^{2.4\sim2.6}$**

*** From IBM Power & Cooling Symposium 2005**

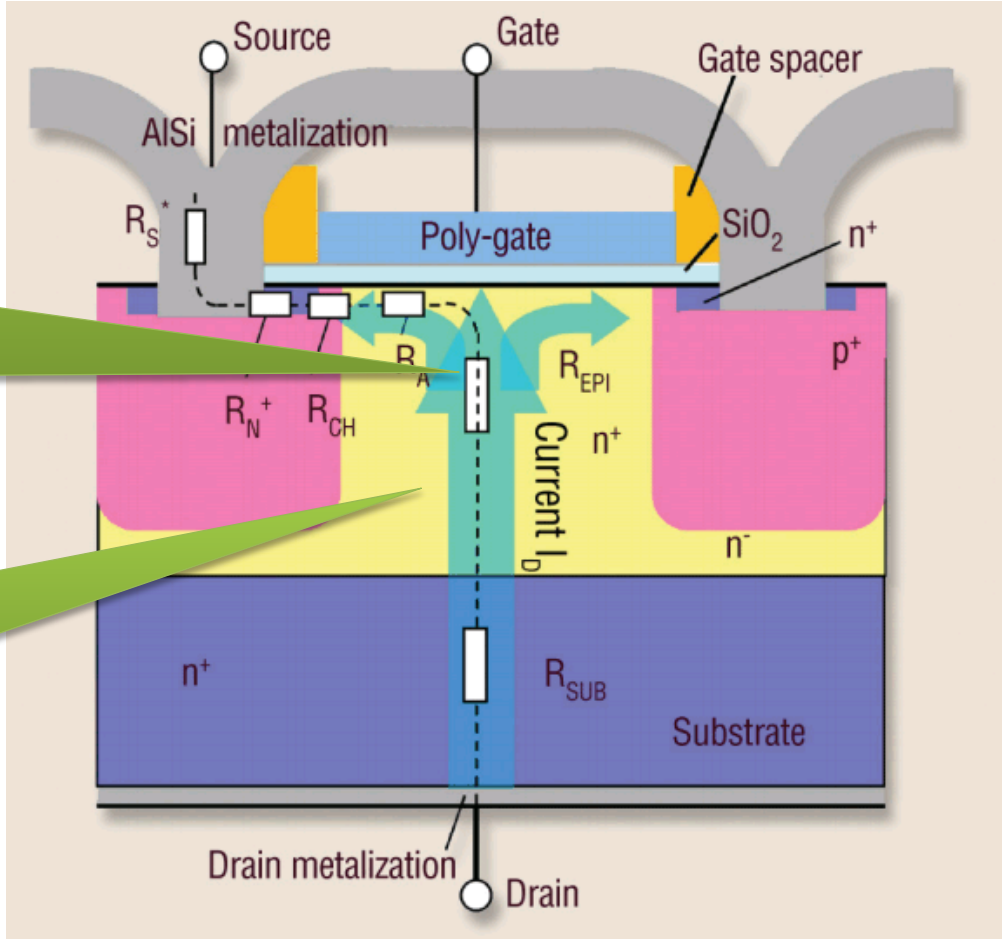
Super Junction MOSFETs use charge compensation principle

When Mosfet is turning on

The main current path is more heavily doped (by a factor of 10) than for a conventional high-voltage MOSFET.

When Mosfet is turning off

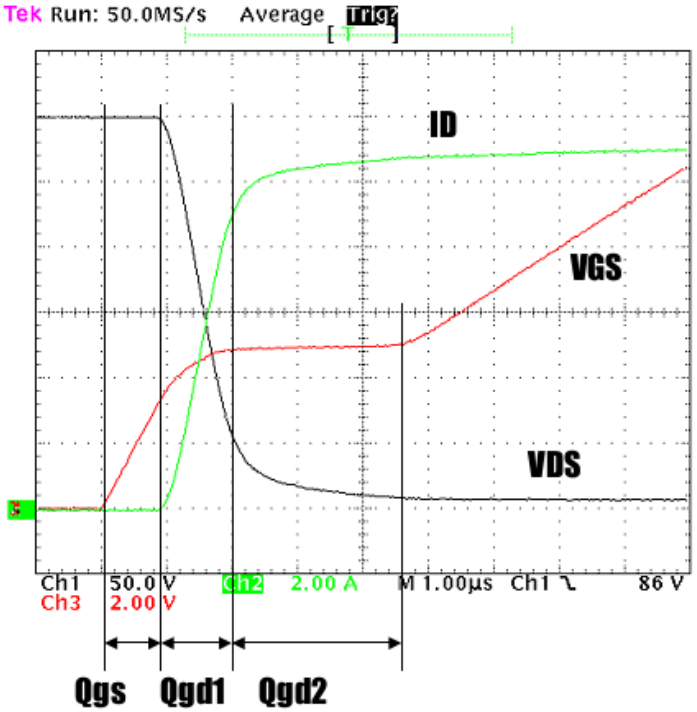
Depletion region forms with merging of carriers from doping in n+ region and p+ region.



