



Product and Technology Overview

2017



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■ GreenMOS

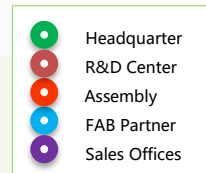
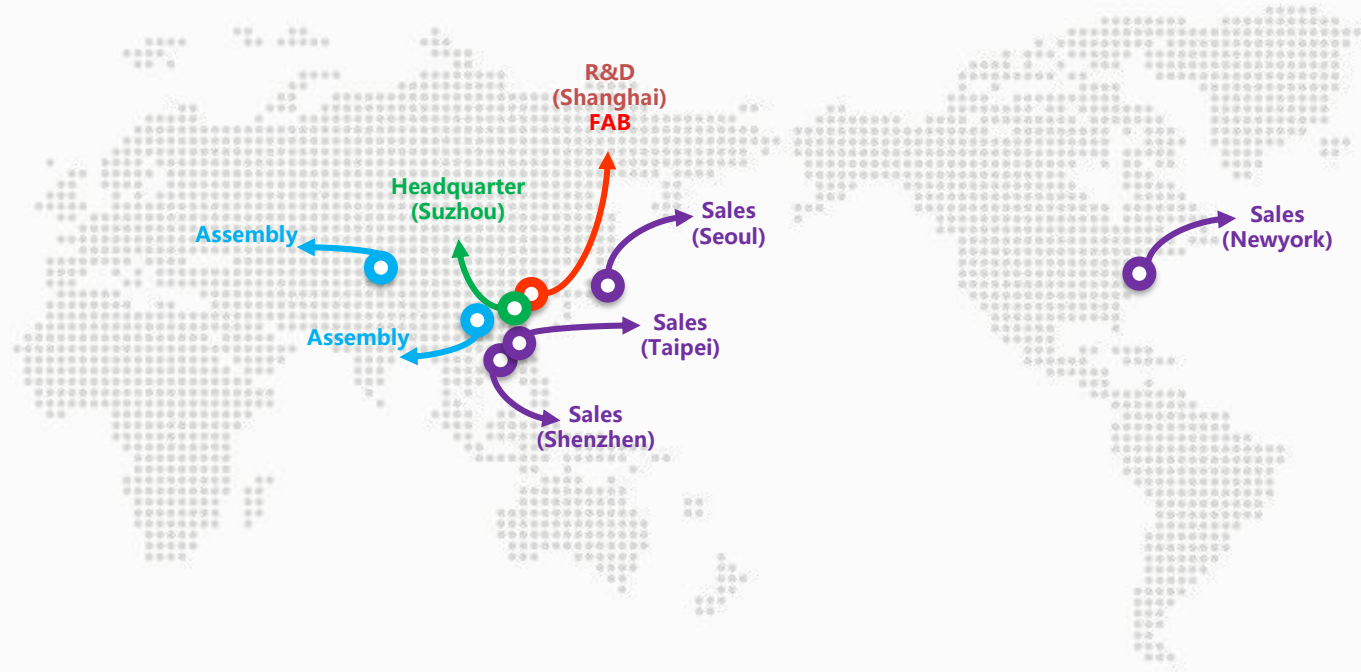
■ SFGMOS

■ User Cases

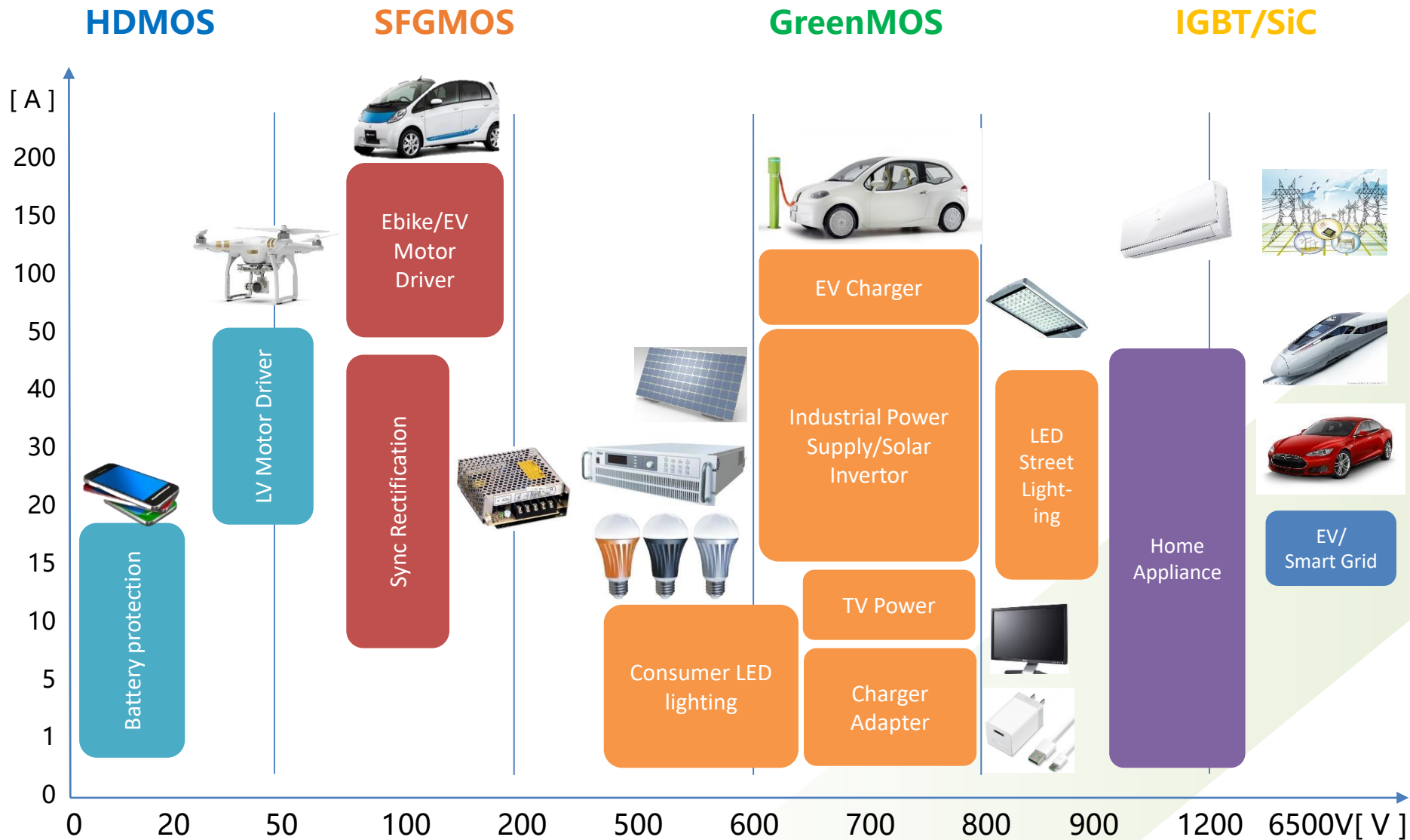
Company Milestones

- ◆ 2008.09 Oriental Semiconductor is founded. The registered capital is 35.2MRMB. Located in SISPARK of Suzhou, Jiangsu.
- ◆ 2012.09 fabricated the world first Semi-Floating Gate transistor (SFGT)
- ◆ 2013.08 published the achievement of SFG Transistor on 《Science》 Journal
- ◆ 2013.12 successfully developed the test chip using SFGT with SMIC
- ◆ 2014.01 novel soft-trench SJMOS – GreenMOS enters mass production
- ◆ 2015.06 China 1st 78A 650V GreenMOS released to EV charger customer
- ◆ 2015.11 Start production of world' s 1st SFG-transistor: SFGMOS

