GaNPower and GaN Power Devices
镓能和氮化镓功率器件

GANPOWER INTERNATIONAL

鎵 能 國 際 半 導 體 有 限 公 司

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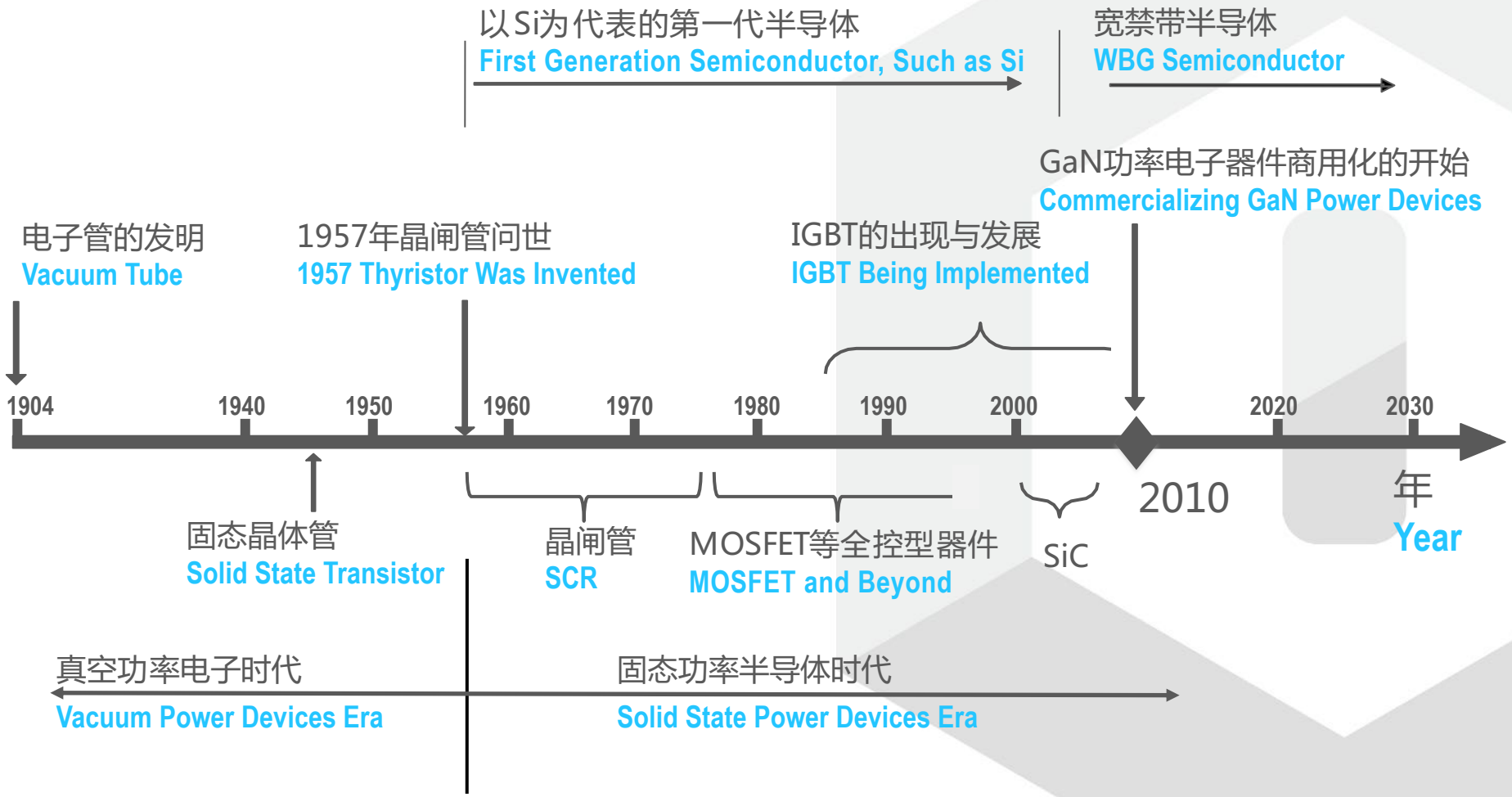
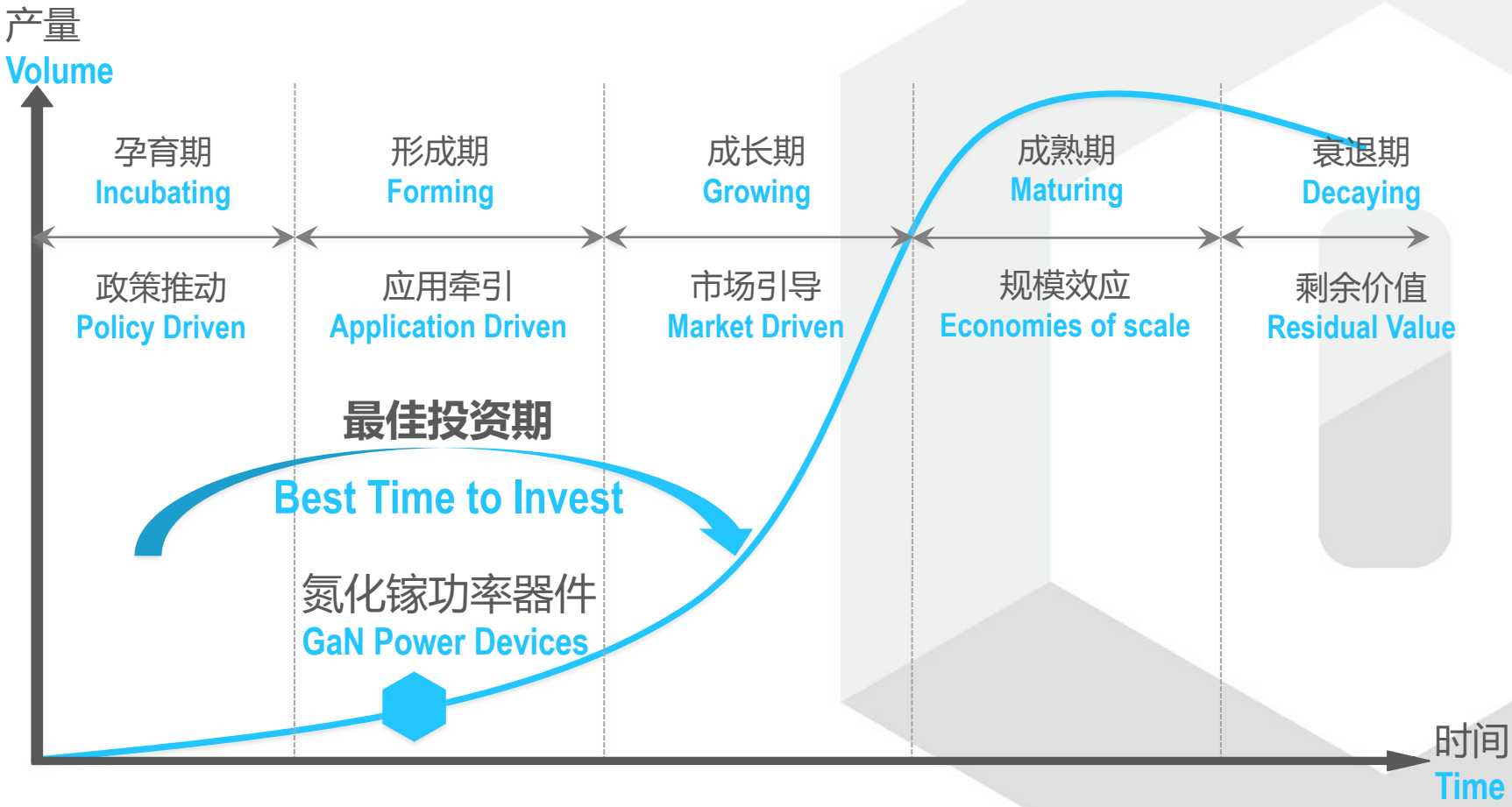
Dr. Fred Fu Co-Founder

氮化镓功率器件，是时候了吗？
GaN Power Devices, Are We There Yet ?



氮化镓功率器件，现在是最佳投资期
Now it's the Best Time to Invest in GaN Power Devices



功率半导体器件全球市场规模
Global Market Size of Power Devices

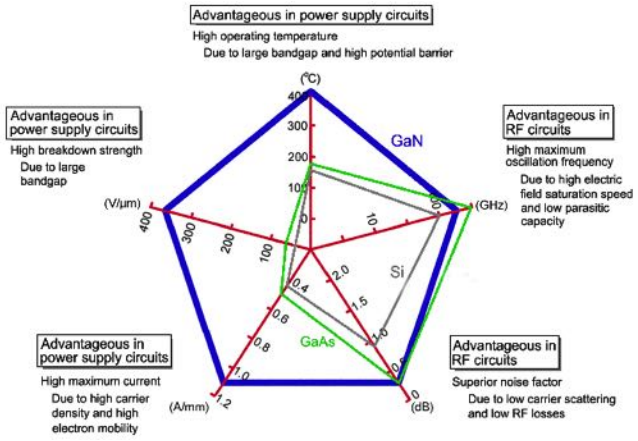
- 一般来说，功率电子器件占整个半导体市场的至少10%
- Power semiconductor device occupies at least 10% of the semiconductor market

- 在2015年, GaN市场是 8.7亿美元
- In 2015, the total market of GaN is 870 million USD
  - EPC占19% = 1.6亿美元
  - EPC takes 19% = 160 million USD
  - 其次是恩智浦半导体(NXP), GaN Systems等
  - Followed by NXP, GaN Systems, etc.