* Rds(on) / Area ∝ $V_{(BR)DSS}^{1.25}$

* From Jpn. J. Appl. Phys. Vol. 36(1997) pp. 6254-6262

Power Mosfet Design Points



Design Points for
Reduction of power loss

Reduce of On Resistance [RDS(on)]
X Gate-Drain Charge[Qgd]

Figure of Merit
FOM=Ron X Qgd [Ω nC]

$$Ploss = (Irms^2 \times R_{DS(on)}) + (I \times \frac{Qgd1 + Qgd2}{Ig} \times V_{DS} \times fc) + (Qg \times V_{GS} \times fc)$$

Conductive Loss **Switching Loss** **Gate Drive Loss**

FOM against Competitor 600V SJ MOSFET

	ST	Silan	Infineon
Device	STP13NM60N	SVS11N60F	SPA11N60C3
Package	TO-220F	TO-220F	TO-220F
Vds	600V	600V	600V
Vgs	±25V	±30V	±20V
Id	11A	11A	11A
Vth	3.1V	3.1V	3.0V
Rds(on).typ	0.3Ω	0.32Ω	0.28Ω
Qg.typ	24.4 nC	21 nC	42 nC
Qgd.typ	12 nC	10.8 nC	20.1 nC
FOM: Qgd*Rds	3.6 ΩnC	3.45 ΩnC	5.628 ΩnC

Same level of FOM

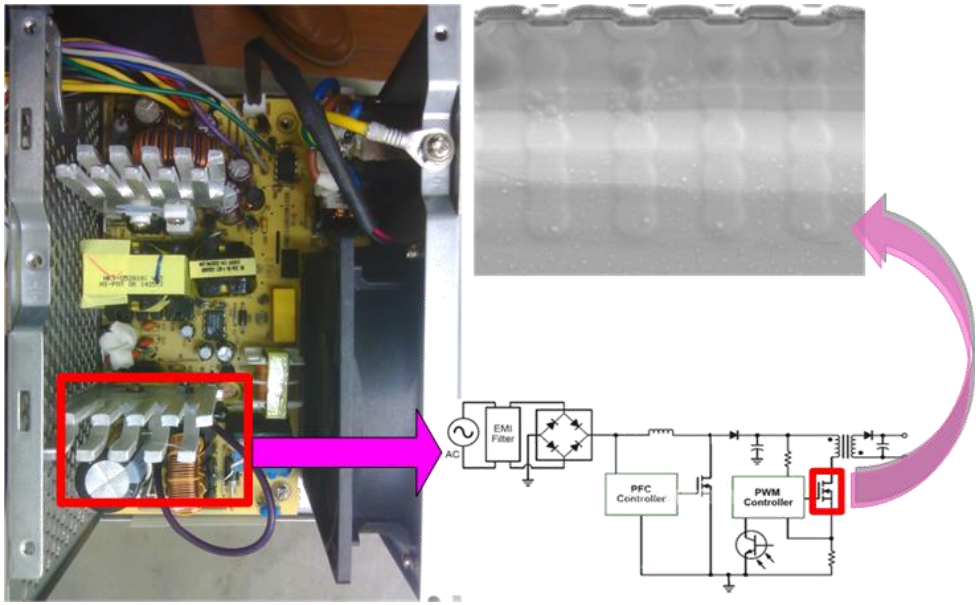
More than 1.6 times Of FOM

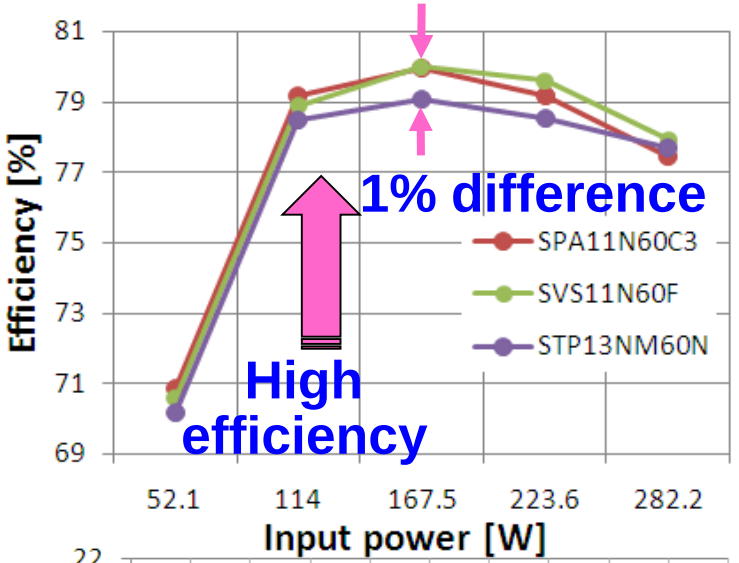
System Efficiency and Power losses

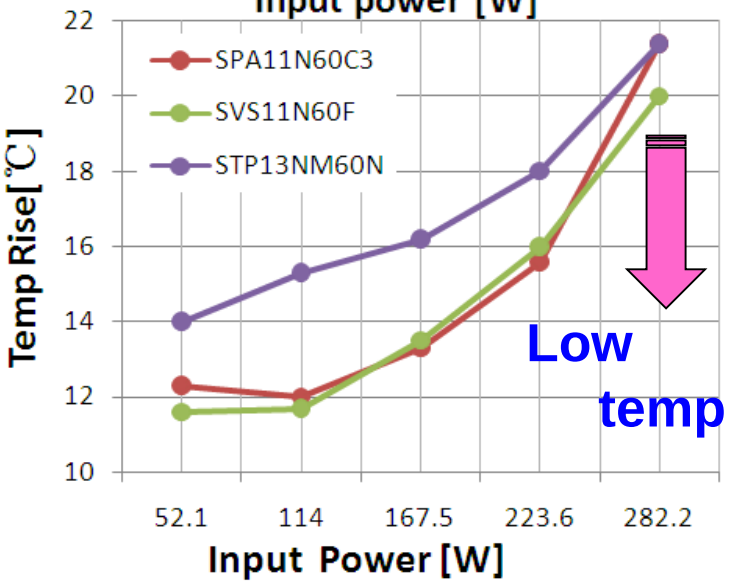
Application: PC Power

Test condition:

- Vin: 220VAC 60Hz
- Input : 50W~280W
- Gate resistance : 24Ohm

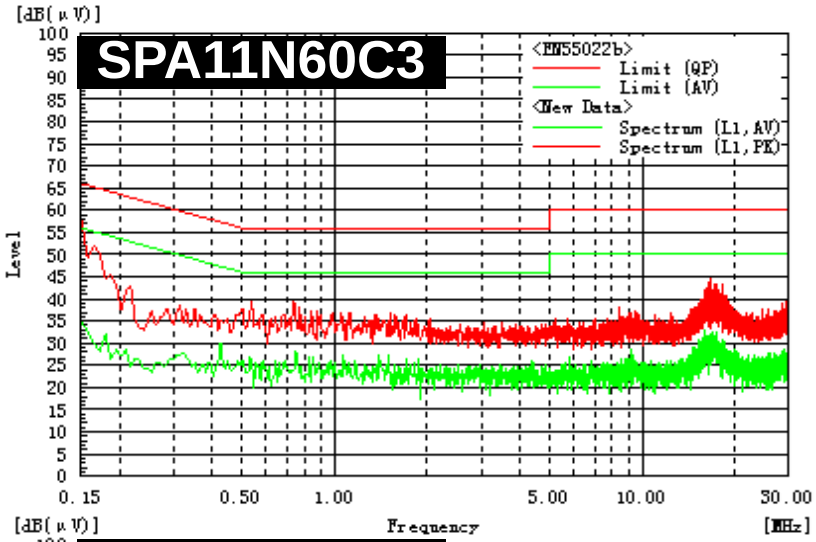


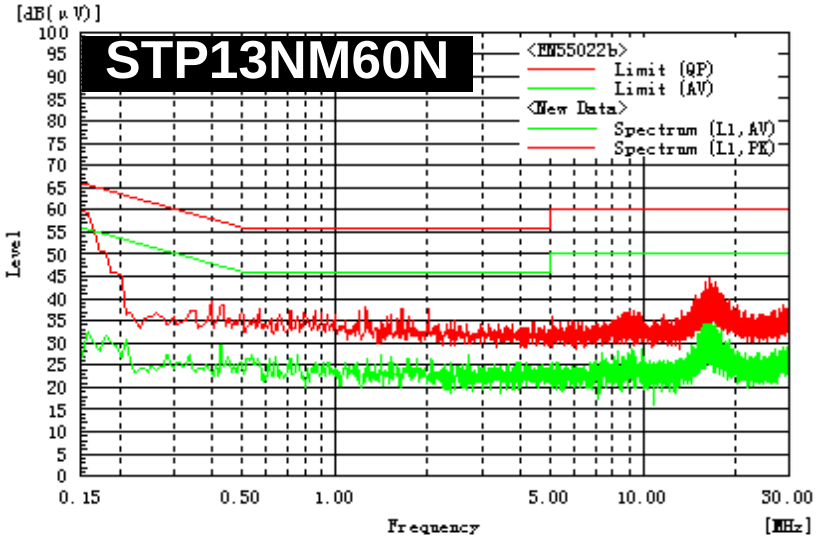


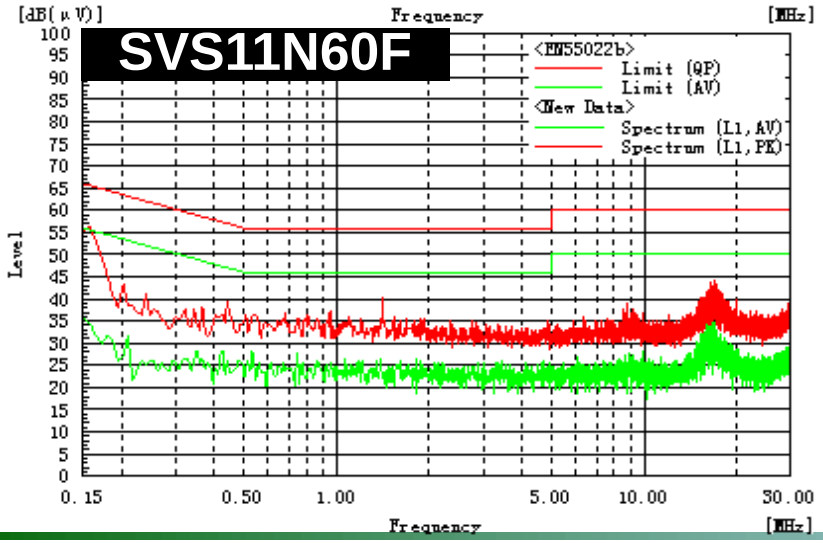


EMI performance — Conduction Test

