



Power GaN FETs
Quality and Reliability

Introduction

- Manikant
- GaN Quality Architect

- Giuliano Cassataro
- GaN Marketing & Commercial Director



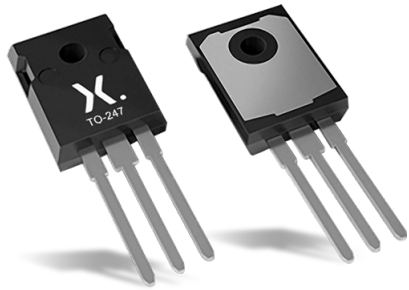
Nexperia GaN Products

GaN quality and reliability

- 650V TO-247 package



- GAN063-650WSA
- GAN041-650WSB

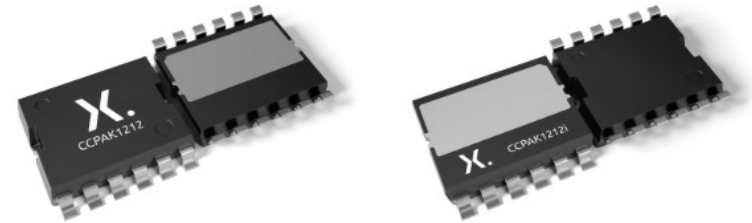


Both products released

- 650V Copper clip package



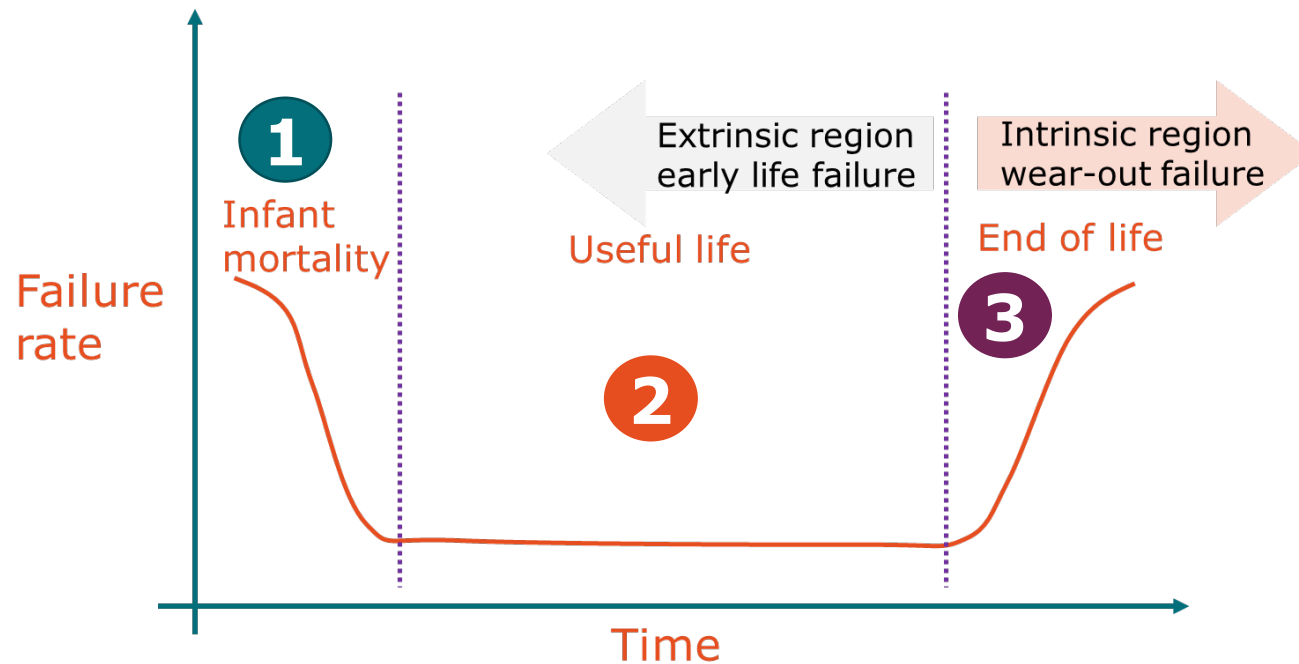
- Bottom-side cooling (CCPAK1212)
- Top-side cooling (CCPAK1212i)
- GAN039-650NTBA/NBBA