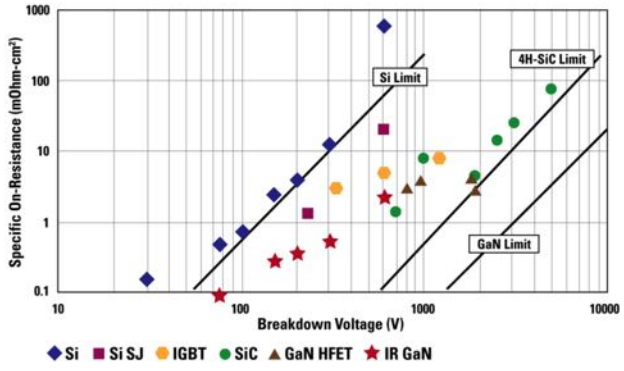
- 全球功率器件市场是每年至少**400**亿美元，氮化镓有很大的发展空间
- Global power semiconductor market worth at least 40 billion USD, GaN has great potential

功率半导体器件材料比较
Power Device Materials Comparison

材料特性 Material Property	硅 Silicon	碳化硅 SiC-4H	氮化镓 GaN
禁带宽度 Band-gap (eV)	1.1	3.2	3.4
击穿电场 Critical Field (1E+6V/cm)	0.3	3	3.5
电子迁移率 Electron Mobility (cm^2/V-Sec.)	1450	900	2000
电子饱和速率 Electron Saturation Velocity (1E+6 cm/Sec.)	10	22	25
热传导系数 Thermal Conductivity (W/cm^2K)	1.5	3.8	1.3
品质因素 Baliga Figure of Merit (FOM)=$\varepsilon_s \mu E_c^3$	1	675	3000



Comparison of R_{on} for Si, SiC, and GaN

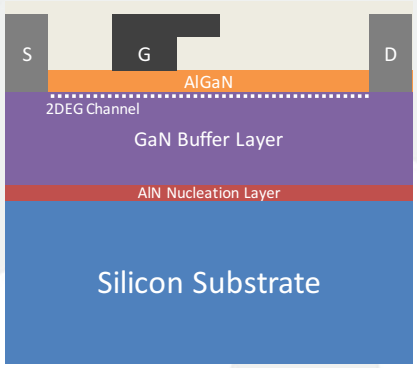


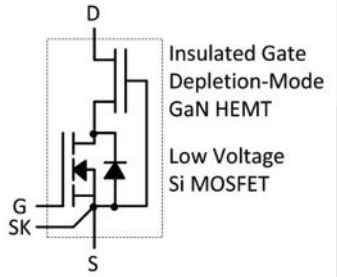
氮化镓器件的优势
Advantages of GaN

物理特性 Physical Character	材料性能 Material Character	器件特性 Device Character	系统特性 System Performance
宽禁带 Wide Bandgap	高临界电场 High Critical Field	高击穿电压 High Breakdown Voltage	应用于需要耐受高压的场合 Suitable for High Voltage Applications
存在二维电子气 2-Dimensional Electron Gas (2DEG)	高电子浓度，高迁移率 High Electron Concentration, High Mobility	低导通损耗 Low Turn-on Loss	提升系统效率 Boost System Efficiency
	低门级电荷 Low Gate Charge	高开关频率，低开关损耗 High Switching Frequency, Low Switching Loss	减小系统体积，提高功率密度 Reduce System Volume and Increase Power Density
本征电子浓度低 Low Intrinsic Carrier Density	高耐热性 High Temperature Capability	高耐热性 High Temperature Capability	减小或去掉庞大的散热系统 Reduce or Eliminate Heat Sink

氮化镓器件基础
Basics of GaN Devices

属性 Attributes	硅衬底 Si substrate	碳化硅衬底 SiC substrate	氮化镓衬底 GaN substrate
缺陷密度 Defect density (cm^{-2})	1E+9	5E+8	1E+3 to 1E+5
晶格失配 Lattice mismatch (%)	17	3.5	0
热导率 Thermal conductivity (W/cm-k at 25 oC)	1.5	3.0~3.8	1.3
热膨胀系数 Coefficients of thermal expansions (%)	54	25	0
漏电流 Off-state leakage	high	high	low
可靠性和良品率 Reliability and yield	low	low	high
横向或纵向器件 Lateral or Vertical device	lateral	lateral	lateral or vertical
集成可能性 Integration possibility	Very high	Moderate	-
衬底尺寸 Substrate size (mm) (as of 2012)	300	150	50
衬底价格 Substrate cost (relative)	Low	high	Very high

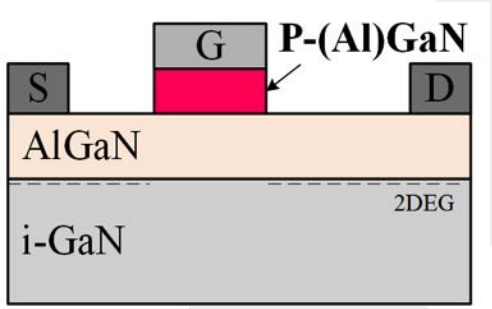


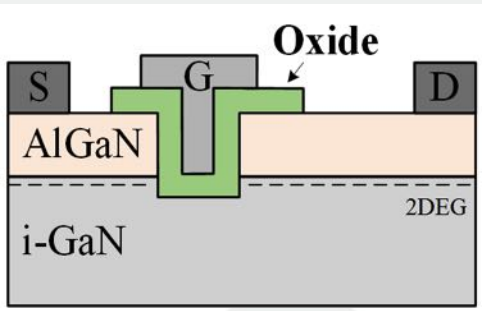


类别 Modes	优点 Merits	缺点 Drawbacks	应用 Applications
常开型 D-Mode	结构及工艺制程简单，成本低 Simple structure and process flow, low cost	负电压关断，无法用于电力电子系统 Negative threshold, no good for power electronics applications	射频/微波, 单片集成 RF/MMIC, Monolithic
常关型 E-Mode	正阈值电压 Positive Threshold Voltage	结构及工艺制程复杂，成本较高，门极电压范围窄，需要特别的驱动 Complicated structure and process, higher cost, narrow gate drive voltage, special driver needed	射频及功率 RF/MMIC, Power Electronics
级联型 Cascode	门级无须特别驱动，工艺制程简单 No special gate drive circuitry, simple process flow for HEMT	通态电阻增大，上下管匹配，有Qrr，成本较高 High Rdson, transistor matching, Qrr and higher cost	功率 Power Electronics

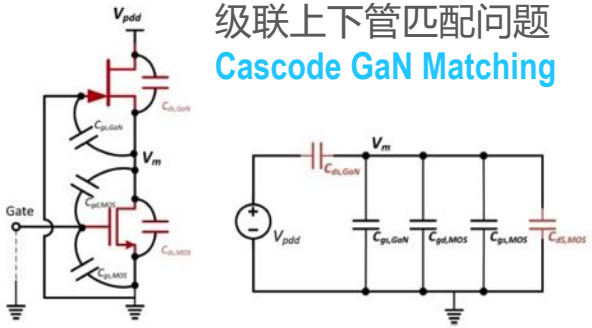
常关型氮化镓功率器件
Normally-off GaN Devices

- P-GaN 增强型器件
- **P-GaN enhancement mode device**
- 凹槽栅增强型器件
- **Recessed gate enhancement mode device**
- 级联型器件
- **Cascode device**
- TI直接控制级联器件
- **TI direct drive cascode device**

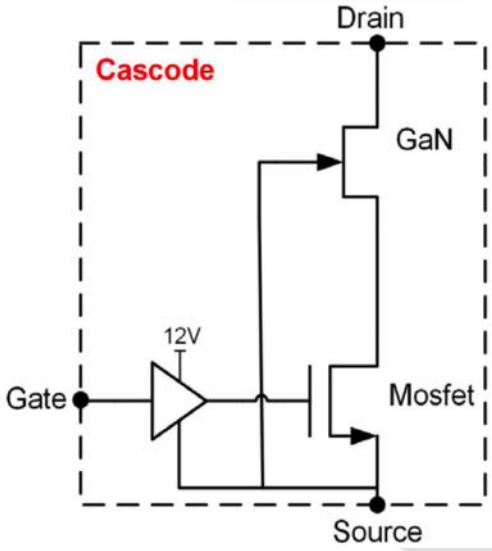


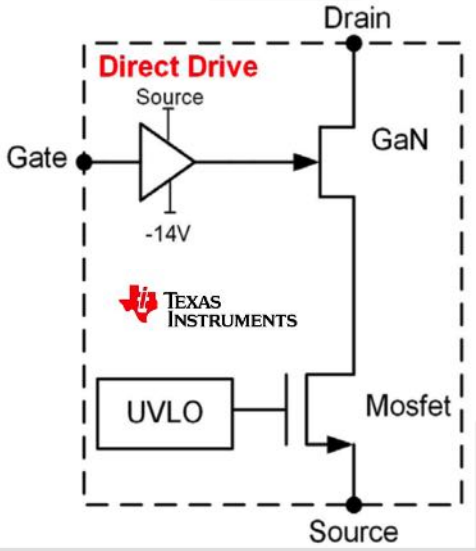


级联上下管匹配问题
Cascode GaN Matching



$$V_m = V_{pdd} \cdot \frac{C_{ds,GaN}}{C_{ds,GaN} + C_{ds,MOS} + C_{gd,MOS} + C_{gs,GaN}} \approx V_{pdd} \cdot \frac{C_{ds,GaN}}{C_{ds,GaN} + C_{ds,MOS}}$$





全球氮化鎵功率器件工業布局
Global GaN Industry Map

*不完整统计
Incomplete Statistics

氮化镓功率半导体器件目前各公司技术
Technology from Various Vendors

	EPC	transphorm	Navitas	ON Semiconductor	GaN Systems	Panasonic
600V 以下 常关型 Below 600V E-Mode	✓				✓	
600V/650V 常关型 600V/650V E-mode					✓	✓
600V/650V 级联型 600V/650V Cascode		✓		✓		
单片集成 Monolithic			✓			

Company	Part No.	BVdss (V)	Rdson (mΩ)	Idmax (A)	Qg (nC)	Package	Rdson*Qg
Panasonic	PGA26E07BA	600V	56	26	5	DFN	280
Panasonic	PGA26E19BA	600V	140	13	2	DFN	280
Transphorm	TPH3208LD	650V	110	20	10	PQFN88	1100
Transphorm	TPH3206LD	600V	150	17	6	PQFN88	900
GaN Systems	GS66504B	650V	100	15	3	GaNpx	300
GaN Systems	GS61004B	100V	15	45	6.2	GaNpx	93
EPC	EPC2032	100V	4	48	12	No pack	48
EPC	EPC2025	300V	120	6.3	1.8	No Pack	216

氮化镓公司商业模式
Business Models

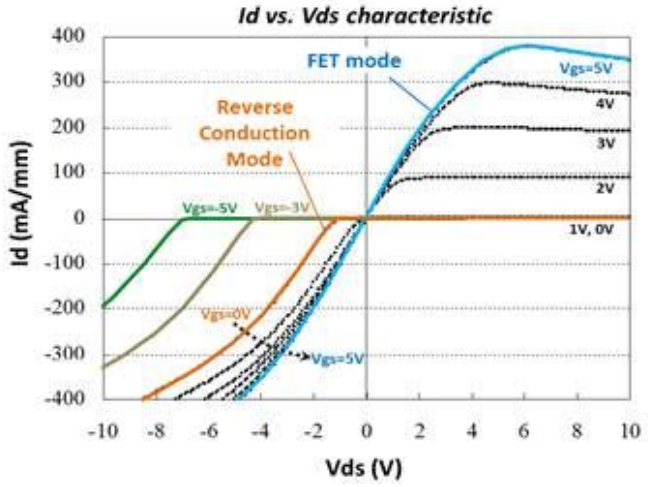
	硅衬底 Si Substrate	器件设计 Device Design	氮化镓外延 GaN Epi	工艺制程 Processing	应用方案 Applications
商业模型1 Model 1	siltronic, SUMCO, SunEdison, Shin-Etsu, SAS, TOPSIL, WAFER WORKS	transphorm, Panasonic, power integrations, ON, TI, IR, Infineon			CET, YASKAWA, DELTA, HUAWEI, FINSiX, zolt
商业模型2 Model 2		EXAGAN Accelerate Power Transition		FAB, GCS	
商业模型3 Model 3		GaN Systems, EPC, GaNPOWER	EPISIL	tsmc	
商业模型4 Model 4		没有外延片知识产权的功率器件公司 Power device players without GaN epiIP	NTT AT, DOWA, EPISEMI, EpiGaN, IQE	没有外延片知识产权的功率器件公司 Power device players without GaN epiIP	