Global Locations



Product Portfolio



Contents

■ Overview

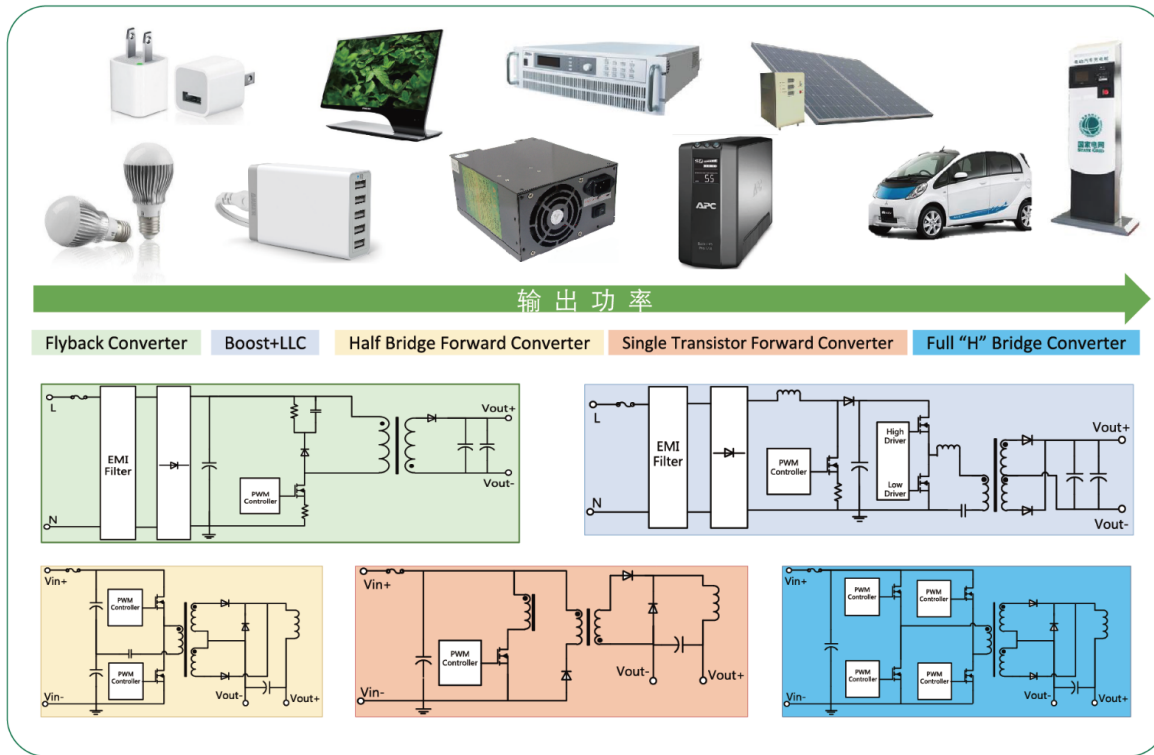
■ GreenMOS

High Voltage (500-900V) SJ MOSFET
for AC-DC Conversion Applications

■ SFGMOS

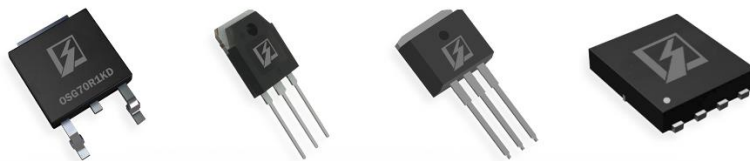
■ User Cases

Applications

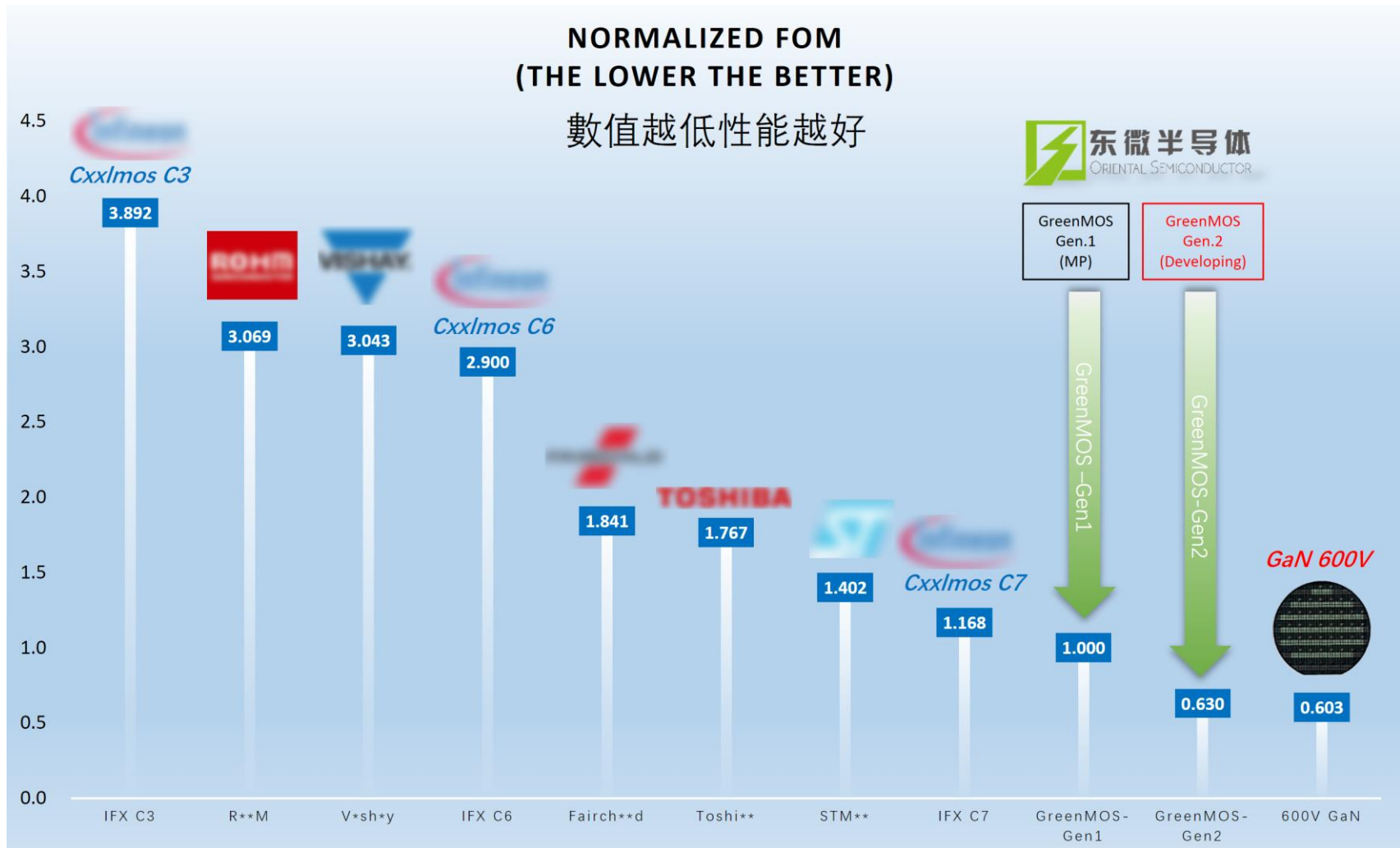


Applications :

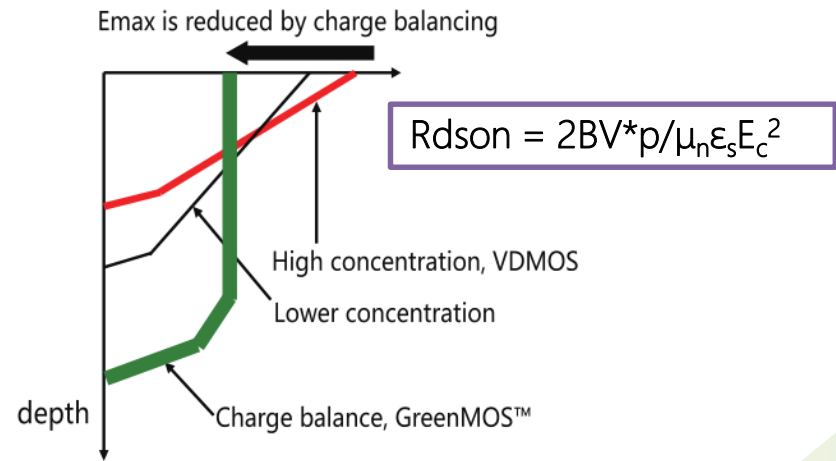
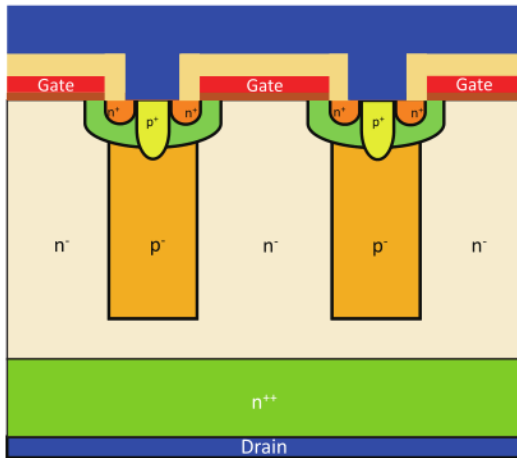
- LED lighting
- adapters
- Quick charger
- TV power
- PC power
- Server power
- UPS
- inverter
- EV charging pile
- Industrial power