Ongoing AEC Q101 qualification

Contents

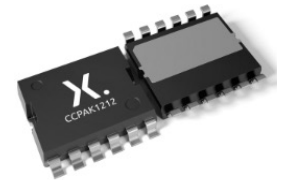
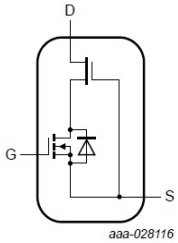
- GaN Quality and Reliability



Our plans on addressing each region.

Nexperia GaN Product Journey

GaN quality and reliability



Concept



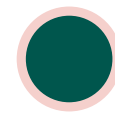
Specify



Freeze



Validate



Release

- Initial idea
- Prototype design

- Technical concepts: product, process, package
- Validation plan based on targeted application.
- Risk assessment and Qualification strategy, test plan.

- Prototype builds and dynamic evaluation.
- Risk assessment based on outcome of trials.
- BOM, Process and Assembly frozen.

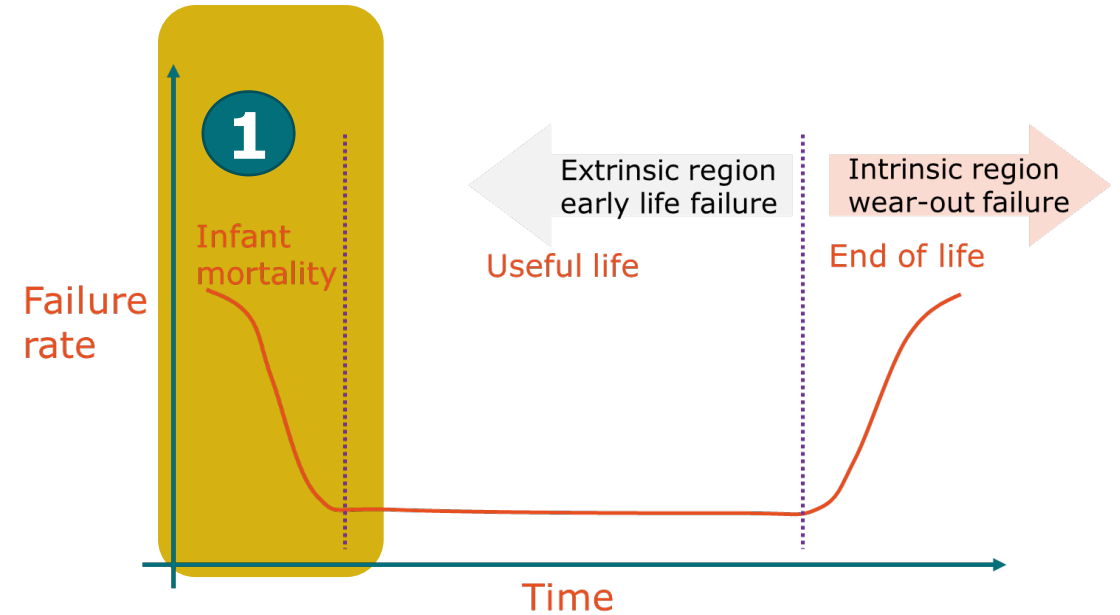
- Test to standards, qualification PASS.
- Validation report on design and manufacturing.

- Safe launch and start of reliability.