松下半导体氮化镓技术
X-GaN Device from Panasonic

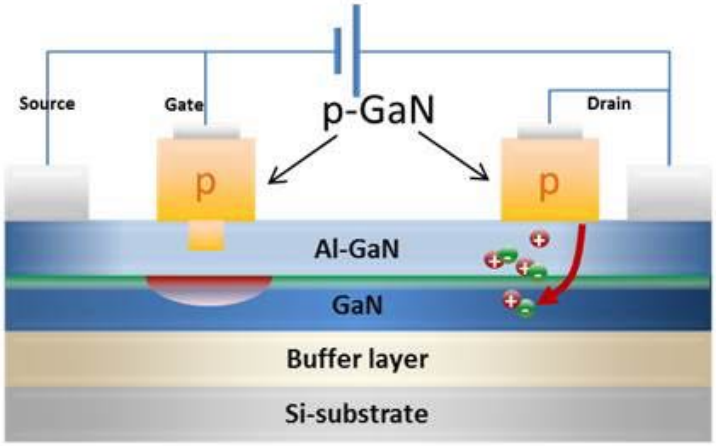
- P-GaN 增强型器件
- **P-GaN enhancement mode device**

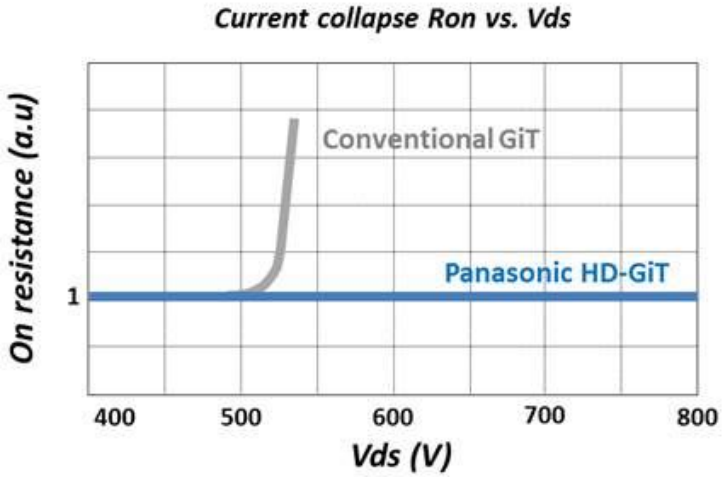
- 创新结构设计解决电流崩塌的问题
- **Novel structure design that reduces the current collapse issue**

- 仅提供600V器件，可能因为100V未必合理
- **Only offers 600V device, since 100V may not be cost effective using this structure**



OFF state: hole injection from the drain under Vds stress



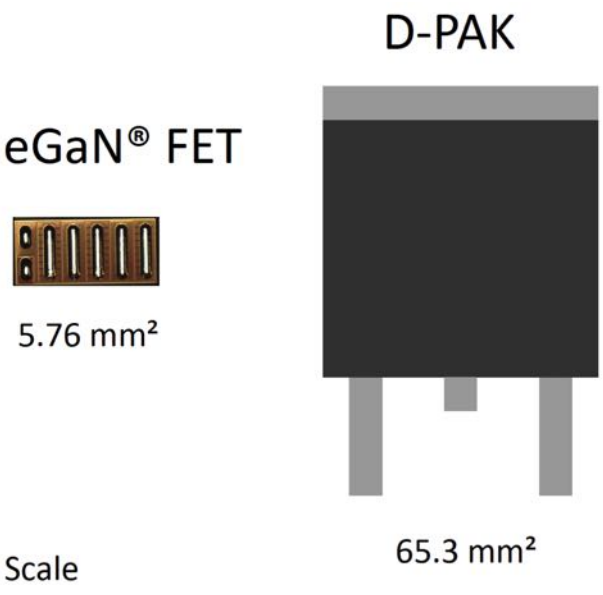


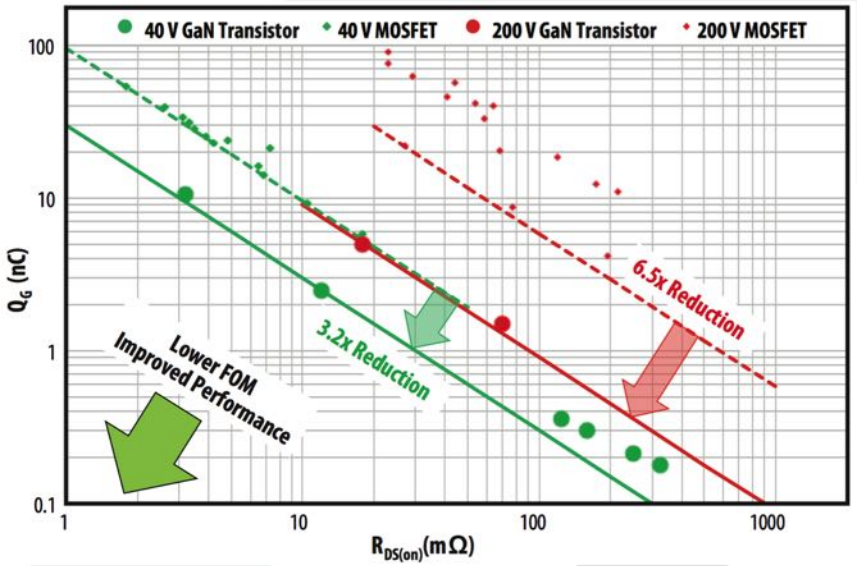
宜普公司氮化镓技术
eGaN Device from EPC

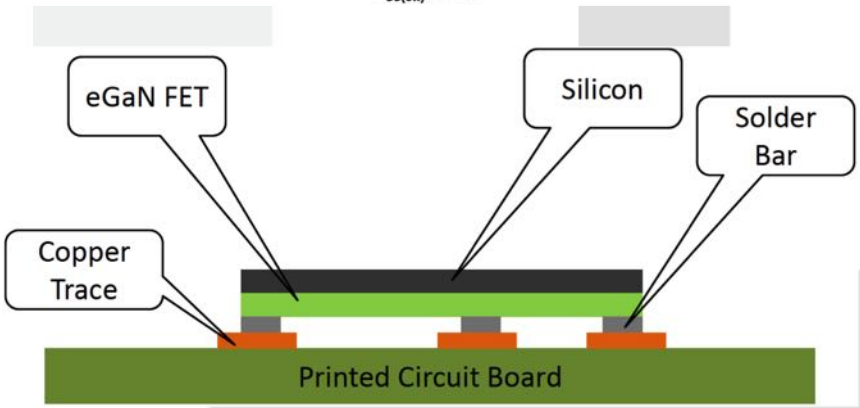
- 增强型p-GaN器件的先行者
- **Pioneer in P-GaN enhancement mode device**

- 创新的无封装设计
- **Novel package-less design**

- 仅提供<450V器件，可能因高压器件封装要求提高
- **Only offers 600V device, since high voltage devices pose a higher requirement for packaging**







Transphorm公司氮化镓技术
GaN Devices from Transphorm

- 级联增强型器件解决方案
- **Cascode E-Mode solution**

- 第一个通过AEC-Q101汽车电子认证的氮化镓器件
- **World's first AEC-Q101 automotive-qualified GaN**

- 仅提供600/650V器件，可能因低压级联不经济
- **Only offers 600V device, since low voltage cascode is not economical**

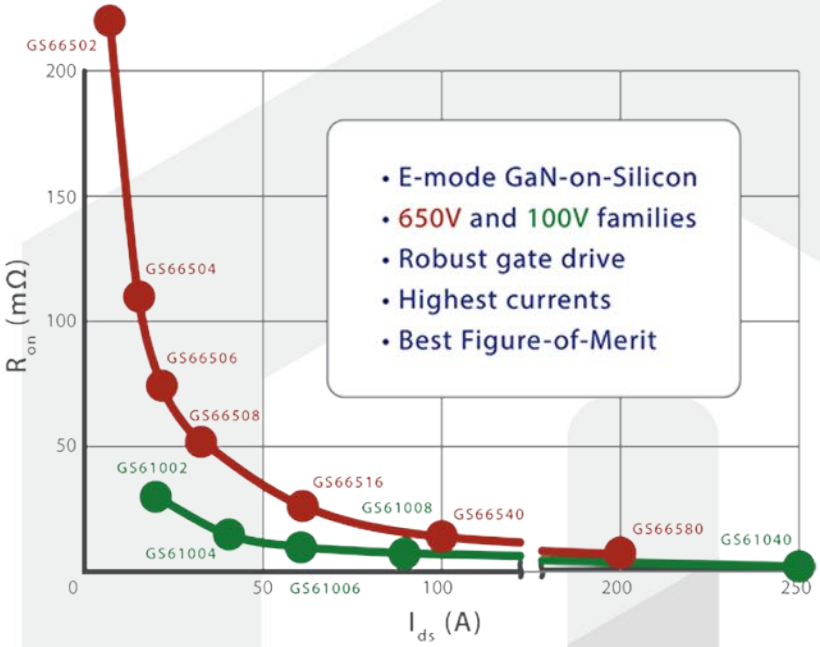
transphorm
Highest Performance, Highest Reliability GaN

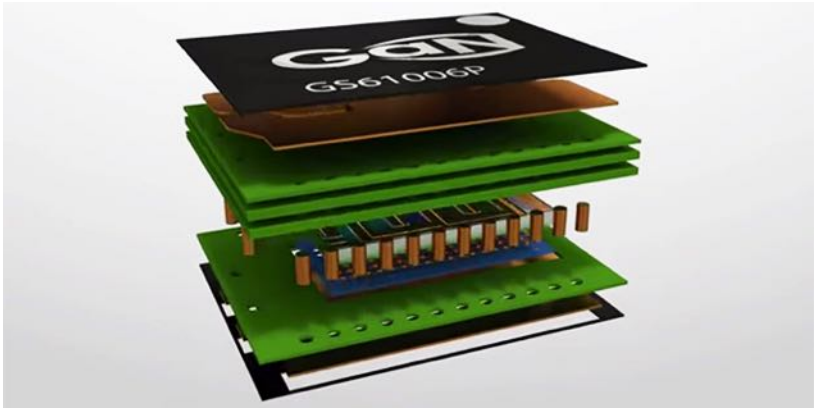
GaN Systems 公司氮化镓技术
GaN Devices from GaN Systems