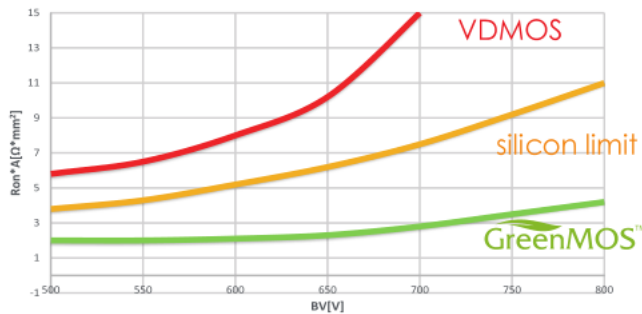
Best-in-Class FOM (Rdson*Qg)



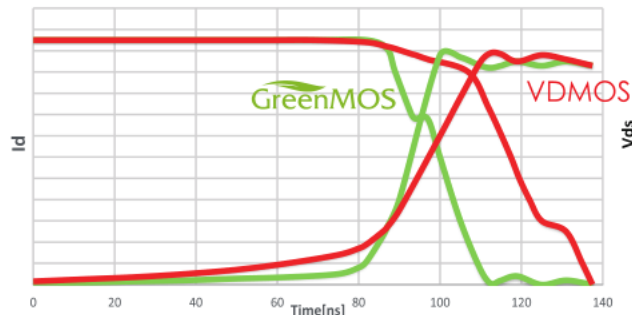
Innovative GreenMOS Technology



GreenMOS™ 与VDMOS特征导通电阻对比



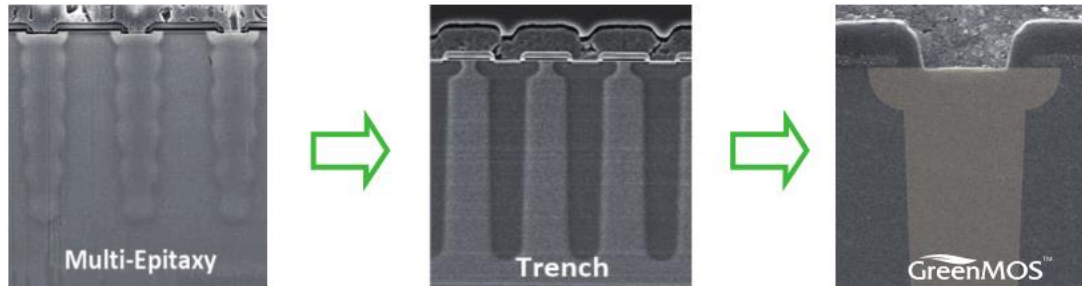
GreenMOS™与VDMOS开关特性比较



GreenMOS Key Features :

- Soft-trench technology: Better EMI Performance
- Extremely low Qg: reduce driver IC output, extremely low switching loss to enable high efficiency and high speed applications.
- High reliability, high uniformity

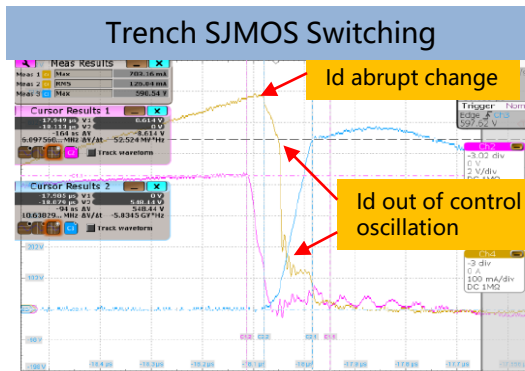
Key Feature 1: Soft Trench improves EMI



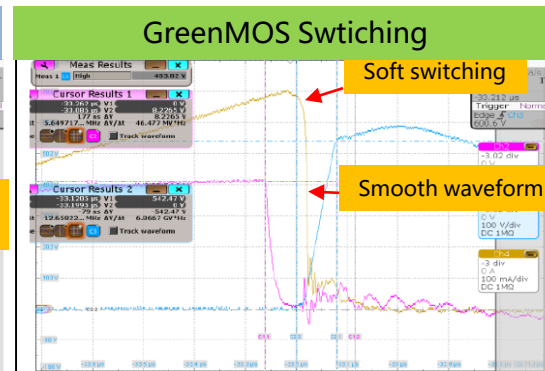
Con : Cost
Pro : Soft Switching

Con : Hard Switching
Pro : Cost

Cost
Soft Switching



CH2:V_{GS} CH3:V_{DS} CH4:I_D
GS-T_{FALL TIME}:164ns DS-T_{RISE TIME}:94ns

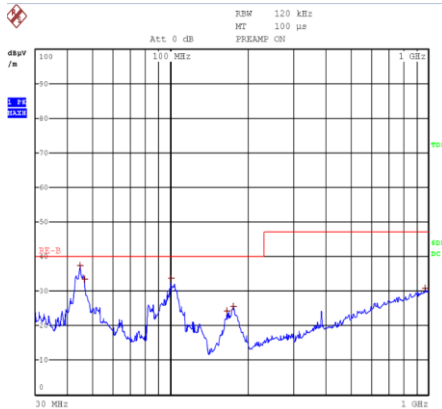


CH2:V_{GS} CH3:V_{DS} CH4:I_D
GS-T_{FALL TIME}:177ns DS-T_{RISE TIME}:79ns

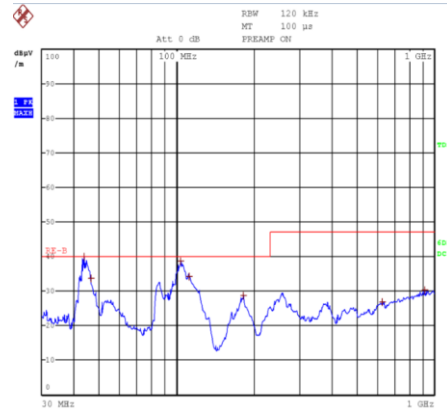
GreenMOS switching waveform is smooth → improve EMI

Key Feature 1: Improve EMI at MOSFET level

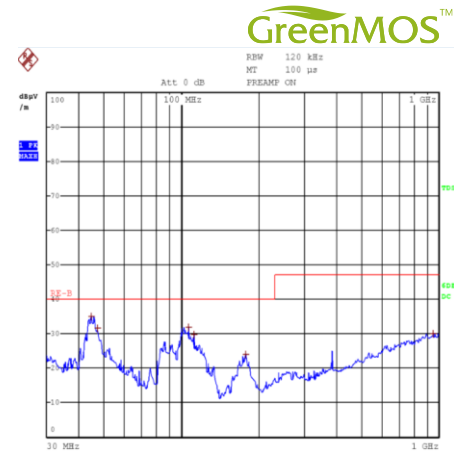
Customer's PMIC for 18W adapter



4A VDMOS
DIP , EMI pass



Competitor' s 2A SJMOS
SOP , EMI over spec



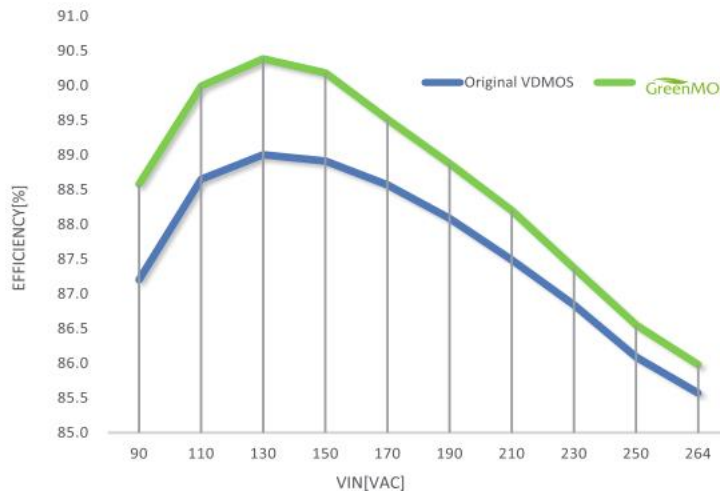
2A GreenMOS
SOP, EMI pass

Novel technology: EMI suppression by soft trench-SJMOS technology (patented)

GreenMOS improved switching smoothness, enabled system EMI performance as good as VDMOS. With its small die advantage, customer reduced package cost by 50%.