Test condition: Vin: 220VAC 60Hz; Input : 280W



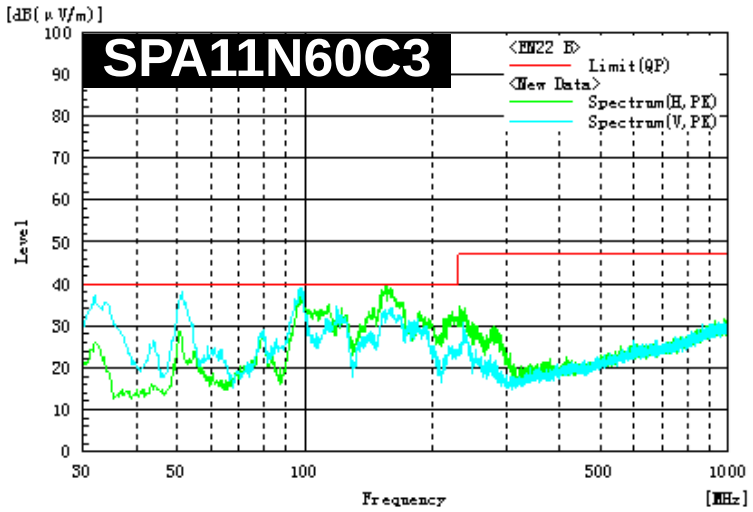


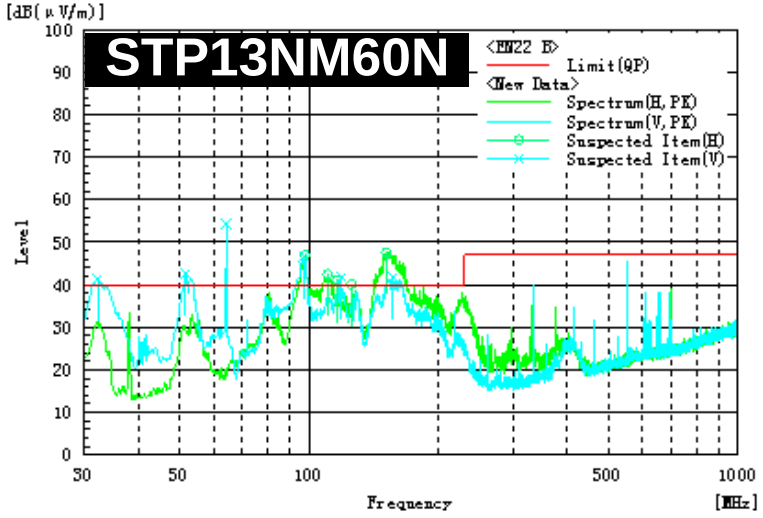


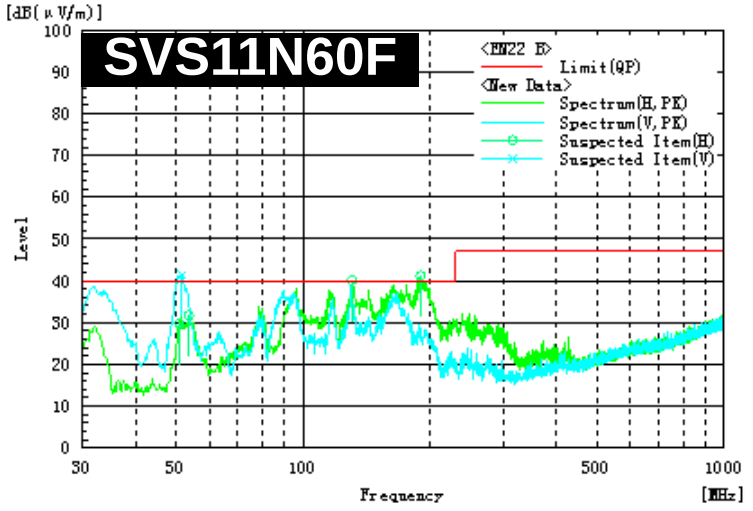
At the same Level.