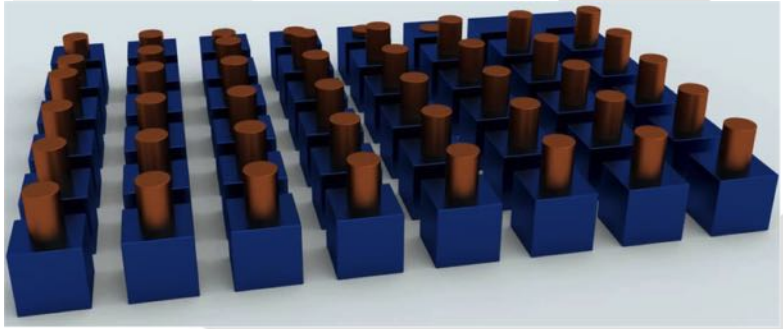
- 增强型器件
- **E-Mode solution**

- Island Technology及独特的封装技术
- **Island Technology and unique packaging technology**

- 提供100V及600V功率开关管
- **Offers both 100V and 600V power transistors**





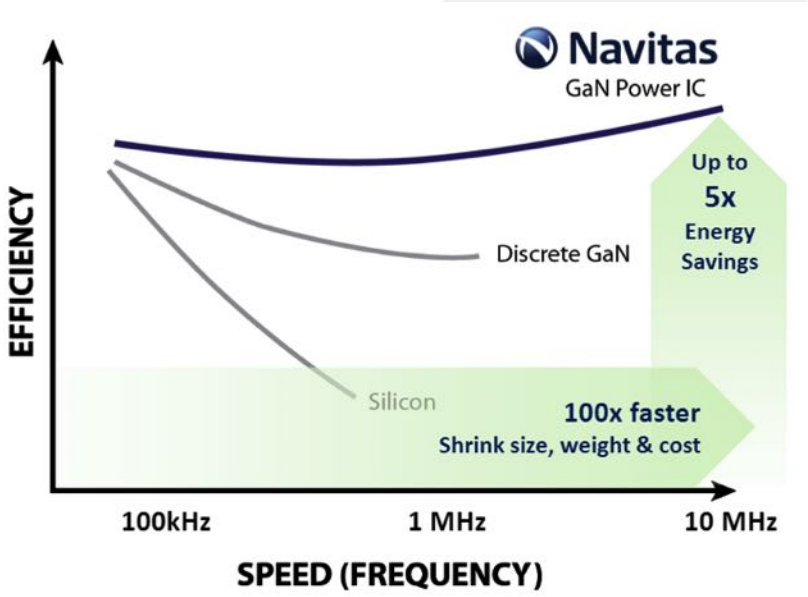


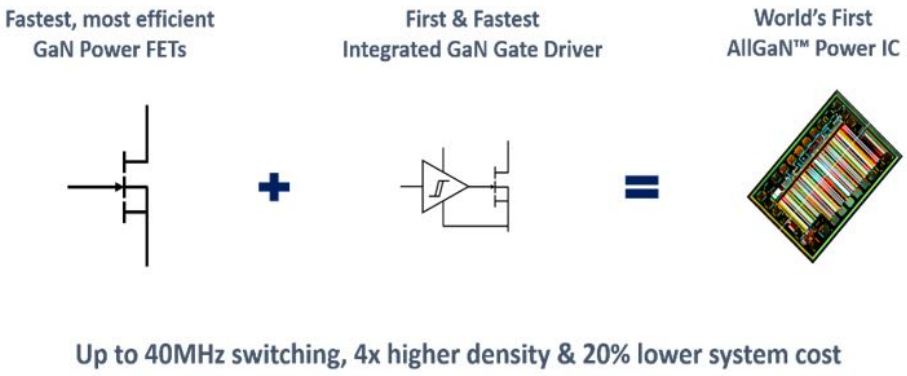
Navitas 公司氮化镓技术
GaN Devices from Navitas

- 第一个单片集成的氮化镓器件+驱动
- **First monolithically integrated GaN+Driver IC**

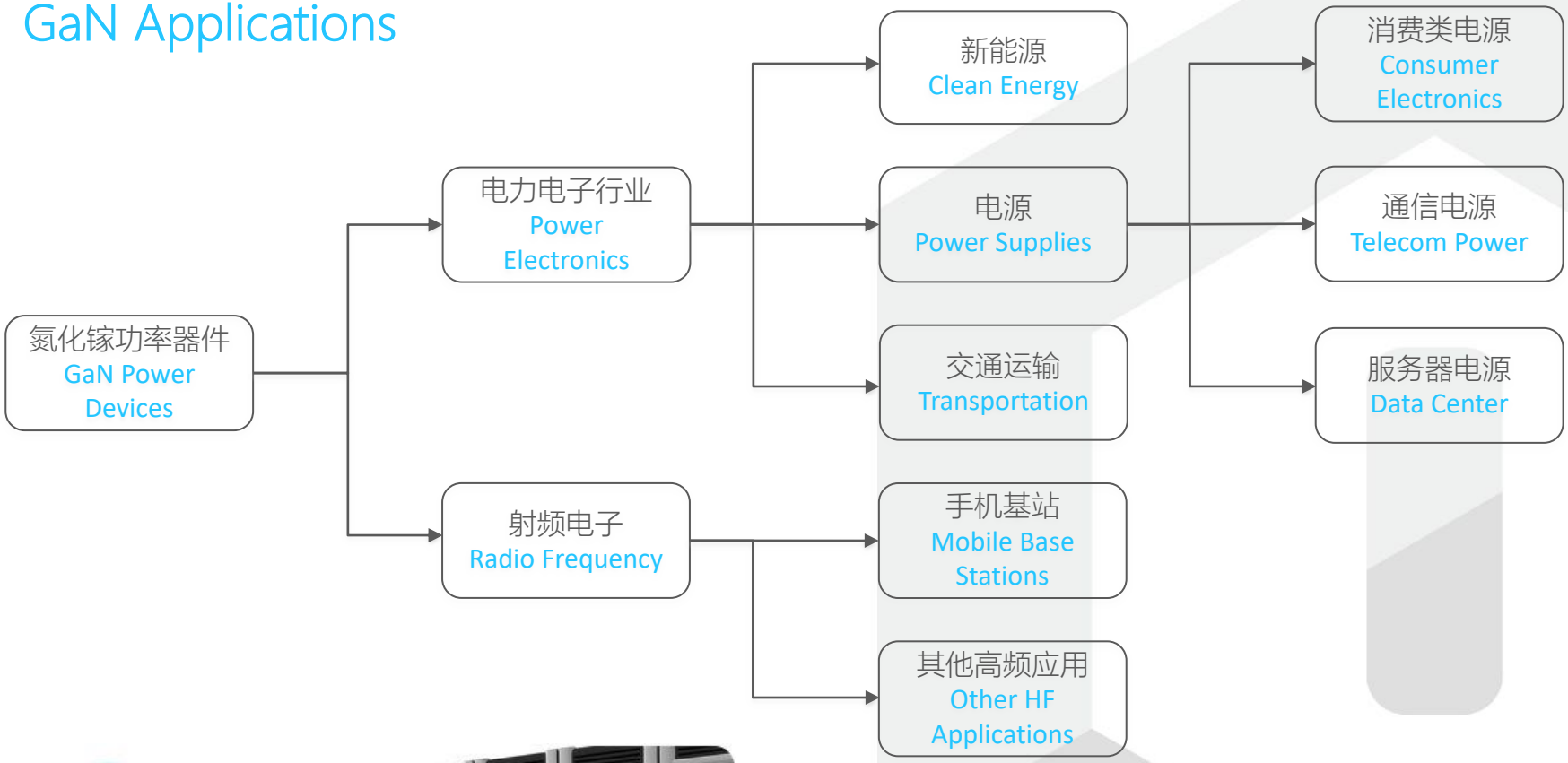
- 大大减小了寄生电感和开关过程中的震荡
- **Greatly reduced the parasitic inductance and ringing**

- 能否满足设计多样性的要求呢？
- **Can Navitas satisfy the requirements for variety?**

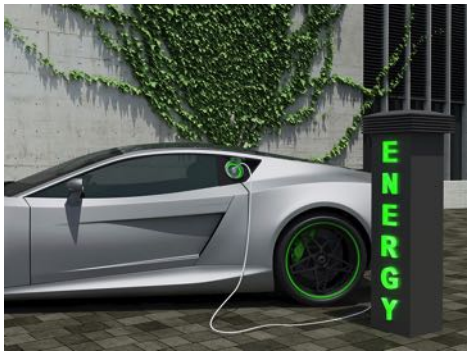




氮化镓功率器件应用
GaN Applications



未来氮化镓器件的一些应用
Future GaN Applications



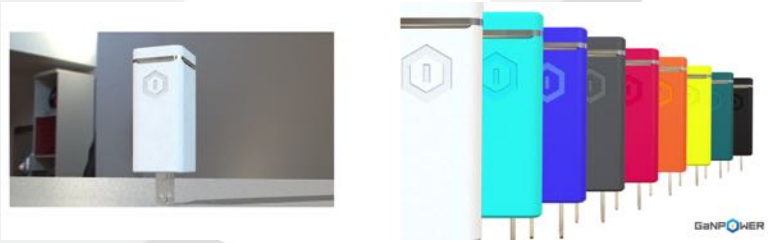
新能源汽车 / 自动驾驶 / 光学雷达
EV / Autonomous Vehicle / LiDAR