Key Feature 2 : Extremely low FOM

parameters	unit	conditions	GreenMOS	IFX Co*Imos C6	Competitor B
			OSG65R900F	XXX65R900	XXX65R900
V(BR)DSS	V	VGS =0V, ID =250μA	682	680	662
VGS(th)	V	ID =250μA, VGS =VDS	3	3.3	3.3
RDS(on)	Ω	VGS =10V, ID =2A	0.72	0.87	0.71
Ciss	pF	VGS =0V, VDS =50V, f=1MHz	243	280	460
Coss			26	41	45
Crss			1.5	1.7	3.5
Qg	nC	VDD =480V, ID =5A, VGS =10V	8	15	13.2
Qgs			1.6	2.5	3
Qgd			3.9	9	6.2
trr	ns	VR =300V, IF=5A, diF /dt=100A/μs	139	144	165
Qrr	μC		0.81	0.92	1.1
Irrm	A		10.4	10.1	12.2

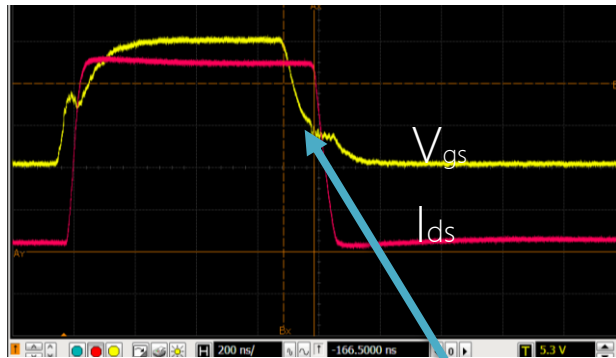


- Extremely low Qg enables smaller gate driver to reduce gate driver IC cost.
- Extremely fast switching, reduce switching loss and improve efficiency.

Key Feature 2 : Extremely low FOM

GreenMOS™

OSG60R580A :
Vds=300V, Rg=100ohm

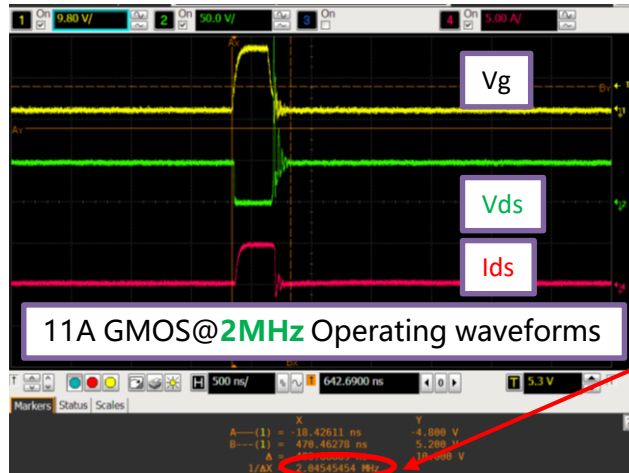


C6:
Vds=300V, Rg=25ohm



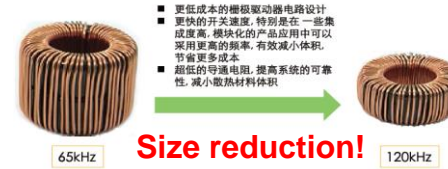
GreenMOS has shorter miller plateau than IFX Co*Imos C6, reduce switching loss and improve EMI.

Extremely low FOM : 2MHz switching!

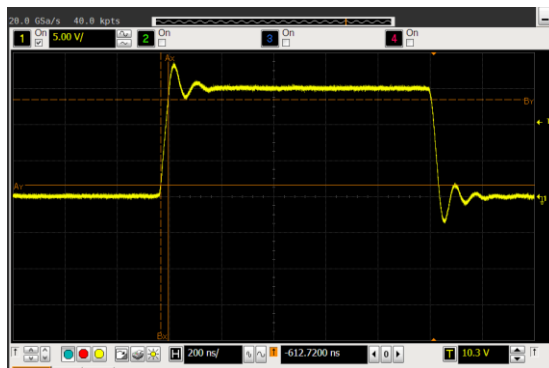


GreenMOS has extremely low FOM ($R_{dson} * Q_g$), close to GaN HEMT.

AC-DC operation frequency up to 2MHz: enables high density power module.



- 更低成本的栅极驱动器电路设计
- 更快的开关速度, 特别是在一些集成度高, 模块化的产品应用中可以采用更高的频率, 有效减小体积, 节省更多成本
- 超低的导通电阻, 提高系统的可靠性, 减小散热材料体积



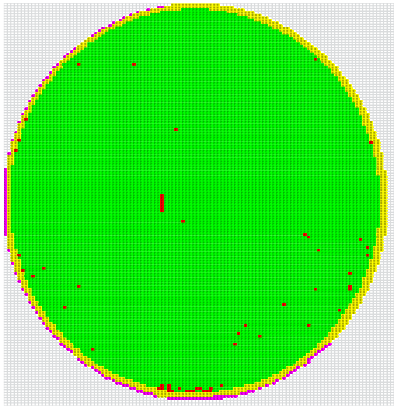
8A GMOS Vgs waveform



12A GaN Vgs waveform

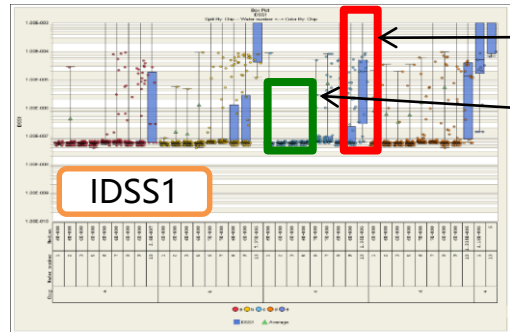
Key Feature 3: Reliability and Uniformity

Typical GreenMOS wafer map



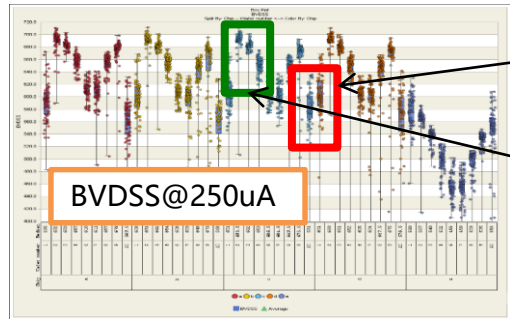
High Yield -> High Reliability

Mass production proven reliability and stability



competitor
GMOS

Lower Idss



competitor

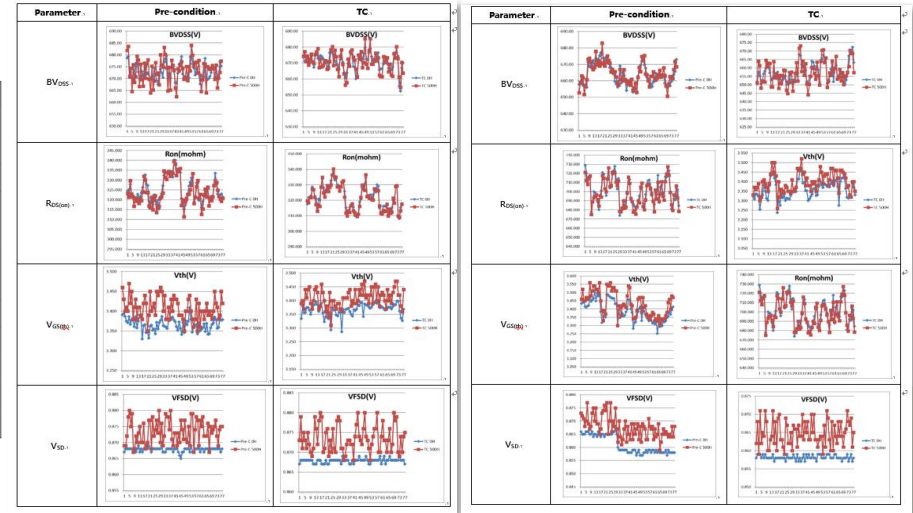
GMOS

Higher Bvdss

Patented process flow design enables higher yield and margin

Key Feature 3: Reliability and Uniformity

#	Reliability	Condition	Time	Sample Size	Standard	Fail/Tested
1	Pre-condition	192hr 30 °C /60% RH + 3 cycle reflow @260 °C	-	77	JESD22-A113	0/77
2	TC	-65 °C to 150 °C,	500 cycle	77	JESD22-A104	0/77
3	PCT	121 °C, 29.7 psi, 100% RH	96h	77	JESD22-A102-C	0/77
4	UHAST	130 °C, 33.3 psi, 85% RH	96h	77	JESD22-A110	0/77
5	THT	85 °C, 85% RH	500h	77	JESD22-A101	0/77
6	Solder ability	5±0.5 sec	-	5	JESD22-B102D	0/5
7	HTST	150 °C	500h	77	JESD22-B102D	0/77
8	HTRB	150 °C, V _{DS} =480V	500h	77	JESD22-A108C	0/77
9	HTGB	150 °C, V _{GS} =30V	500h	77	JESD22-A108C	0/77