EMI performance — Radiation Test

Test condition: Vin: 220VAC 60Hz; Input : 280W





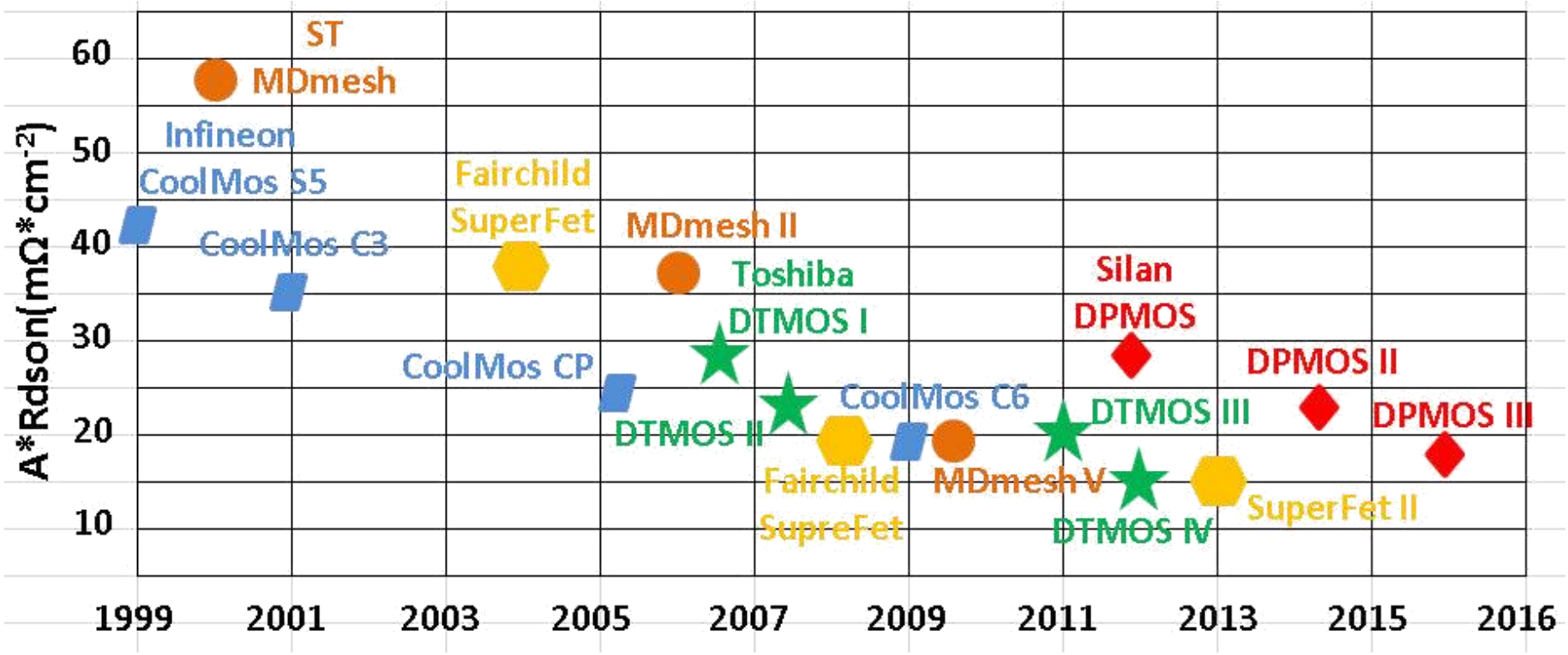


SPA11N60C3 1DB margin √

SVS11N60F Over 1DB

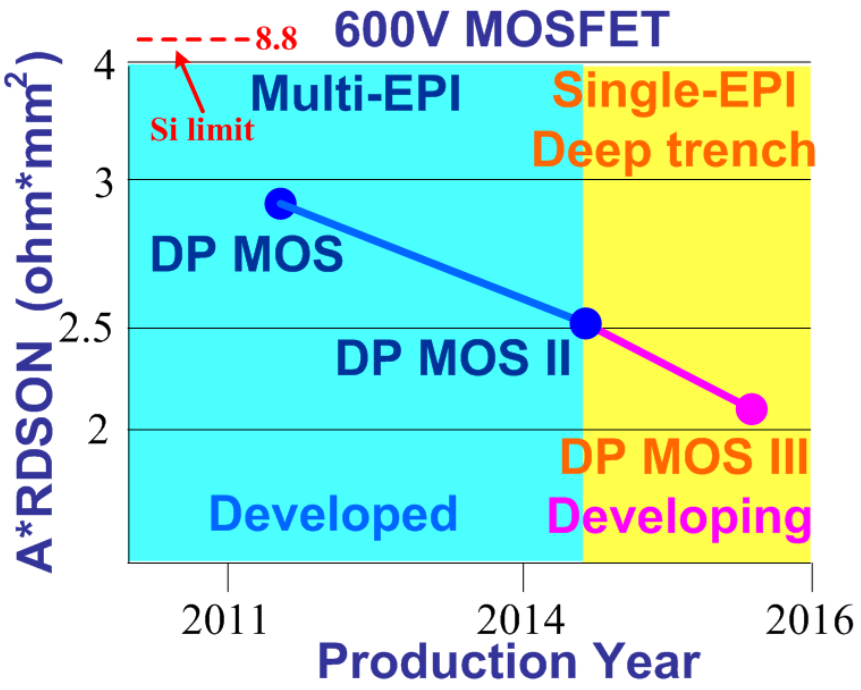
STP13NM60N Over 3DB

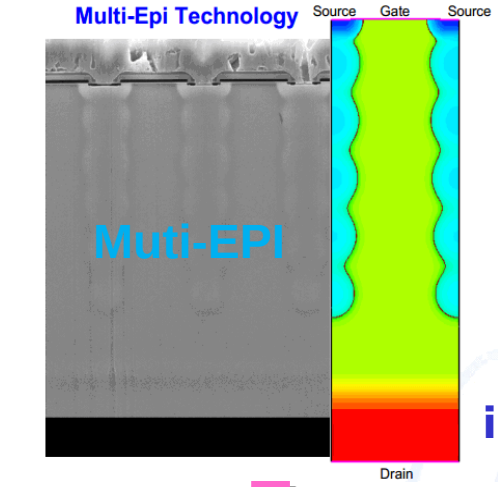
Silan DPMOS Cross Reference

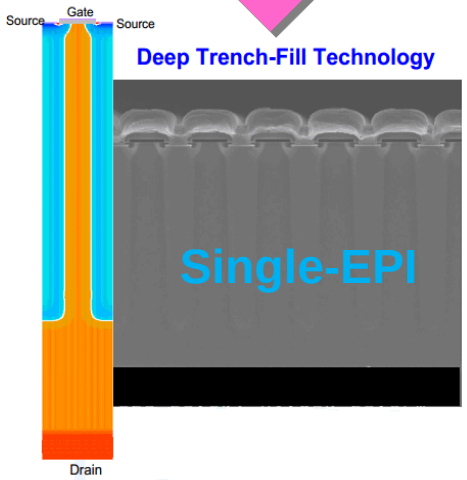


Silan DPMOS Technology development

DPMOS has low rdson and rich package, can support more efficient and compact design of power supply.