无线充电
Wireless Charging

光伏微逆变器
PV Micro-inverters

数据中心
Data Center

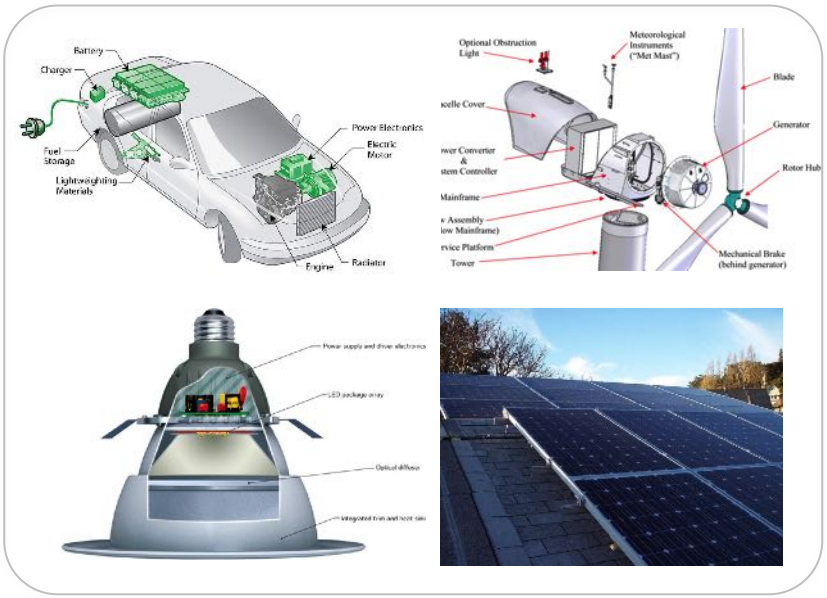
不间断电源及电机驱动
UPS and Motor Drive



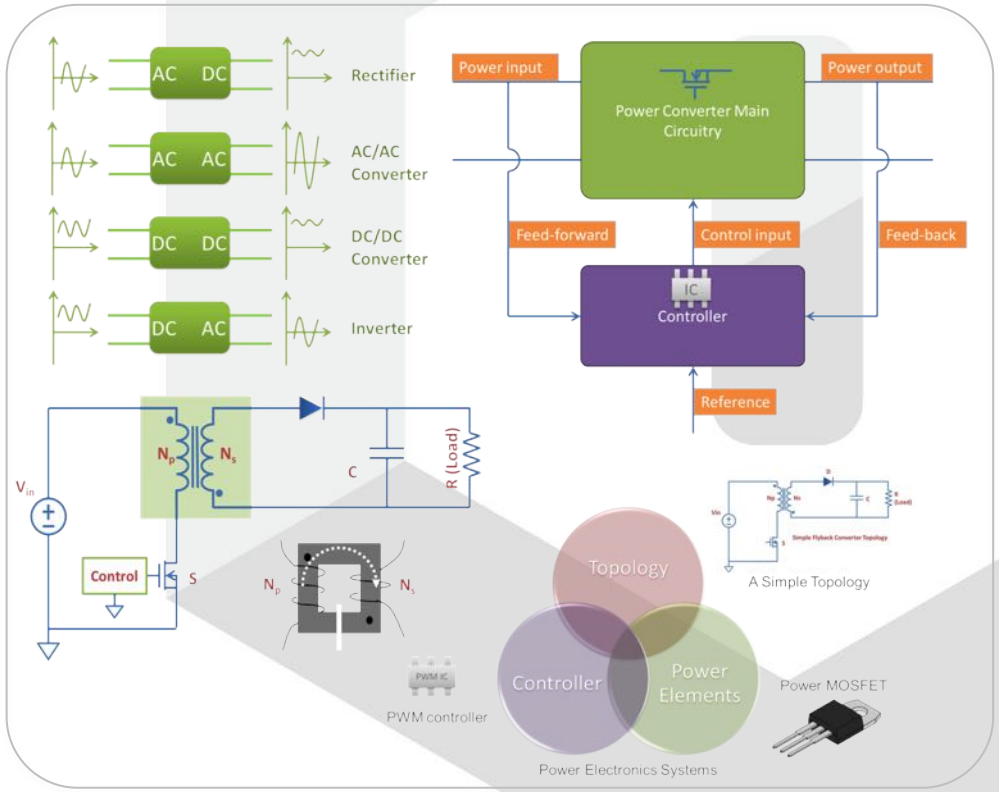
开关电源及功率因数矫正
SMPS and PFC

- 就目前而言，氮化镓器件适合应用在高附加值产品中; 下一步将大量渗透到低成本的消费类电子产品中
- **At this moment, GaN is more suitable for high value added products. It will infiltrate the low cost consumer electronics in the near future**

电力电子行业的简单介绍
About Power Electronics



电力电子无处不在！
Power Electronics is Everywhere！



功率器件推动电力电子技术革新
Power Electronics Evolution is Driven by Power Devices

氮化镓功率器件在电力电子中的应用要求
Requirements for GaN Used in Power Electronics

- 低通态电阻
- **Low Rdson**

- 低开关损耗
- **Low switching loss**

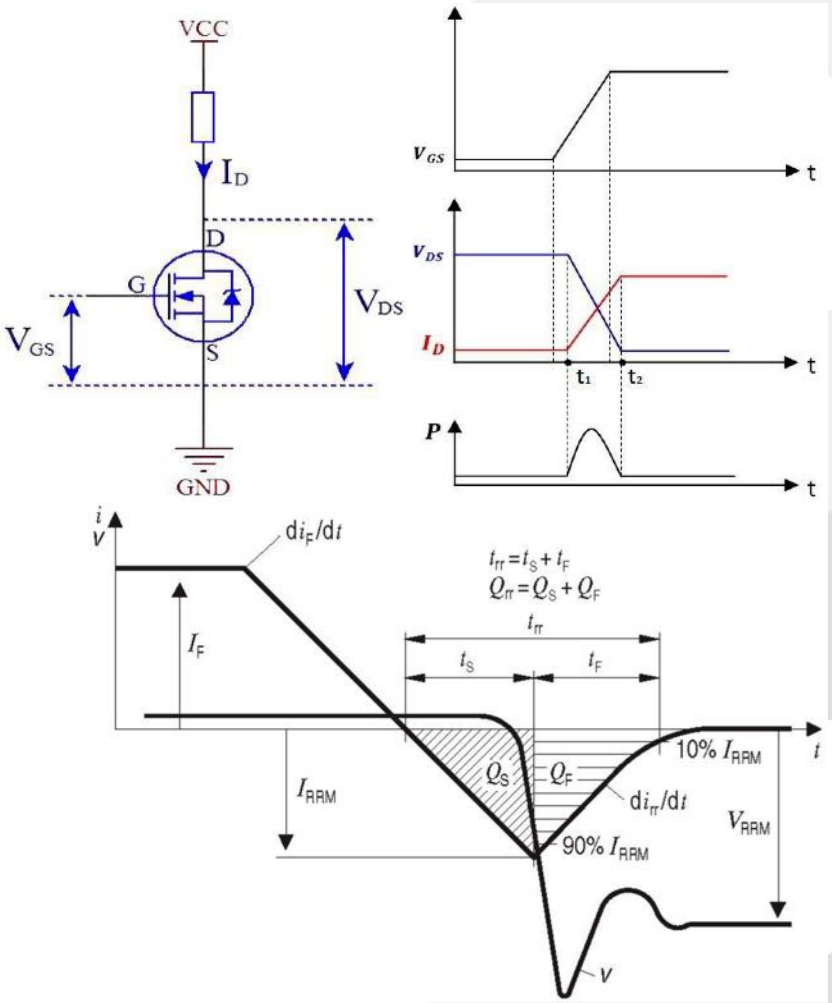
- 低反向恢复电荷
- **Low reverse recovery charge**

- 低门极电荷
- **Low gate charge**

- 实现高开关频率
- **Achieve high switching frequency**

- 高耐热性
- **High temperature stability**

- 高可靠性
- **High reliability**



氮化镓功率半导体在消费类电源的应用
GaN Applied to Consumer Electronics

- 高频开关（目前为100KHz, 今后可以达到1MHz）→ 大幅减小体积，提高效率
  High frequency switching (currently f=100KHz, 1MHz in the near future) → Greatly reduces the system volume and increases efficiency

- 氮化镓功率管应该从中小功率应用（< 10KW）起飞
  The applications of GaN devices should take-off from mid to low power applications (<10KW)

- 仅仅用氮化镓直接替换硅器件的方式是不现实的,
  Simply replacing the silicon devices with GaN is just not feasible

  - E-mode氮化镓器件的门极电压在5到7V，与通常硅器件的8到20V不同，需要新的驱动设计
    The gate voltage of E-mode GaN devices is between 5 to 7V, which is different from the 8 to 20V applied gate voltage with silicon devices

  - 氮化镓器件的开通关断速度(dv/dt)很高，容易造成EMI辐射，给产品认证造成麻烦。
    High dv/dt slew rate of GaN devices brings EMI radiation effect that makes it difficult to pass the standard qualification tests

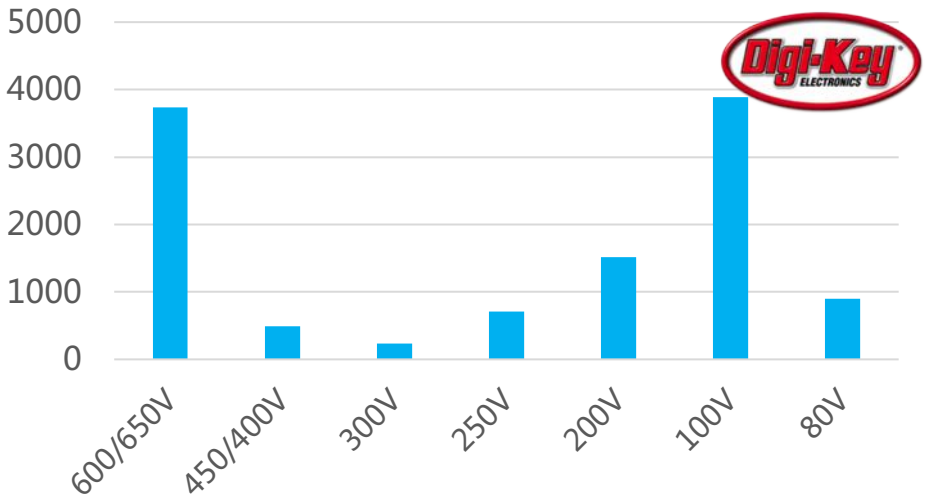
  - 高频应用要求仔细的引线设计，以减小引线上的寄生参数
    High frequency applications require careful layout designs to minimize the parasitics

市场究竟需要耐压多少伏的器件?
What Are the Voltage Ratings Needed?