High Temperature Gate Bias						
	Parameter	Fail Pcs	Hours	Test Conditions	Test equipment	Current Status
HTRB	High Temperature Reverse Bias	0/77	500H	TJ=150°C, Bias=480V	HR-1680	Pass

Electrical Characteristics @TJ=25°C (unless otherwise specified)				
	Parameter	Units	Test Conditions	Test equipment
BV _{DSS}	Drain-to-Source breakdown voltage	V	ID= 250uA	DC-1
R _{DS(on)}	Static Drain-to-Source on-resistance	Ω	ID= 4.0A VGS= 10V	
V _{GS(th)}	Gate threshold voltage	V	V _{DS} =V _{GS} , I _D =250uA	
I _{DSS}	Drain-to-Source leakage current	A	V _{DS} =650V, V _{GS} =0V	
I _{GSS}	Gate-to-Source forward leakage	A	V _{GS} =30V	
	Gate-to-Source reverse leakage		V _{GS} =-30V	
V _{SD}	Diode Forward Voltage	V	IS=8A, VGS=0V	

Summary	Shift Table	0hrs	168hrs	500hrs	1000hrs	168hrs Shift	500hrs Shift	1000hrs Shift	...	+	:	◀
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0/77 fail @ 500 hour
HTRB, HTGB

0/77 fail @ 1000 hour
HTRB, HTGB

GreenMOS Flagship: 80A GreenMOS with FRD

	GreenMOS 65R038HZ	IFX 65R041CFD	TOSHI** 65R041W5	Fairch**d 65R041F
Trr (ns)	190	193	230	250
BV (V)	741	740	690	720
Rdson (mohm)	32	34	36	38
Qg (nC)	172	260	172	252
FOM (ohm*nQ)	5.5	8.84	6.19	9.58

- Rdson at the same level
- GreenMOS has the lowest Qg and Qgd , reduces dynamic loss by 40%
- GreenMOS has the best FOM
- Overall : GreenMOS/IFX > TOSHI** > Fairch**d

GreenMOS Product Portfolio

500V/550V/600V/650V/800V

super-junction MOSFET

(GreenMOS mass production) ;

1A (3.5ohm)

2A (2.0ohm)

3A (1.5ohm)

4A (1.0 ohm)

5A (0.8 ohm)

8A (0.5 ohm)

11A (0.33 ohm)

15A (0.23 ohm)

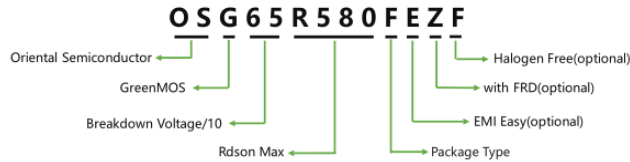
20A (0.15 ohm)

40A (90 mohm)

60A (60 mohm)

78A (36 mohm)

80A (30 mohm)



For detail specifications:

<http://www.orientalsemi.com/english/?p=50>

EV charger, Server Power, Communication Power Supplies

GreenMOS	Infineon	Fairchild	ST	Toshiba	MagnaChip	Planar MOS
OSG5SR580x	-	-	-	-	-	-
OSG5R500F	-	-	STF16N50U	-	-	-
OSG5SR380F	-	-	STD12N50M2	-	MMDSOR380PRH	-
OSG5SR900F	-	-	STD14N50M2	-	MMDSOR280PRH	-
OSG5SR190F	-	-	STD18N55M5	-	-	-
OSG5SR140x	-	-	STD18N55M5	-	-	-
OSG5SR160FZ	-	-	STD18N55M5	-	-	-
OSG6R2K8x	IPx60R3K3C6	-	-	-	-	3N60
OSG6R2K2x	-	-	-	-	-	4N60
OSG6R1K8x	IPx60R2K	-	STx3N6M6N	-	-	4N60/5N60
OSG6R1K2x	IPx60R1K4	FCP4N60	STx6N60M2	-	-	6N60/7N60
OSG6R900x	IPx60R950C6	-	STx7N60M2 STx9N60M2	TK5x60W	MMx60R900PRH	8N60/9N60/10N60
OSG6R670x	IPx60R750E6	-	STx10N60M2	TK6x60W	MMx60R750PTH	8N60/9N60/10N60
OSG6R380x	IPx60R600	FCx7N60NT	STx10N60M2	TK7x60W	MMx60R380PTH	12N60
OSG6R380x	IPx60R380	FCx9N60NT FCx380N60	STx13N60M2 STx13N60M2	TK10x60W	MMx60R360PTH	15-20N60
OSG6R240x	IPx60R280	FCx13N60NT	STx18N60M2	TK12x60W	MMx60R290PTH	-
OSG6R180x	IPx60R180	FCx22N60NT FCx170N60 FCx190N60	STx24N60M2	TK16x60W TK20x60W	MMx60R190PTH	-
OSG6R150x	IPx60R160	FCx130N60	STx28N60M2	TK20x60W	MMx60R115PTH	-
OSG6R092x	IPx60R099CP	FCx36N60NT	STx40N60M2	TK31x60W5	-	-
OSG6R092x	-	FCx43N60NF FCP104N60F	STx45N60DM2AG STW43N60M2ND	TK31x60W5	-	-
OSG6R070x	IPW60R070C6	FCH47N60N	STW48N60M2	TK39N60X	MMQ60R07PTH	-
OSG6R070x	-	FCH072N60F	STW48N60M2	TK39N60W5	-	-
OSG6R069H	IPx60R070C6	FCH47N60N	STx48N60M2	TK39x60W	MMx60R070PTH	-
OSG6R069H	SPW47N60CFD	FCx47N60NF FCH47N60F	STW48N60DM2	TK39x60W5	-	-
OSG6R040H	IPx60R041P6	FCx76N60N FCH043N60	STW70N60M2	TK62x60W	-	-
OSG6R041HZ	-	FCH76N60NF FCH041N60F	STW70N60DM2 STW55N60M2ND	TK62x60W5	-	-
OSG6R2K4x	-	-	-	-	-	4N65
OSG6SR2Kx	-	-	-	-	-	4N65/5N65
OSG6SR1K4x	IPx6SR1K4C6	-	STB6N65M2	TK6x65W	-	6N65/7N65
OSG6SR7A5F	IPx6SR1K0C6	-	STF7N65M2	TK6Q65W	-	7N65
OSG6SR900x	IPx6SR950C6	-	STx9N65M2	TK6x65W	-	8N65/9N65/10N65
OSG6SR900x	-	-	-	-	-	-
OSG6SR740x	-	-	STx9N65M2	TK7x65W	-	8N65/9N65/10N65
OSG6SR580x	IPx6SR600C6	-	STx8N65M5	TK9x65W	-	12N65
OSG6SR580x	-	-	-	-	-	-
OSG6SR380x	IPx6SR380x	-	STx16N65M2	TK11x65W	-	15-20N65
OSG6SR460z	IPD6SR420CFD	-	-	-	-	-
OSG6SR340z	IPB6SR310CFD	FCPF380N65FL1	-	TK14A65W5	-	-
OSG6SR290x	IPx6SR280C6	-	STx16N65M5	TK14x65W	-	-
OSG6SR290x	-	-	-	-	-	-
OSG6SR220z	IPB6SR190CFD	-	-	TK17A65W5	-	-
OSG6SR200x	IPx6SR190C6	-	STx20N60M5	TK17x65W	MMx6SR190PTH	-
OSG6SR099x	IPx6SR099C6	-	STx40N65M2	TK28x65W	-	-
OSG6SR099z	-	FCH110N65F	STW50N65DM2AG	TK35x60W5	-	-
OSG6SR069H	IPx6SR074C6 IPx6SR070C6	FCB070N65S3	STx42N60W5	TK35x65W	-	-
OSG6SR069H	IPW6SR080CFD	-	STW56N65DM2	-	-	-
OSG6SR042H	IPx6SR037C6	-	STx69N65M5	TK49x65W	-	-
OSG6SR041HZ	IPW6SR041CFD	FCH041N65F	STW65N65DM2AG	TK49x65W5	-	-
OSG6SR035HZ	-	FCx76N60NF	-	-	-	-
OSG6SR038HZ	IPW6SR041CFD	FCH041N60F	-	-	-	-
OSG70R2K6x	-	-	-	-	-	-
OSG70R1K4x	\$\$S0N70 IPx70R1K4CE	-	-	-	MMx70R1K4PRH	4N70
OSG70R1Kx	\$\$S0N70 IPx70R950CE	-	STP9NK70Z	-	MMx70R900PTH	5N70
OSG70R750x	-	-	STP10NK70ZFP	-	MMx70R750PRH	-
OSG70R500x	IPx70R600CE	-	-	-	-	-
OSG70R350x	-	-	-	-	MMx70R380PTH	-
OSG80R4Kx	IPD80R4K5P7	-	STF3N80K5	-	-	3N80
OSG80R1K4x	IPAB0R1K4CE	-	STI6N80K5	-	MMF80R1K2PTH	3N80
OSG80R1Kx	IPAB0R1K0CE	-	STUBN80K5	TK7AB0W	MMF80R900PTH	-
OSG80R650x	IPx80R650CE	-	STx10N80K5	TK10AB0W	MMx80R650PTH	8N80
OSG80R460x	SPT11N80C3	-	STW13N80K5	TK12AB0W	MMF80R450PTH	-
OSG80R090x	SPT17N80C3	FCB29PN80	STx23N80K5	TK17AB0W	MMF80R290PRH	-
OSG80R049x	SPT65N80C3	FCH060N80	STW65N80K5	-	-	-
OSG90R1K2x	IP90R1K2C3	-	-	-	-	-