Benefits

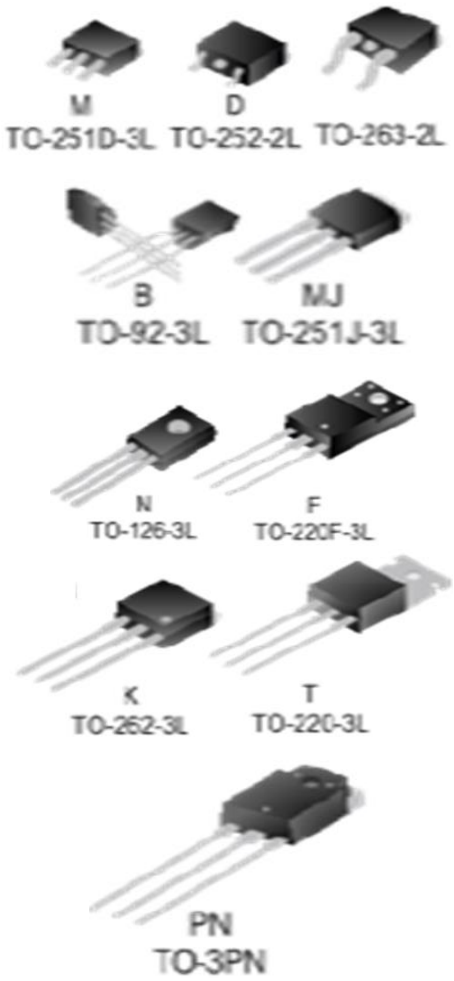
A*Rdson improve

Rdson can improve 25% in the same size

manufactur-time can reduce 30%!

DPMOS I / II Line UP

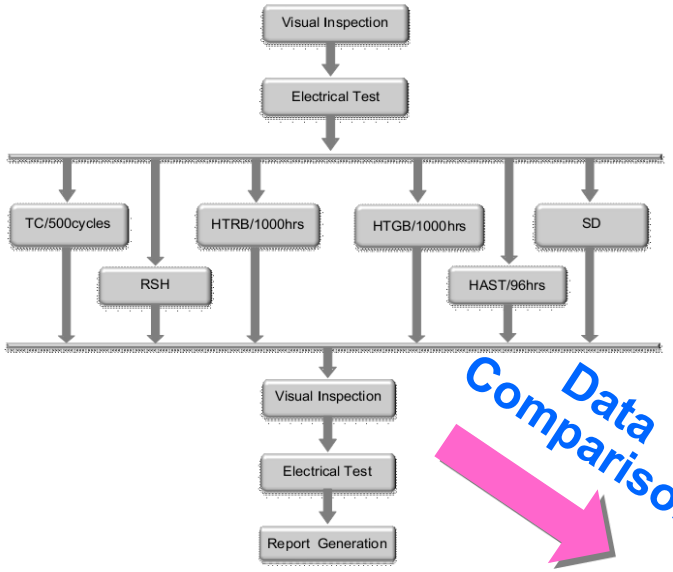
Vds	Part Number	Parameter		Package	Status	Generation
		ID	RDSON (TYP)	Symbol : Package type		
600V	SVS2N60D/M	2A	1.4Ω	D: TO-252-2L;M:TO-251-3L	MP	DPMOS I
	SVS4N60D/M	4A	0.88Ω	D: TO-252-2L;M:TO-251-3L	MP	DPMOS I
	SVS6N60D/M	6A	0.6Ω	D: TO-252-2L;M:TO-251-3L	MP	DPMOS I
	SVS7N60D/MJ	7A	0.48Ω	D: TO-252-2L;MJ:TO-251J-3L	MP	DPMOS I
	SVS11N60F	11A	0.32Ω	F:TO-220F-3L	MP	DPMOS I
	SVS20N60F/PT	20A	0.16Ω	F:TO-220F-3L; PN:TO-3PN	MP	DPMOS I
	SVS24N60F/PT	24A	0.14Ω	F:TO-220F-3L; PN:TO-3PN	MP	DPMOS I
	SVS47N60PN	47A	0.055Ω	PN:TO-3P	MP	DPMOS I
650V	SVS4N65D/M	4A	1.1Ω	D: TO-252-2L;M:TO-251-3L	MP	DPMOS I
	SVS7N65D/MJ	7A	0.6Ω	D: TO-252-2L;MJ:TO-251J-3L	MP	DPMOS I
	SVS11N65F	11A	0.4Ω	F:TO-220F-3L	MP	DPMOS I
	SVS20N65F/PT	20A	0.2Ω	F:TO-220F-3L; PT:TO-3PN	MP	DPMOS I
700V	SVS6N70M/D	6A	1.05Ω	D: TO-252-2L;M:TO-251-3L	Sample	DPMOS II
	SVS7N70M	7A	0.78Ω	M:TO-251-3L	Sample	DPMOS II
800V	SVS13N80F	12A	0.95Ω	F:TO-220F-3L	Coming soon	DPMOS II
	SVS8N80F	6A	0.45Ω	F:TO-220F-3L		DPMOS II