- 对于宽范围输入(80~260V)，260V经过整流滤波后的母线电压为370V，再外加电压尖峰，一般要求原边功率器件能承受600~650V电压。600V/650V是目前市面上应用最多的功率器件电压等级。
- **For wide input range (80~260V), bus voltage becomes 370V after rectification and filtering from 260V input. Considering voltage spikes on the drain, the breakdown voltage requirement for power devices should exceed 600V. 600/650V rated power devices are thus most popular in the market**
- 大部分电源产品需要原副边隔离，副边输出提供直流电压。一般笔记本电脑的输入电压是19V或12V(如微软Surface)，副边如需提高效率需要用MOS管替代肖特基二极管。这个MOS管的电压要求在100V以内。
- **Most power supplies require insulating primary and secondary side, with DC voltage output at the secondary side. Most laptop computers' input voltage is either 19V or 12V (Surface), MOSFETs are usually used to replace Schottky diode to reduce conduction loss and boost efficiency. This secondary side MOSFET should be able to sustain a breakdown voltage of less than 100V**

Digi-key上在售的MOSFET种数

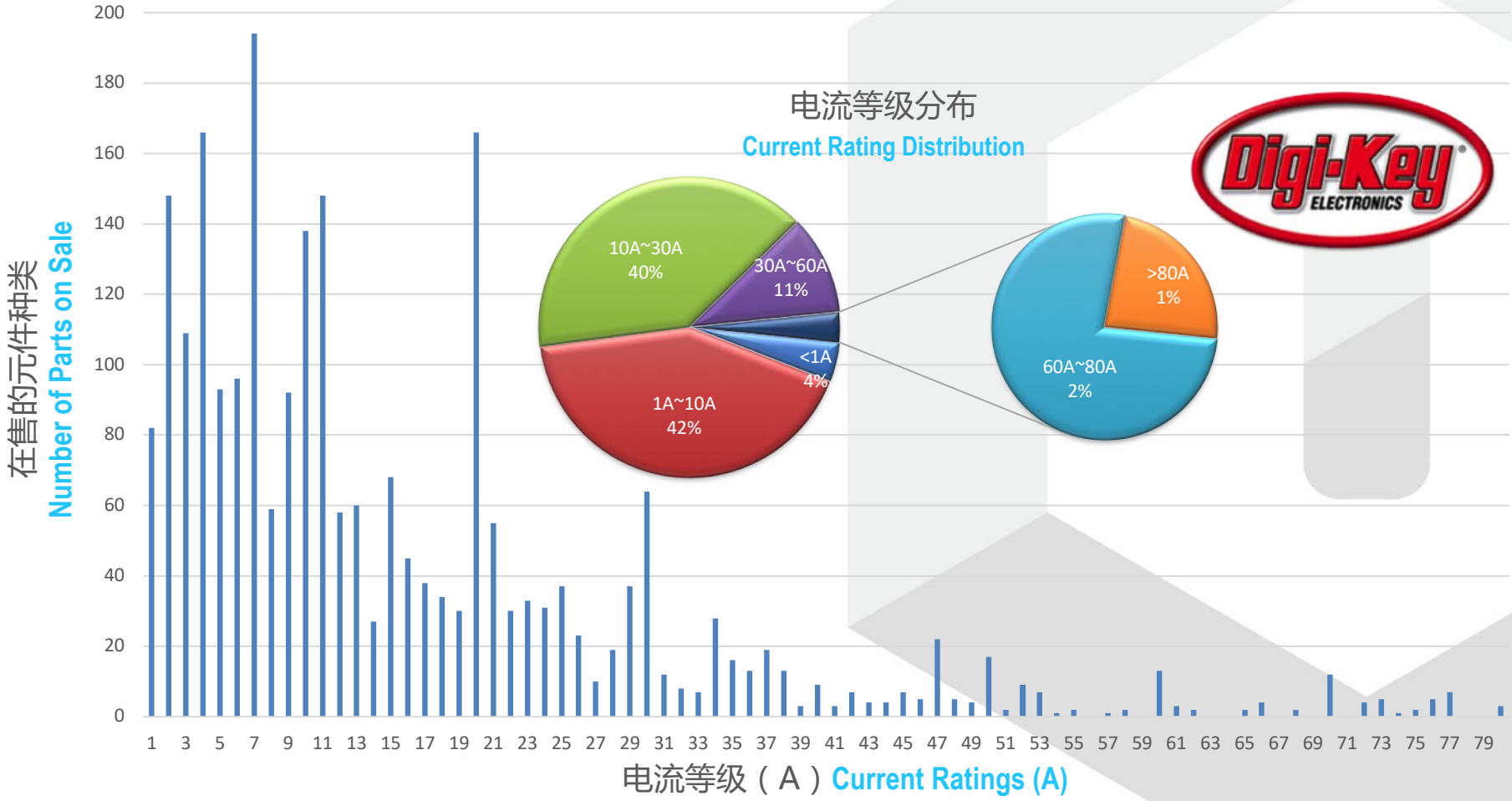
Number of MOSFET Parts on Sale in Digi-key



市场究竟需要多大电流器件?
What Are the Voltage Ratings Needed?

Digi-key 上目前在售的600V NMOS 种类按电流等级排列

Number of 600V NMOS Active in Digi-Key Arranged According to Current Ratings



氮化镓功率器件的挑战I
Challenges We Are Facing I

挑战 Challenges	常开型 Normally On	电流崩塌 Current Collapse	没有雪崩击穿 No Avalanche Breakdown	高频寄生参数 Parasitics @ High Frequency	成本 Cost	可靠性 Reliability
解决方案1 Solution 1	级联 Cascode	增加裕量 Increase Margin	增加裕量 Increase Margin	优化器件设计 Optimize Device Design	硅衬底 Silicon Substrate	工艺优化 Optimize Process
解决方案2 Solution 2	P-GaN P-GaN	松下 X-GaN Panasonic X-GaN	有源钳位 Active Clamp	优化驱动回路设计 Optimize Gate Drive Loop Design	大尺寸 Larger Wafer Size	尽量不用级联方案 Avoid Cascode
解决方案3 Solution 3	凹栅 Recess-Gate		RCD 吸收 RCD Absorption	单片集成 Monolithic Integration of Gate Driver and HEMT	量产，提高良品率 Mass Production, Improve Yield	

- 很高的dv/dt 速度（比如接近100V/nS）加上很低的Cg/Cgd比值会造成氮化镓器件误导通并立即炸管
- High dv/dt (i.e. 100V/nS) and low Cg/Cgd ratio can lead to parasitic turn-on and lead to immediate transistor damage

氮化镓功率器件的挑战II
Challenges We Are Facing II

挑战 Challenges	封装材料不能耐受高温 Packaging Materials Cannot Sustain High Temperature	没有体二极管第三象限导通性能变差 No Body-Diode Resulting Poor 3rd Quadrant Performance	超快上升下降沿照成电磁干扰 Ultra Fast Slew Rate Causes EMI Issues	缺少副边高频同步整流驱动芯片 No HF Driver Chip for Synchronized Rectifier	缺少超高频磁芯材料及绕线集肤效应 Lack Ultra High Frequency Core Materials and Skin Effect
解决方案1 Solution 1	陶瓷封装 Ceramic Packaging	并联快恢复二极管 Add A Fast Recovery Diode	做好辐射屏蔽 Use Better Radiation Shielding	自己设计一个 Design by Yourself	使用空心变压器 Use Air-Core Transformer
解决方案2 Solution 2	金属封装 Metal Packaging	并联GaN / SiC肖特基二极管 Add A Fast Recovery GaN/SiC Schottky	使用软开关 Use Soft Switching	使用肖特基管 Use Schottky Diode	使用新磁性材料 Use New Core Materials
解决方案3 Solution 3	其他封装材料 Other Packaging Materials	使用级联器件 Use Cascode Devices	使用慢速开关管 Use Devices with Lower Slew Rate	等待新产品上市 Wait for the New Chip	

镓能国际半导体公司介绍
Introduction to GaNPower

公司愿景：世界一流氮化镓功率器件提供商
GaNPower Vision: A global player in the field of GaN power devices

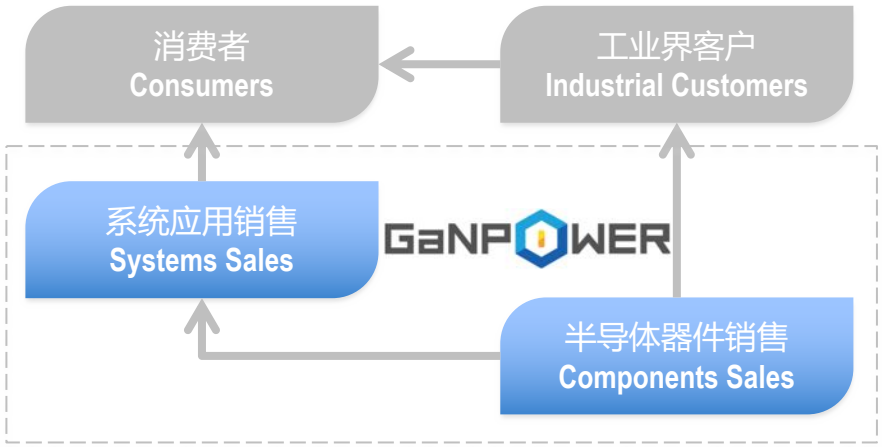
公司使命：帮助全球清洁能源实现高效率转换
GaNPower Mission: Helping highly efficient clean energy conversion

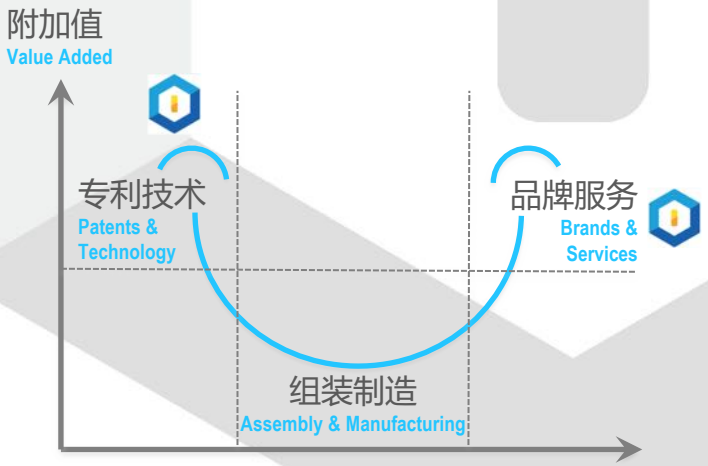
公司价值：团结，乐观，奋进
GaNPower Value: United, Positive, Hard-working

公司定位：垂直整合的价值提供者
GaNPower Position: Vertically integrated value provider

镓能商业及盈利模式
The Business + Revenue Model

- 创新的垂直整合模式（系统应用+功率器件芯片设计）催生系统应用和功率芯片的协同效应，最大化公司的核心竞争力
  Novel integrated business model (system applications + power semiconductor IC chips) to create synergy between electronics systems and components and to maximize the key value of the company
- 与一些竞争对手相比，我们采用无晶圆厂设计公司模式，避免巨大的制程开发费用
  Fabless semiconductor design house to avoid hefty process development costs compared to some leading competitors
- 轻资产系统设计公司模式，引导最具弹性的设计环境以达到快速成长的目的
  Asset light design house model for power electronics systems that provides most flexible design environment and potential for quick growth
- 盈利模式：B2B（功率器件及驱动芯片）+ B2C（某些系统应用）
  Revenue Model: B2B(power devices and driver IC) + B2C (some of the system applications