Contents

■ Overview

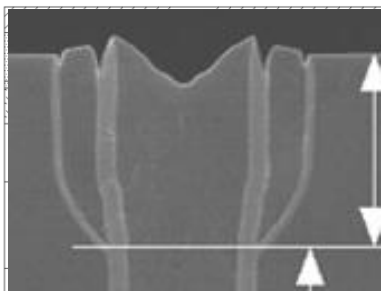
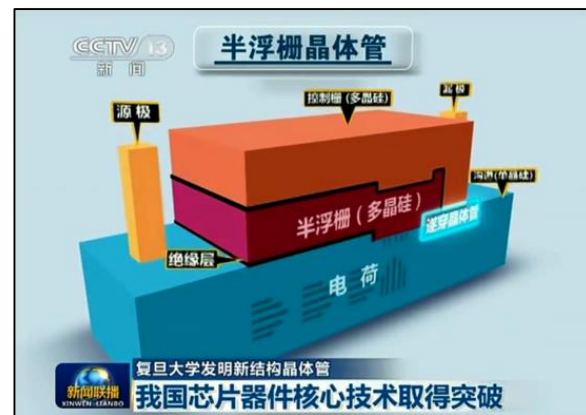
■ GreenMOS

■ **SFGMOS**

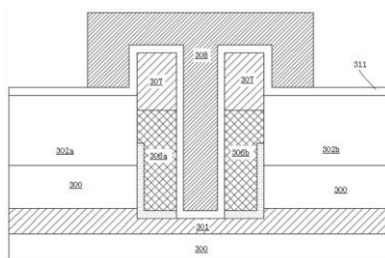
Mid-Voltage(60-200V) Low Qg MOSFET
for Rectification and Motor Driver Applications

■ User Cases

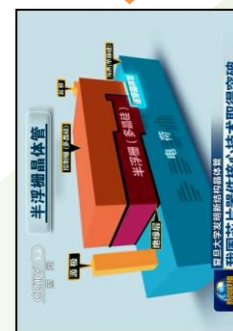
Original Invention of SFGMOS



SFGMOS



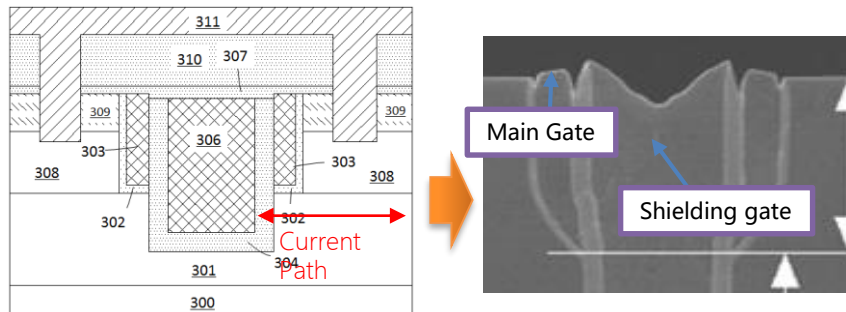
Patented Structure



Vertical SFG

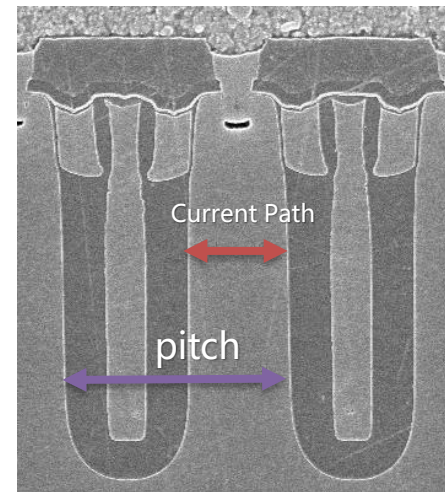
SFGMOS Advantages

SFG-MOS



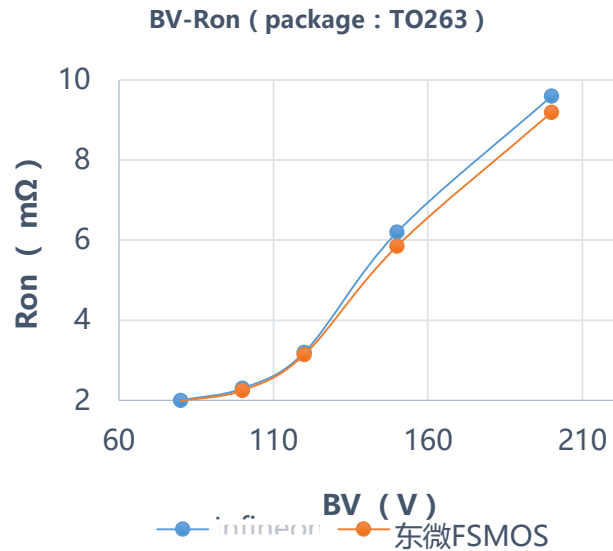
Lean process to enable high reliability and manufacturability for Rectification and Motor driver applications.