1. Infant Mortality

GaN quality and reliability

- Occurrence of failures normally attributed to:
- Manufacturing defects
 - design, device process or assembly



Nexperia GaN:

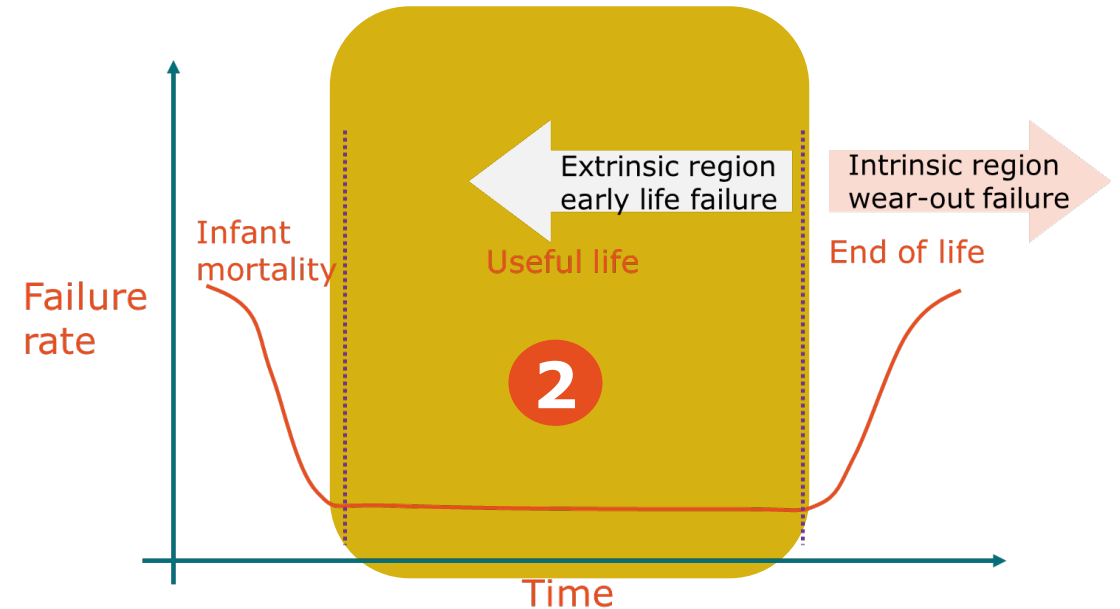
- Screen test for GaN HEMT
- Switching test to screen weak MOSFET

For every GaN product manufactured

2. Useful Life

GaN quality and reliability

- Constant part, called the “useful life period”, failure rate is stable and lower
- Failures under this area can't be predicted, random.



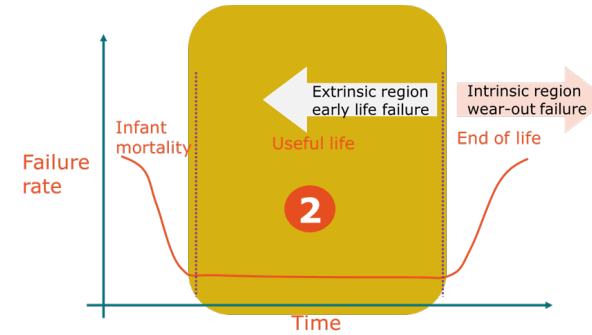
Nexperia GaN:

- AEC-Q101 rev E
- Nexperia RQS (Industrial)

Is typical qual primarily for silicon sufficient for GaN?

2. Useful Life

GaN quality and reliability



Existing standards

AEC-Q101 & JESD47

standard for product qualification

Extended life testing

Zero-Defect program

including Six-Sigma and Safe-launch



Wide band gap(WBG)

- H3TRB** { • No limited to 100V, extended up to rated voltage
- Dynamic HTRB, H3TRB** { • Capability up to 1000V & 300Khz
- Dynamic R_{dson}** { • Impact pre & post temperature and humidity
- Mechanical stress** { • Impact of mechanical stress on GaN HEMT under operation