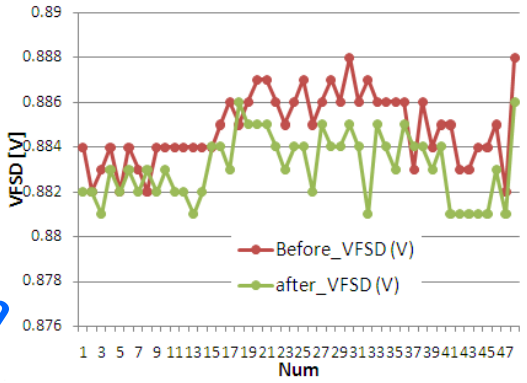
DPMOS Reliability Test Items

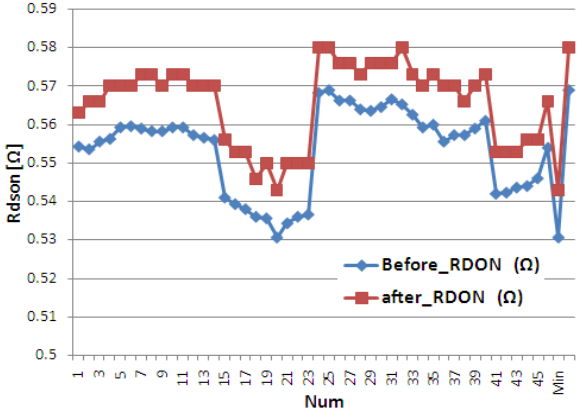
Test items	Explanation	Testing conditions and duration	Size	Reference document
HTRB	High Temperature Reverse Bias	TJ = 150℃/ specified TJ(max) 80% Reverse bias junction breakdown voltage； 1000 hrs	22/45/77	JESD22A-108 AEC - Q101
HTGB	High Temperature Gate Bias	TJ = 150℃/specified TJ(max) 100%Grid voltage； 1000hrs	22/45/77	JESD22A-108 AEC - Q101
TC	Temperature Cycling	-65℃to +150 ℃,1000cycs	22/45/77	JESD22A-104 AEC - Q101
UHAST	Unbiased Temperature/Humidity	130℃,85% RH ,96hrs	22/45/77	JESD22A -118
H3TRB	High Humidity High Temp Reverse Bias	85℃ / 85% RH 80%Reverse bias junction breakdown voltage, 100V MAX； 1000 hrs	22/45/77	JESD22A-101 AEC -Q101
HAST	Highly Accelerated Stress Test	130℃/ 85% RH 80%Reverse bias junction breakdown voltage(42V max)； 96hrs	22/45/77	JESD22A-110 AEC -Q101
RSH	Resistance to Solder Heat	SMD: Reflow soldering ,top temperature,260℃ keep 10s,3cycle	22	AEC-Q101 001
SD	Solderability	245±3℃,5s，solder area>95%	22	AEC-Q101 001

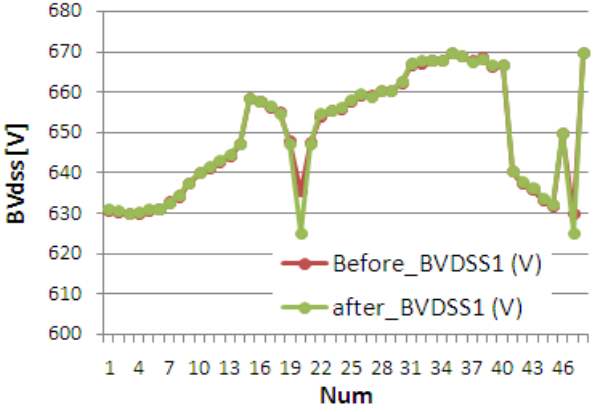
DPMOS Reliability Test Flow

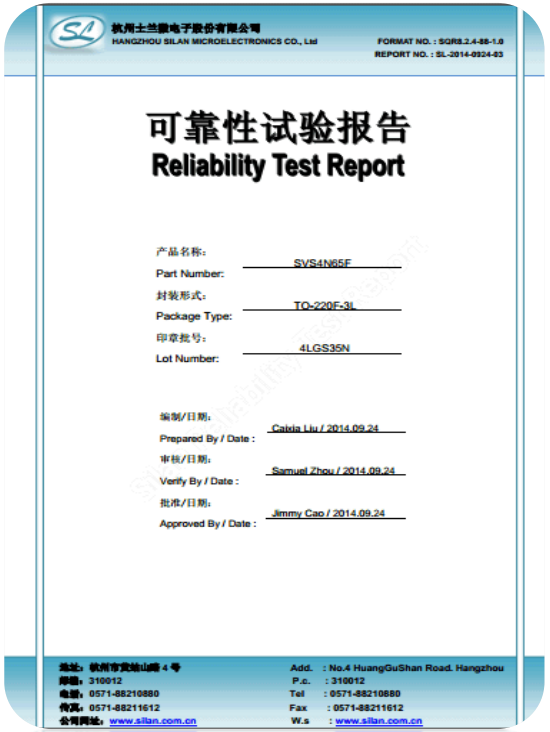


Data Comparison








可靠性试验报告
Reliability Test Report

产品名称:
Part Number: SVS4N65F
封装形式:
Package Type: TO-220F-3L
印章批号:
Lot Number: 4LGS35N

编制/日期:
Prepared By / Date : Caixia Liu / 2014.09.24
审核/日期:
Verify By / Date : Samuel Zhou / 2014.09.24
批准/日期:
Approved By / Date : Jimmy Cao / 2014.09.24

Report to Customer

DPMOS Reliability Test Equipment

Equipment	Manufacturer	Application	QTY
Oven	ESPEC /LC-233	HTOL,HTRB,HTGB, HTSL/IOL	15
High/low temperature alternating temperature humidity test chamber	ESPEC/ESL-02KA	H3TRB,THB	1
Highly Accelerated stress tester	ESPEC/EHS-221	HAST,UHAST	2
Small ultra-low temperature test chamber	ESPEC/MC-711	LTOL,LTSL	1
Thermal Shock Chamber	ESPEC/TSE-11-A	TC	2
HTRB Monitoring System	ESPEC/SILAN /HTR-21A1000B	HTRB	2
Reflow oven	SUN EAST	Reflow , RSH	1
Model Power Cycle System	Gaoyu/PC-10A300B	IOL, PC	1
Lead-free Solder Furnace	CT	SD	1

DPMOS Reliability Test Equipment

Small ultra-low temperature test chamber(ESPEC MC-711)

Reflow Solder
SUN (EAST Reflow Oven)

High temperature test chamber (ESPEC PH-101)

High temperature test chamber (ESPEC LC-233)