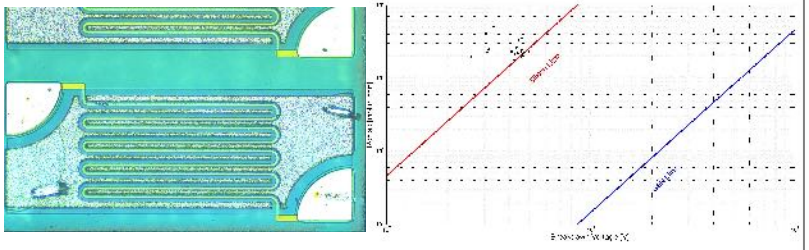




镓能蓝宝石衬底氮化镓功率器件产品

GaNPower's Sapphire Based GaN Power Devices

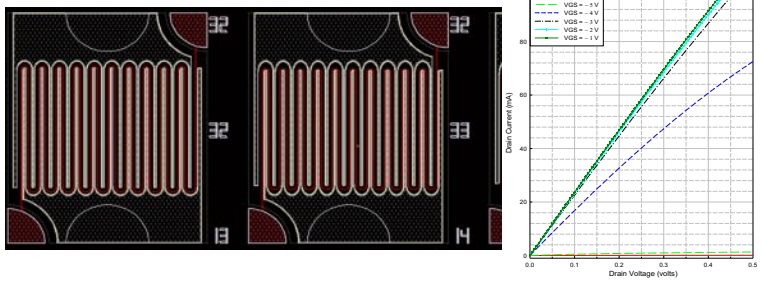
第一代 First Generation



第一代氮化镓功率器件:击穿电压(BV)=480V，电阻($R_{on,sp}$)=12mΩ*cm^2

First Generation GaN HEMT: BV=480V, Ron,sp=12mΩ*cm^2

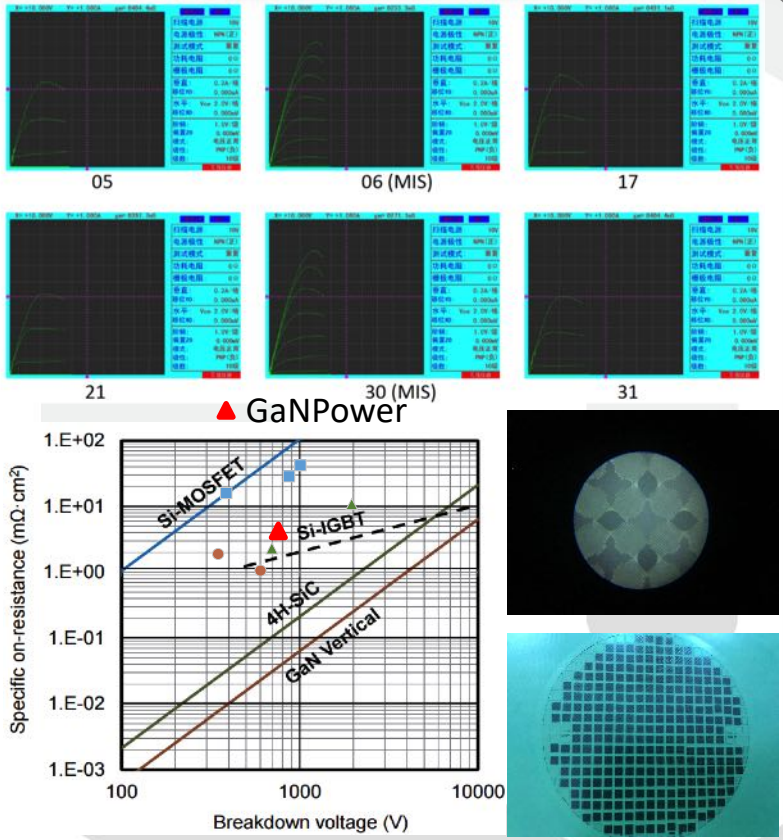
第二代 Second Generation



第二代650V氮化镓功率器件(常规设计): 击穿电压(BV)=700V，电阻(Ron,sp)=4mΩ*cm^2

Second Generation GaN HEMT (Standard Design): BV=700V, Ron,sp=4mΩ*cm^2

第三代 Third Generation

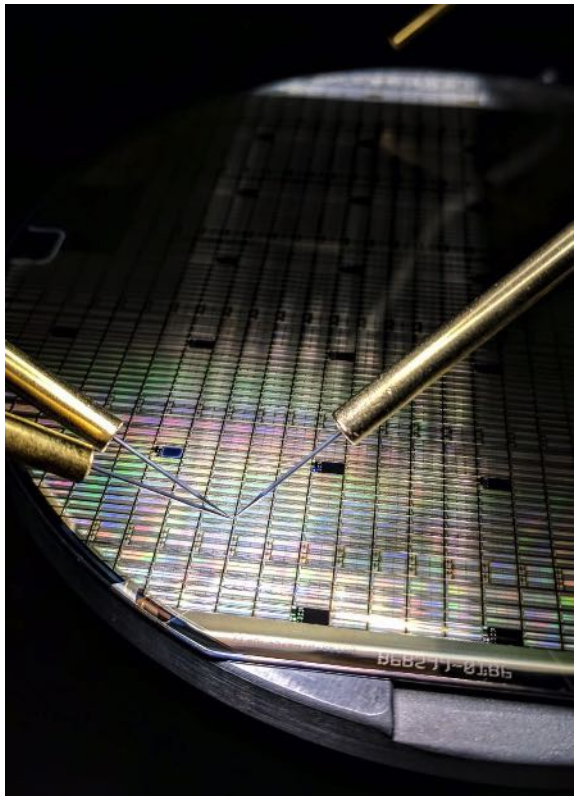


第三代650V氮化镓功率器件(创新的晶钻晶格设计)击穿电压(BV)=850V，电阻(Ron,sp)= 3mΩ*cm^2

Third Generation GaN HEMT (Innovative Crystal Lattice Design): BV=850V, Ron,sp=3mΩ*cm^2

镓能硅衬底氮化镓功率器件产品

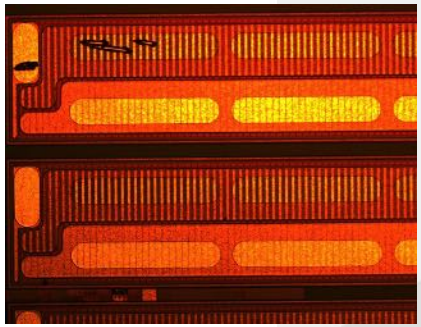
GaNPower's Silicon Based GaN Power Devices

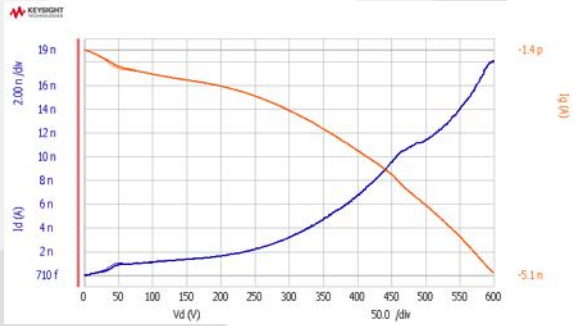


- 流片一次性成功
- Success on first tape-out

- 包含从10A到30A功率器件及驱动IC芯片
- Includes power devices from 10A to 30A and driver ICs

- 多种封装设计, 包括TO220, iGaN-LGA, etc.
- Multiple packaging designs, including TO220, iGaN-LGA, etc.





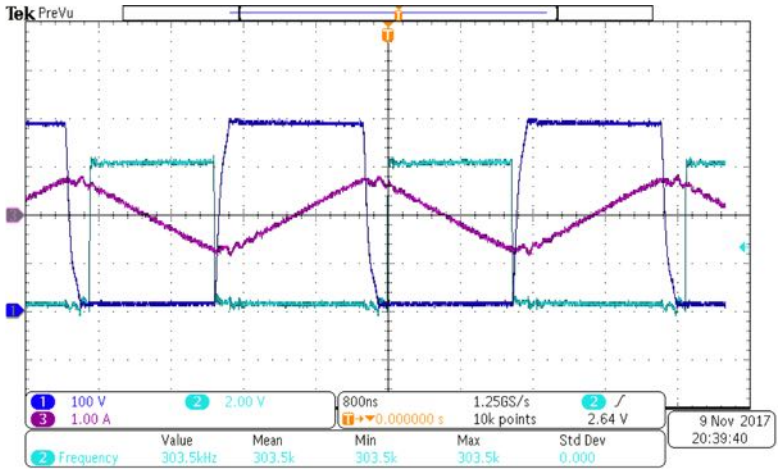
- 镓能国际6寸真实晶圆照片
- Real photo of GaNPower Wafer

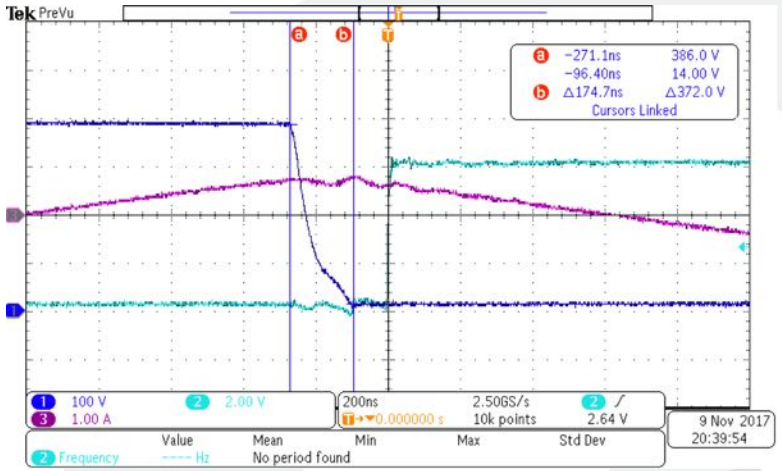
- 镓能晶圆级测试照片
- Wafer level testing photo

- 极低的关闭状态漏电流
- Very low off-state leakage

镓能硅衬底氮化镓功率器件产品实际应用

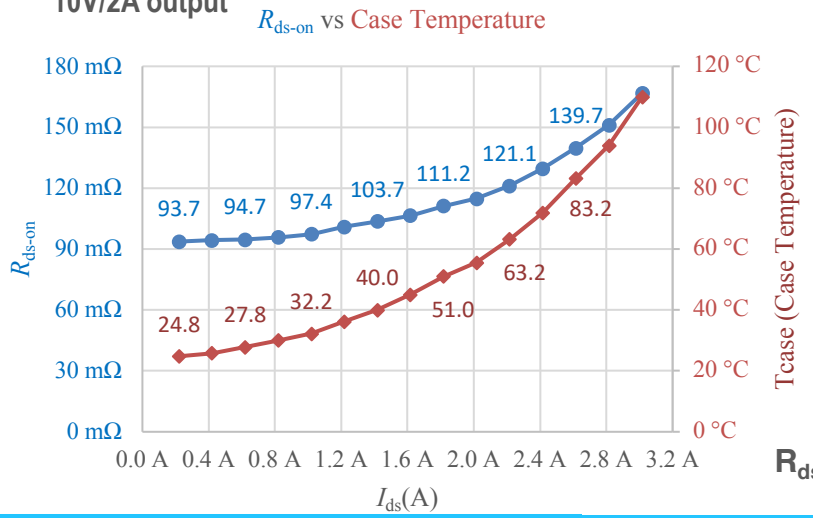
GaNPower's Silicon Based GaN Power Devices Applications