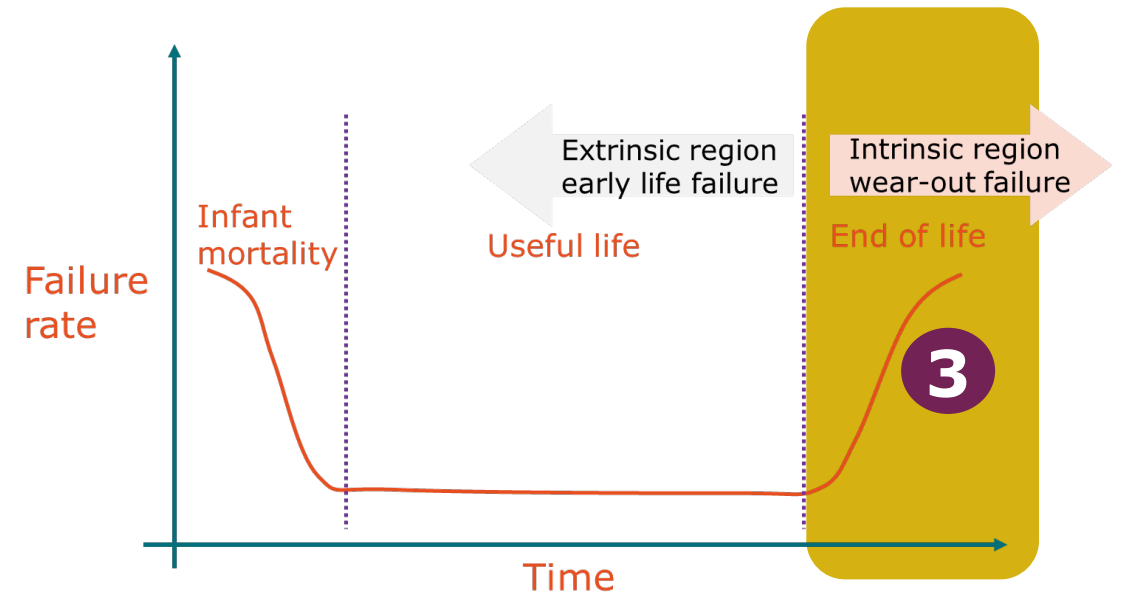
3. End of Life (Intrinsic Region)

GaN quality and reliability

- Part to predict where product has outlived its useful operating life.
- Assumed that product will breakdown, degrade rapidly in this period.
- Wear out mechanism, time to failure.