IFX Opt*mos

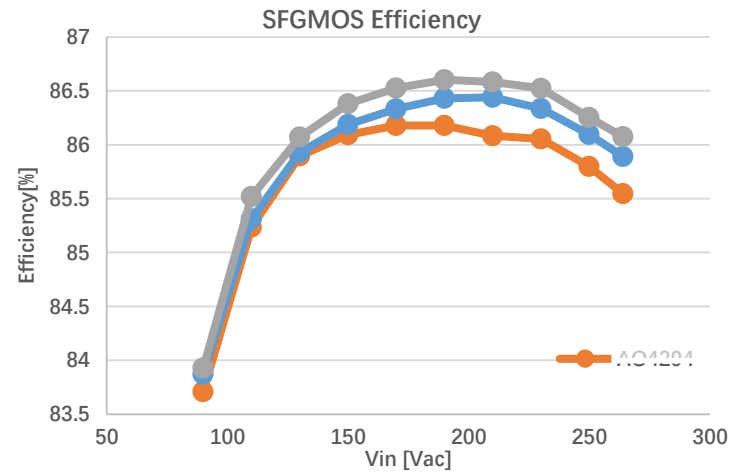


- Higher AA utilization
- Better process control
- Larger current path (1.47X of original SGT technology)
- Less oxidation in AA → better thermal conduction → better reliability
- Larger current path for better EAS performance → stronger device

Performance Comparison

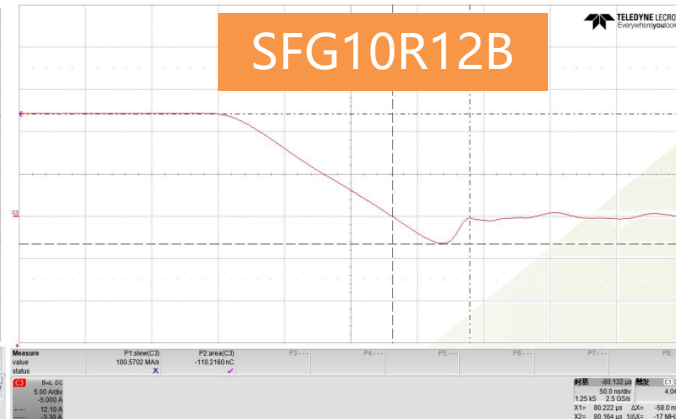
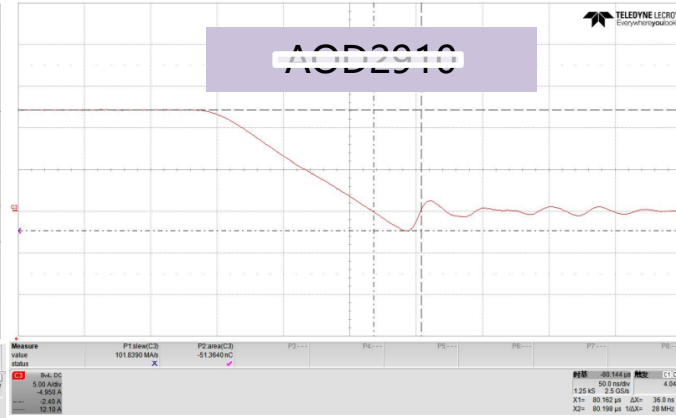


Ronsp is smaller than Opt*mos



Higher efficiency than A*S

Reverse Recovery



SFGMOS has fastest reverse recovery time and less oscillation.

SFGMOS Product Portfolio

ALL Products are halogen free

Platform	ProductName	Package	Vdss(V)	Id(A)	Rdson max(mΩ)	
					Vgs=10V	Vgs=4.5V
SFGMOS 60V Family	SFG06R12B	SOP8	60	12	12	14
	SFG06R12A	IPAK	60	50	12	14
	SFG06R12D	DPAK	60	50	12	14
	SFG06R12G	DFN5*6	60	50	12	14
	SFG06R09B	SOP8	60	14	9	13
	SFG06R09A	IPAK	60	60	9	13
	SFG06R09D	DPAK	60	60	9	13
	SFG06R09G	DFN5*6	60	60	9	13
	SFG06R05P	TO220	60	120	5	7
	SFG06R05A	IPAK	60	120	5	7
	SFG06R05D	DPAK	60	120	5	7
	SFG60R03P	TO-220	60	130	3	4
	SFG60R03K	TO-263	60	130	3	4
	SFG200N06K	TO-263	60	200	1.3	
	SFG180N06P	TO-220	60	180	1.6	
	SFG180N06K	TO-263	60	180	1.6	
	SFG150N06P	TO-220	60	150	1.9	
	SFG120N06K	TO-263	60	120	2.2	
SFG110B06K	TO-263	60	110	2.5		
SFGMOS 80V Family	SFG08R15D	DPAK	80	60	13	15
	SFG150N08K	TO-263	80	150	2.3	
	SFG150N08P	TO-220	80	150	2.3	
	SFG130N08K	TO-263	80	130	4.2	
	SFG130N08P	TO-220	80	130	4.2	
	SFG100N08P	TO-220	80	100	5.8	
SFG100N08K	TO-263	80	100	5.8		

60V/100V/150V Low Qg FG MOS

100V 10 mohm (Synchronized Rectification , Vt=1.8V)

100V 12 mohm (Synchronized Rectification , Vt=1.8V)

100V 20 mohm (Synchronized Rectification , Vt=1.8V)

100V 4 mohm

60V 5 mohm

60V 10 mohm

60V 2 mohm

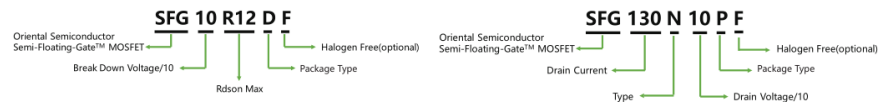
150V Class (Synchronized Rectification, Motor)

200V Class (Motor)

Platform	ProductName	Package	Vdss(V)	Id(A)	Rdson max(mΩ)	
					Vgs=10V	Vgs=4.5V
SFGMOS 100V Family	SFG10R05G	DFN5*6	100	100	5	6.5
	SFG10R08B	SOP8	100	14	8	10
	SFG10R08D	DPAK	100	70	8	10
	SFG10R08G	DFN5*6	100	70	8	10
	SFG10R10B	SOP8	100	12	10	12
	SFG10R10D	DPAK	100	60	10	12
	SFG10R10G	DFN5*6	100	60	10	12
	SFG10R12B	SOP8	100	10	12	14
	SFG10R12D	DPAK	100	50	12	14
	SFG10R12G	DFN5*6	100	50	12	14
	SFG10R20B	SOP8	100	8	20	22
	SFG10R20D	DPAK	100	40	20	22
	SFG10R20G	DFN5*6	100	40	20	22
	SFG10R26B	SOP8	100	6	26	30
	SFG10R26D	DPAK	100	30	26	30
	SFG10R26G	DFN5*6	100	30	26	30
	SFG200N10P	TO220	100	200	2.5	
	SFG180N10P	TO220	100	180	3	
	SFG180N10K	TO263	100	180	3	
	SFGMOS 150V Family	SFG15R19G	DFN5x6	150	50	19
SFG15R75A		IPAK	150	20	75	88
SFG15R75D		DPAK	150	20	75	88
SFG15R75B		SO-8	150	20	75	88
SFG110N15K		TO263	150	110	5	
SFG100N15K		TO-263	150	100	7	
SFG100N15P		TO-220	150	100	7	
SFG80N15P		TO-220	150	80	10.5	
SFG80N15K		TO-263	150	80	10.5	
SFG80N20K		TO263	200	80	9	
SFGMOS 200V Family	SFG20R09K	TO263	200	80	9	
	SFG20R10D	DPAK	200	17	100	

SFGMOS™命名规则 (同步整流)

SFGMOS™命名规则 (电机驱动)



Contents

■ Overview

■ GreenMOS

■ SFGMOS

■ User Cases

User Case - 1

应用实例 B - 10W 快充电源

系统名称: QC2.0 快速充电器
 峰值功率: 10W
 拓扑结构: Flyback
 工作模式: 断续工作模式(DCM)