High/low temperature alternating temperature humidity test chamber (ESPEC ESL-02KA)

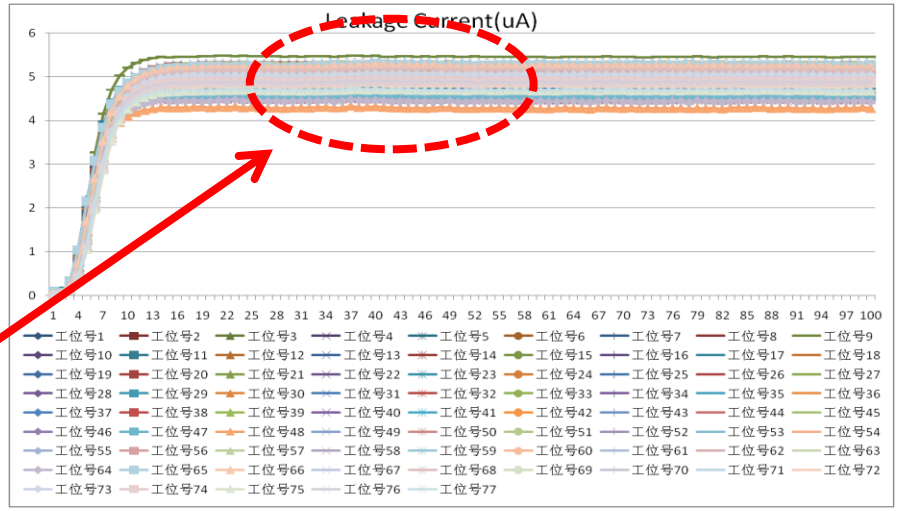
Thermal Shock Chamber (ESPEC TSE-11-A)

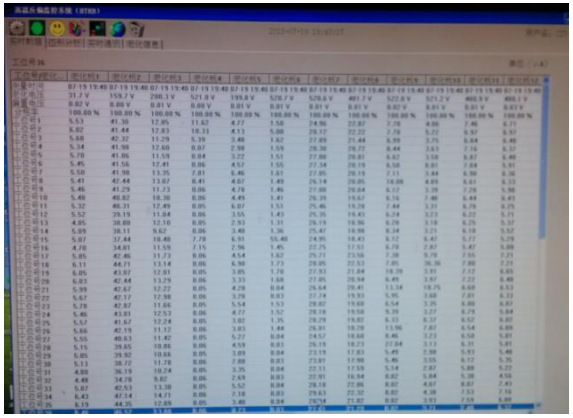
Highly Accelerated stress tester (ESPEC EHS-221)

DPMOS HTRB monitoring system

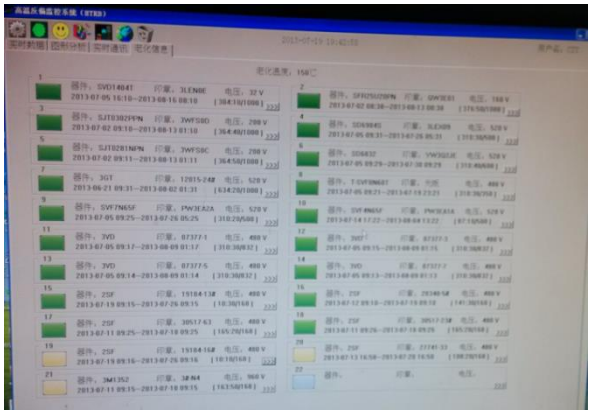
HTRB Monitoring System

Leakage current analysis





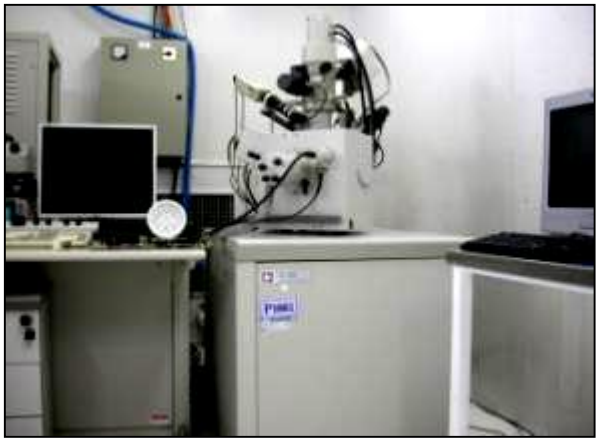
Real-time detection of leakage current of each test device



Up to 77*21 devices at the same time for aging

Silan FA Tool-1

SEM + EDX (Hitachi S-4700)

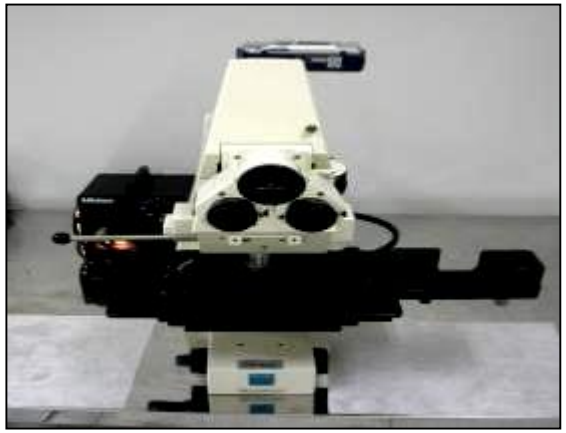


FIB (FEI FIB-200)

WET STATION

CURVE TRACER(HP 4145B)

CURVE TRACER(Tektronix 576)



MIROSCOPE

Thanks!

http://www.silan.com.cn