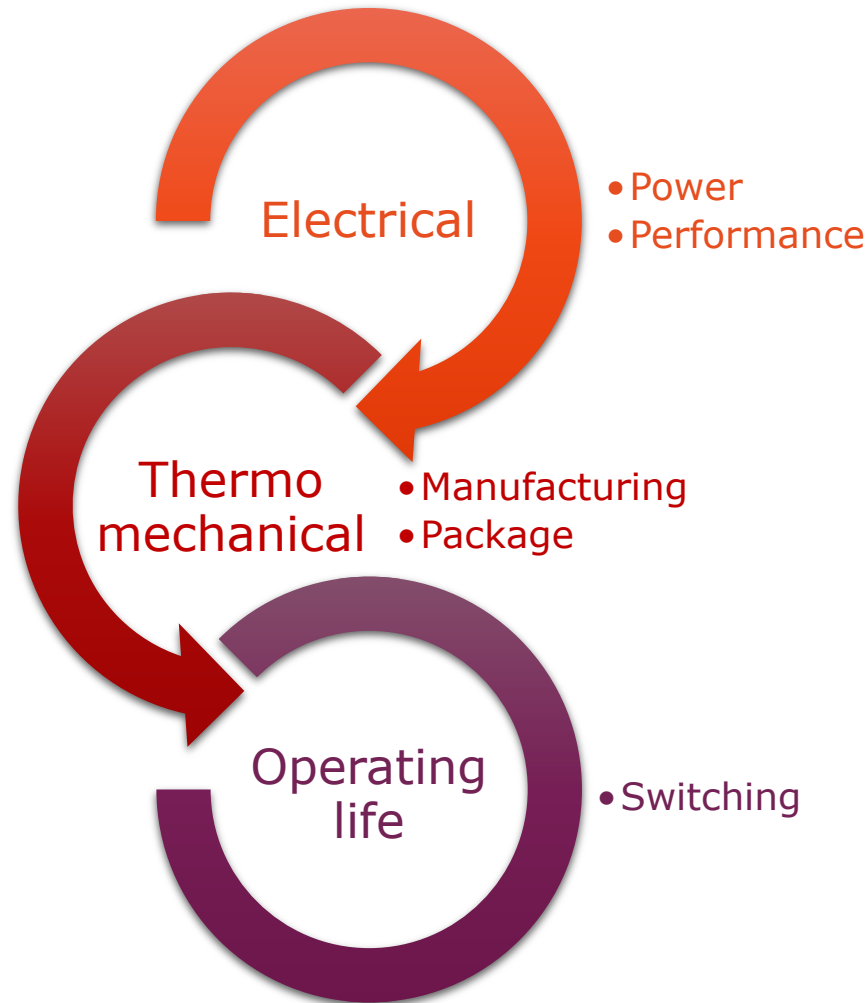
Dedicated reliability team at Nexperia

- Sara Martin Horcajo (leader)



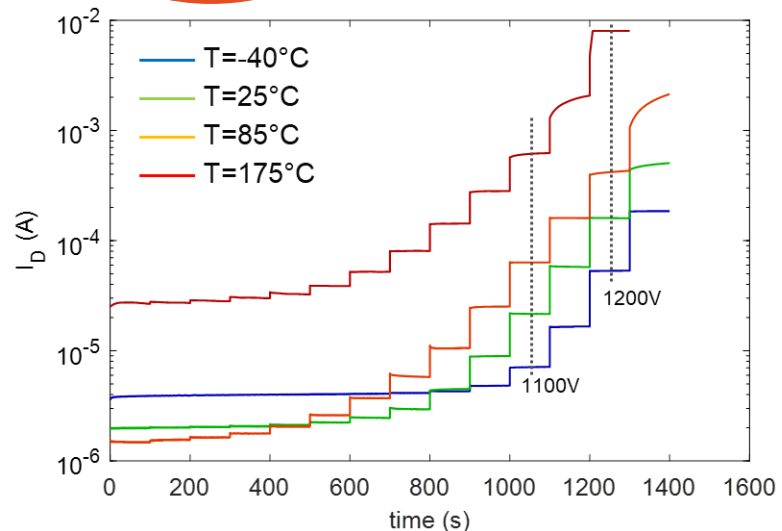
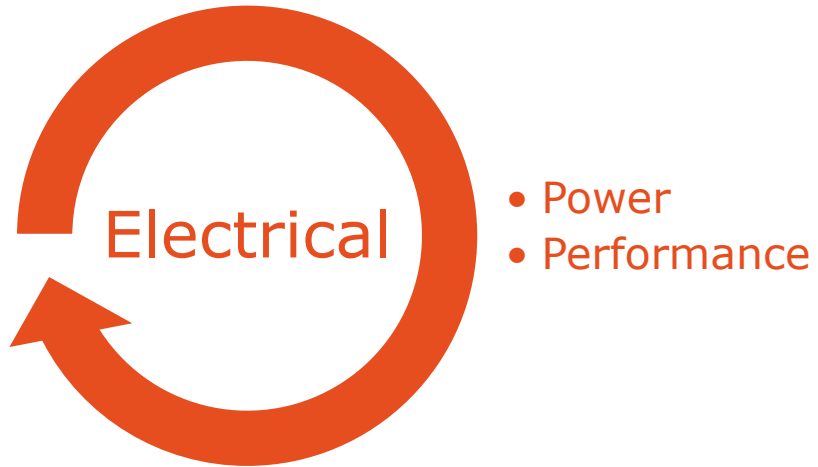
3. End of Life (Intrinsic Region)

GaN quality and reliability



3. End of Life: GaN Reliability Test

GaN quality and reliability



Test: High voltage off-state stress (HVOS) generally, accelerates the device failure using both temperature, and voltage stress factors

HVOS tests approach:

- Physics of failure
- Failure criteria: 20% increase in drain leakage current
- Weibull or lognormal distribution

Outcome:

- Activation energy, E_a
- Voltage parameter, γ

3. End of Life: GaN Reliability Test

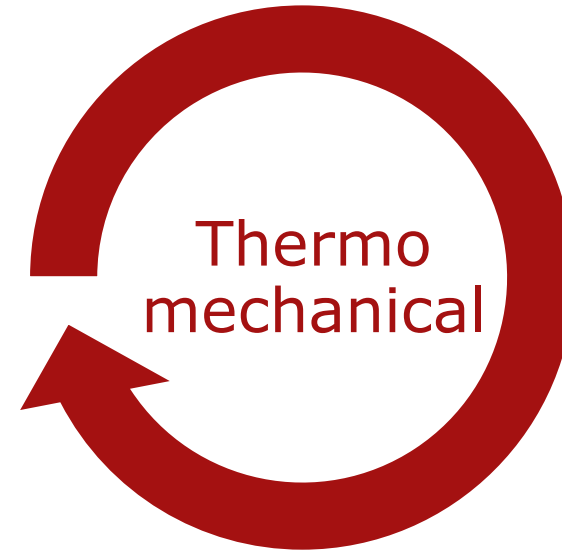
GaN quality and reliability

Tests: Thermal and Power cycling to evaluate the impact of temperatures and transitions between **temperature extremes** linked to external sources.

Tests approach:

- Physics of failure
- Failure criteria: 20% increase in R_{on}
- Weibull or lognormal distribution
- Lifetime modeling using Power Law:

$$L(x(t)) = \left(\frac{a}{x(t)} \right)^n$$



- Manufacturing
- Package

Outcome:

- Acceleration factor, **n**

3. End of Life: GaN Reliability Test

GaN quality and reliability

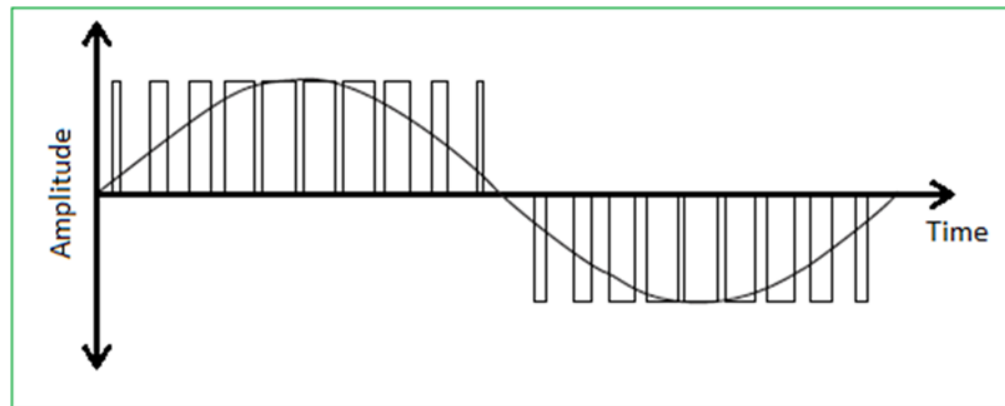


Test: DC/AC farm

Aim is to identify potential failure modes during real applications by sweeping through a continually varying range of operating points at high load and full supply voltage.

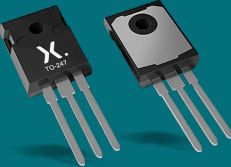
Outcome:

Evaluation under operating conditions

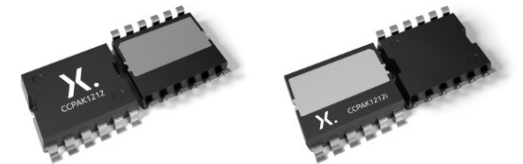


Present Status

GaN quality and reliability

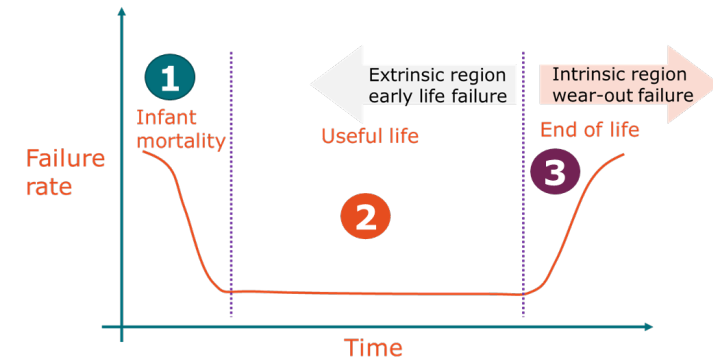
Product	Tests	Standard Requirement	Results	Nexperia Extended Results		Current Status
GAN041WSB 	Temp cycling	1000cyc	PASS	4000cyc	4x AEC-Q101	Ongoing
	IOL	15,000cyc	PASS	43,600cyc	4x AEC-Q101	Ongoing
	HTRB	1000hrs	PASS	4500hrs	4x AEC-Q101	Ongoing
	HTGB	1000hrs	PASS	2000hrs	2x AEC-Q101	Completed
	H3TRB	1000hrs	PASS	2000hrs	2x AEC-Q101	Completed
	HAST	96hrs	PASS	198 hrs	2x AEC-Q101	Completed
	UHST	96hrs	PASS	198hrs	2x AEC-Q101	Completed

CCPAK1212:
Qualification ongoing.



Nexperia GaN

GaN quality and reliability



AEC-Q101 / 100 for product qualification

Extended life testing
(More than defined in AEC-Q101/100)

JEDEC & WBG forums

Committee on WBG JC-70.1
JEP 180
Tests defined by WBG forums

Customer requirements

GaN specific tests
Application mission profiles
Known Failure modes

GaN reliability program

Test to fail, Wear out failure
Lifetime models
Lifetime of products

Nexperia GaN product quality & reliability

Further information

Please visit [Nexperia.com/GaN-FETs](https://www.nexperia.com/GaN-FETs)

GaN FETs

Efficient and effective high-power FETs

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Whether designing a motor drive/controller for the next generation of battery-electric vehicles, or a power supply for the latest 5G telecommunication networks, Nexperia's GaN FETs will be key to your solution. Offering high power performance and high-frequency switching, the design and structure of our normally-off GaN FET products ensure standard, low-cost gate drivers can be used in your design.

Featured product	Description
GAN063-650WSA	650 V, 50 mΩ Gallium Nitride (GaN) FET in a TO-247 package
GAN041-650WSB	650 V, 35 mΩ Gallium Nitride (GaN) FET in a TO-247 package
GAN039-650NBB	650 V, 33 mΩ Gallium Nitride (GaN) FET in a CCPAK1212 package
GAN039-650NTB	650 V, 33 mΩ Gallium Nitride (GaN) FET in a CCPAK1212I package



Find out how we are empowering innovation with our demonstrations and technical discussions

[Visit the hub >](#)



Nexperia GaN FETs - Performance, efficiency, reliability brochure



MOSFET and GaN FET Application Handbook



Focus package: CCPAK

Application notes & white papers



Understanding Power GaN FET data sheet parameters
AN90005



Circuit Design and PCB Layout Recommendations for GaN FET Half Bridges
AN90006



GaN FET technology and the robustness needed for AEC-Q101 qualification
White paper

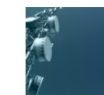
Latest news and blogs



Blog article Apr 27, 2021
GaN FETs help push 80 PLUS Titanium grade



Blog article Apr 22, 2021
GaN shines a light on PV inverter efficiency



Blog article Feb 1, 2021
Eliminating EMC By Replacing A MOSFET With A GaN ...



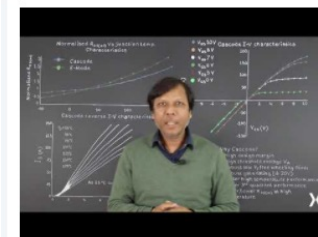
Blog article Oct 12, 2020
CCPAK - the option of top-side cooling for GaN FETs



Blog article Sep 30, 2020
GaN FETs: Why cascode?



Blog article Aug 18, 2020
Power GaN FETs: a strategic approach to bring the ...



Quick Learning: Cascode Vs E-Mode - which to use in your ...



Quick Learning: What is CCPAK? (Surface-mount packaging for ...



Nexperia partners with Ricardo to develop GaN based EV ...

Please share your
questions and insights

EFFICIENCY WINS.