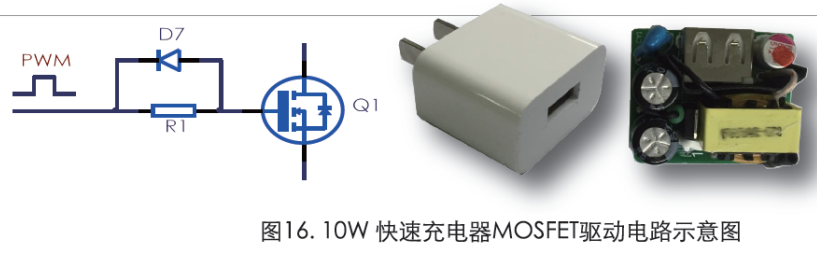


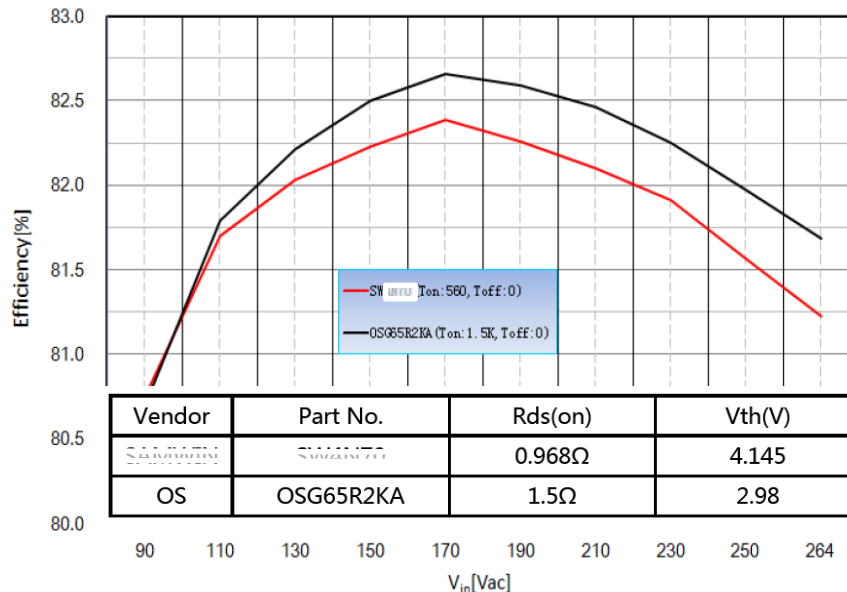
图16. 10W 快速充电器MOSFET驱动电路示意图

Ambient temperature: 25°C

3A GreenMOS to replace competitor's 4A SJMOS

GreenMOS achieves higher efficiency with even higher Rds(on)

GreenMOS extremely low switching loss compensates Ron loss

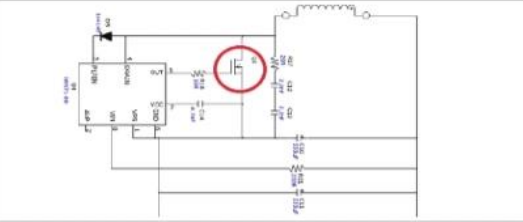


3A GreenMOS replaces 4A SJMOS with even higher efficiency due to GreenMOS extremely Low FOM that reduces dynamic loss.

User Case - 2

15W 快充

峰值功率: 15W
 拓扑结构: Flyback
 工作模式: DCM



效率温升测试



By replacing A*4294 with SFGMOS-SFG10R12B and SFG10R10G, user achieves higher efficiency by 0.37% and 0.2% respectively.

Vendor	Part No.	BVdss(V)	Vth(V)	Ron(mΩ)	Efficiency[%]
ACS	A*4294	106	2.1	10.51	85.68
SFGMOS	SFG10R12B	113	2.14	9.33	85.88
SFGMOS	SFG10R10G	106.2	1.8	7.98	86.05

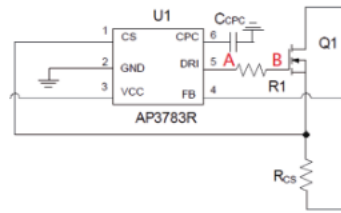
User Case - 3

10W 充电器

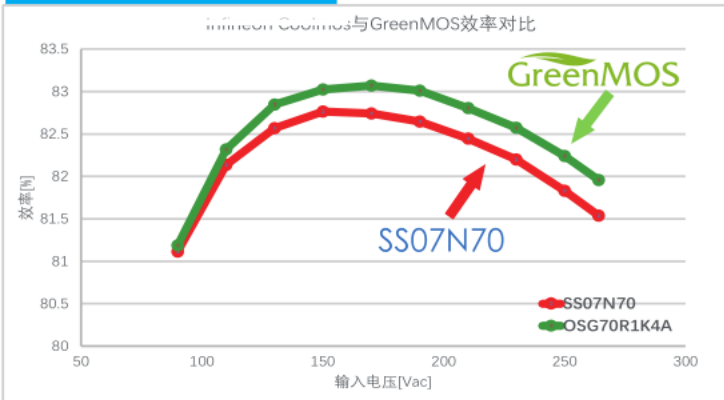
峰值功率: 10W

拓扑结构: Flyback

工作模式: DCM



效率温升测试



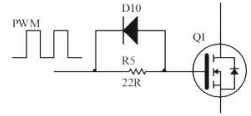
By replacing IFX SS07N70 with GreenMOS OSG70R1K4A, the R_{on} increases from 0.792Ω to 1.232Ω . GreenMOS still achieves 0.31% efficiency improvement and 3.4°C temperature drop.

Vendor	Part No.	Rds(on)	Vth(V)	Avg.Efficiency[%]	Avg.Temp[°C]
Infineon	SS07N70	0.792Ω	3.065	82.19%	70.55
GreenMOS	OSG70R1K4A	1.232Ω	3.365	82.50%	67.15

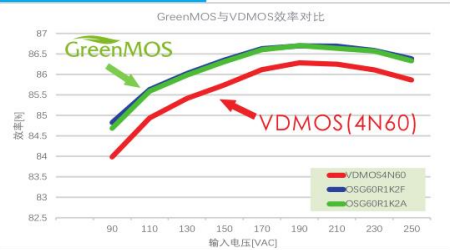
User Case - 4

24W 适配器

峰值功率: 24W
 拓扑结构: Flyback
 工作模式: CCM\DCM




效率温升测试




在此应用中, 客户采用较高规格的两不同封装形式的GreenMOS™替代原4N60的VDMOS, 并去掉了散热片。实测结果在替换后系统效率提升了0.57%, 而温升比带散热片时降低了最多4.7°C。经过替换, 客户不仅降低了物料的整体成本, 还简化了组装的流程, 提高良品率。同时产品性能和可靠性得到了显著提升。

By replacing VDMOS 4N60 with GreenMOS 60R1K2F and 60R1K2A, the efficiency improved by 0.57% and temperature dropped by 4.7 °C even without heatsink. Customer saves BOM cost by removing the heatsink.




VDMOS 4N60
带散热片

平均效率: 85.63%
平均温升: 68.1°C



OSG60R1K2A
无散热片

平均效率: 86.18%
平均温升: 68.2°C



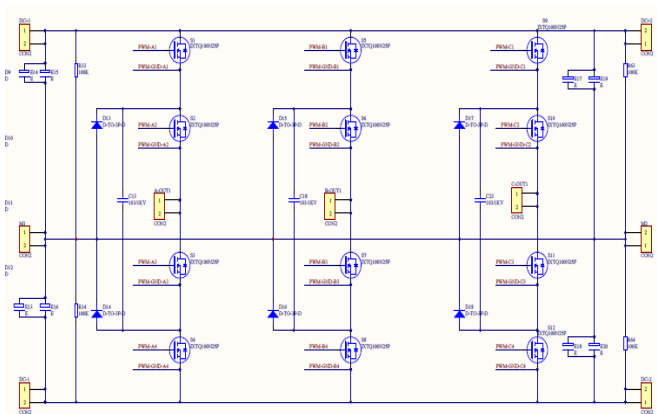
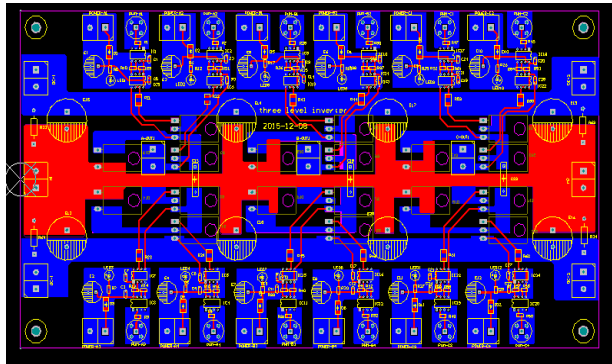
OSG60R1K2F
无散热片

平均效率: 86.20%
平均温升: 63.4°C

Vendor	Part No.	Heatsink	Rds(on)	Vth(V)	Avg.Efficiency(%)	Avg.Temp(°C)
VDMOS	4N60	YES	2.180Ω	3.361	85.63%	68.1°C
GreenMOS	OSG60R1K2A	NO	0.989Ω	3.400	86.18%	68.2°C
GreenMOS	OSG60R1K2F	NO	0.982Ω	3.365	86.20%	63.4°C

User Case - 5

Operating Frequency : 80-300KHz , 20KW EV Charger



Compatible with multiple control topologies of high power applications



ORIENTAL
SEMICONDUCTOR

Thanks for Attention !



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