Waveforms of the LCLC resonant converter at 400V input, 10V/2A output

CH1: Low Side Vds
CH2: Low Side Vgs
CH3: Parallel Resonant Current
Label a: specific point when Vds is 400V
Label b: specific point when Vds is decreasing to 0V



- LCLC电路上取得非常好的测试结果
- 电压电流波形很干净，没有过多震荡

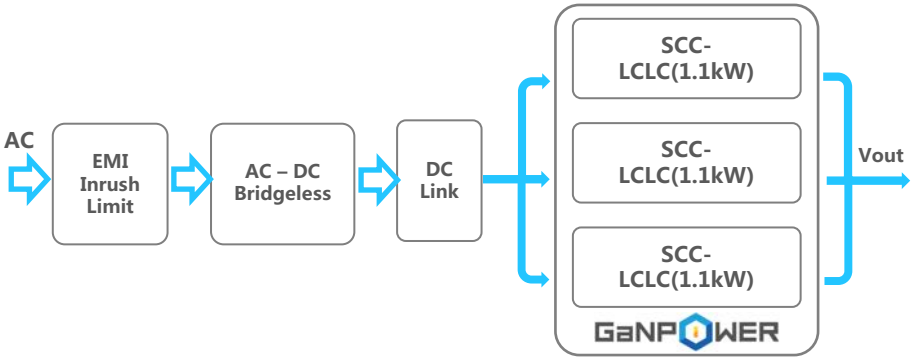
R_{ds-on} and Case Temperature Curves v.s. I_{ds}

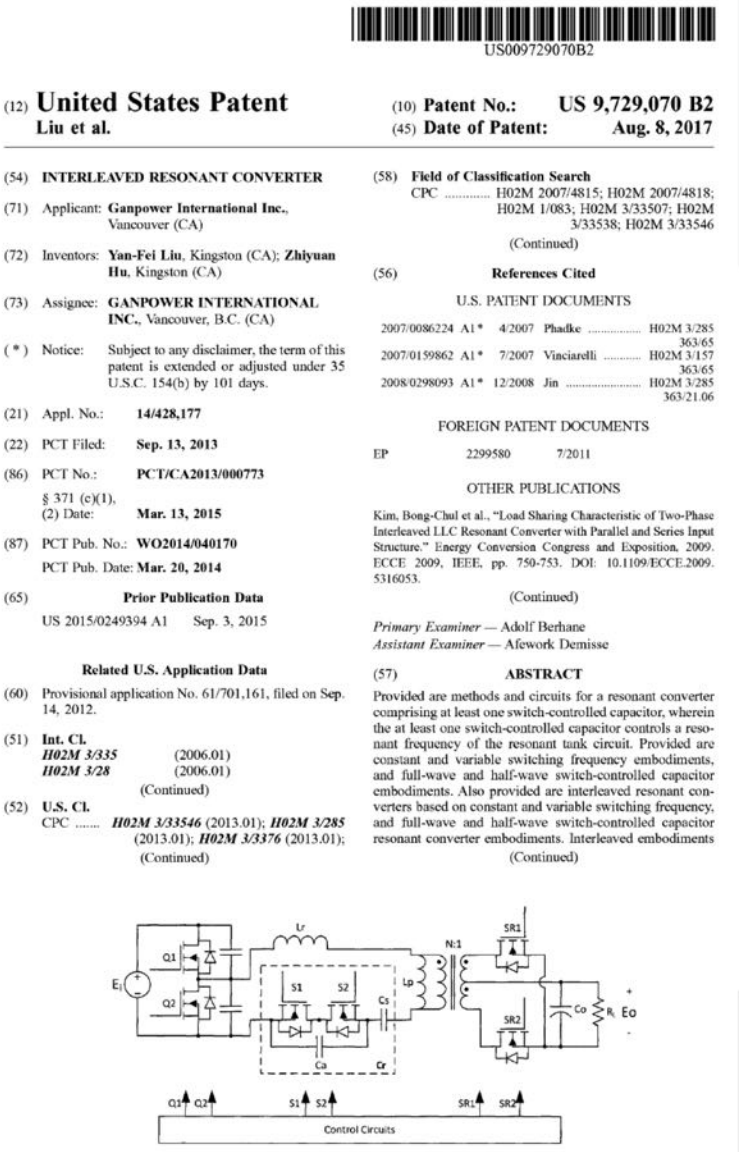
镓能电动汽车车载电源方案设计专利

GaNPower's Patent for Electric Vehicle Charging

- 作为一家垂直整合的新型半导体公司，镓能提供基于镓能公司氮化镓功率器件的创新系统设计方案
- **Being a vertically integrated innovative semiconductor company, GaNPower offers novel system design solutions based on GaNPower's GaN HEMT devices**

- 镓能独有的专利技术——SCC技术，大大提高系统转换效率，提高功率密度并显著减小车载电源的体积和重量
- **GaNPower's Patented SCC technology will greatly increase DC/DC converter efficiency and significantly reduce on-board power adapter size and weight**





US009729070B2

(12) **United States Patent**
Liu et al.

(10) **Patent No.: US 9,729,070 B2**
(45) **Date of Patent: Aug. 8, 2017**

(54) **INTERLEAVED RESONANT CONVERTER**

(71) Applicant: **Ganpower International Inc.**, Vancouver (CA)

(72) Inventors: **Yan-Fei Liu**, Kingston (CA); **Zhiyuan Hu**, Kingston (CA)

(73) Assignee: **GANPOWER INTERNATIONAL INC.**, Vancouver, B.C. (CA)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 101 days.

(21) Appl. No.: **14/428,177**

(22) PCT Filed: **Sep. 13, 2013**

(86) PCT No.: **PCT/CA2013/000773**
§ 371 (c)(1),
(2) Date: **Mar. 13, 2015**

(87) PCT Pub. No.: **WO2014/040170**
PCT Pub. Date: **Mar. 20, 2014**

(65) **Prior Publication Data**
US 2015/0249394 A1 Sep. 3, 2015

Related U.S. Application Data

(60) Provisional application No. 61/701,161, filed on Sep. 14, 2012.

(51) **Int. Cl.**
H02M 3/335 (2006.01)
H02M 3/28 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H02M 3/33546*** (2013.01); ***H02M 3/285*** (2013.01); ***H02M 3/3376*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H02M 2007/4815; H02M 2007/4818; H02M 1/083; H02M 3/33507; H02M 3/33538; H02M 3/33546
(Continued)

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(Continued)

Primary Examiner — Adolf Berhane
Assistant Examiner — Afework Demisse

(57) **ABSTRACT**

Provided are methods and circuits for a resonant converter comprising at least one switch-controlled capacitor, wherein the at least one switch-controlled capacitor controls a resonant frequency of the resonant tank circuit. Provided are constant and variable switching frequency embodiments, and full-wave and half-wave switch-controlled capacitor embodiments. Also provided are interleaved resonant converters based on constant and variable switching frequency, and full-wave and half-wave switch-controlled capacitor resonant converter embodiments. Interleaved embodiments
(Continued)

镓能电动汽车车载DC/DC电源解决方案
GaNPower's EV On-board DC/DC Converter Solution

- 输入：240-430V直流, 输出：9-16V直流，2千瓦，150安培
- Input: 240 – 430V DC, Output: 9 – 16V DC, 2000W, 150A max

	目前设计 Current Design	报道过的最优设计 Reported Design	镓能国际的设计 GaNPower's Design
大小 / 容积 Size / Volume	1.8 Litre	1.3 Litre	0.7 Litre
功率密度 Power Density	0.7 - 1.1 kW / L	1.5 kW / L	3 - 4 kW / L
重量 Weight	与容积相匹配 Proportional to volume		
效率 Efficiency	94 - 95%	95 - 96%	97%
工作温度范围 Operating Temp Range	-45 - 105	-45 - 105	-45 - 105
瞬态速度 Transient Speed	相同 Same	相同 Same	相同 Same
可靠性 Reliability	相同 Same	相同 Same	相同 Same
耐久性 Durability	相同 Same	相同 Same	相同 Same
功率器件 / 成本 Power Devices / Cost	MOSFET Large inductor	GaN 8,400uF cap	With GaN 500uF cap

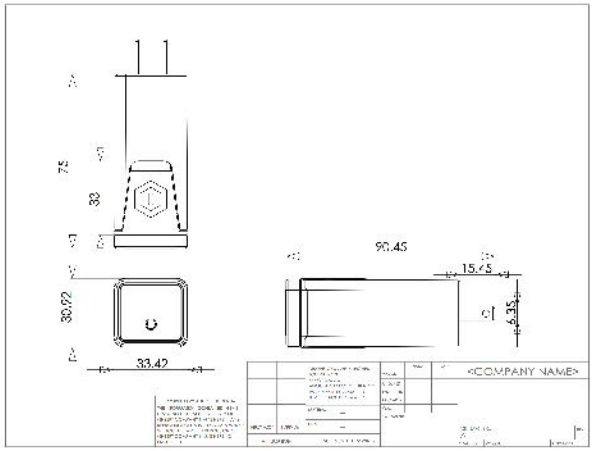
镓能电动汽车车载充电电源解决方案
GaNPower's EV On-board Charger Solution

- 输入：85-265V交流, 输出：240-430V直流，3.3千瓦，14安培
- Input: 85 – 265V AC, Output: 240 – 430V DC, 3300W, 14A

	目前设计 Current Design	报道过的最优设计 Reported Design	镓能国际近期 GaNPower's Design I	镓能国际远期 GaNPower's Design II
大小 / 容积 Size / Volume	3.2 Litre	2.2 Litre	1.2 Litre	0.6 - 0.8 Litre
功率密度 Power Density	1 kW / L	1.5 kW / L	2.5 - 3 kW / L	4 - 5.5 kW / L
重量 Weight	与容积相匹配 Proportional to volume			
效率 Efficiency	92%-94%	95.7%	96.5%	98%
工作温度范围 Operating Temp Range	-45 - 105	-45 - 105	-45 - 105	-45 - 105
瞬态速度 Transient Speed	不需要快速 No need to be fast			
可靠性 Reliability	相同 Same	相同 Same	相同 Same	相同 Same
耐久性 Durability	相同 Same	相同 Same	相同 Same	相同 Same
功率器件 / 成本 Power Devices / Cost	Large inductor	500V/200uF cap ($56)	500V / 12uF cap ($8)	500V / 12uF cap ($8)

基于氮化镓的适配器产品（仅提供解决方案）

Adapter Products Using GaN (Application Solutions Only)



讓 我 們 共 同 成 長
LET'S GROW TOGETHER

Our Believes 我們的理念

Integrity 正直

Technology Innovation 技術革新

Fast Growing 快速成長

参考资料：中山大学刘杨教授，GaN功率电子行业发展动态，2016年中国宽禁带功率半导体产业论坛，四川成都，2016.10.16

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衷心感謝您的耐心與支持

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