Proprietary Packaging Technologies

IXYS Corporation
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Properties of Direct Aluminum Bonded Substrates for Power Semiconductor Components

Andreas Lindemann, *Senior Member, IEEE*, and Gerhard Strauch

***Abstract*—Direct aluminum bonded (DAB) substrates have been developed. They can serve as isolating carriers especially for power electronic circuits or integrated components, respectively, using the standard assembly processes also applied to state of the art direct copper bonded (DCB) substrates. This new type of substrates has been characterized theoretically based on material properties of its layers and experimentally. While it behaves similar to DCB in many respects, the remarkably higher temperature cycling capability of DAB substrates constitutes a major difference, which is also useful to increase reliability of components exposed to extreme environmental temperatures. DAB based moulded integrated components with large chips in this respect have shown to reach a level of reliability which could not be achieved earlier with conventional technology. Outperforming the latter and complementing DCB, DAB can thus, in the future, be expected to explore new, and contribute to optimization of, existing applications with special demand for high reliability or also low weight. This makes this material well suited for use, e.g., in automotive power converters or avionic electronics.**

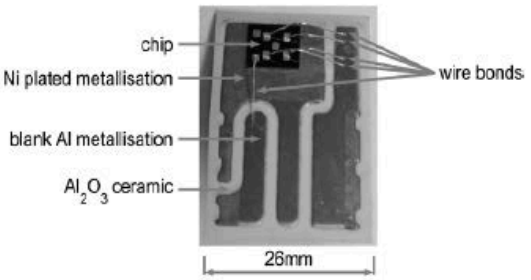
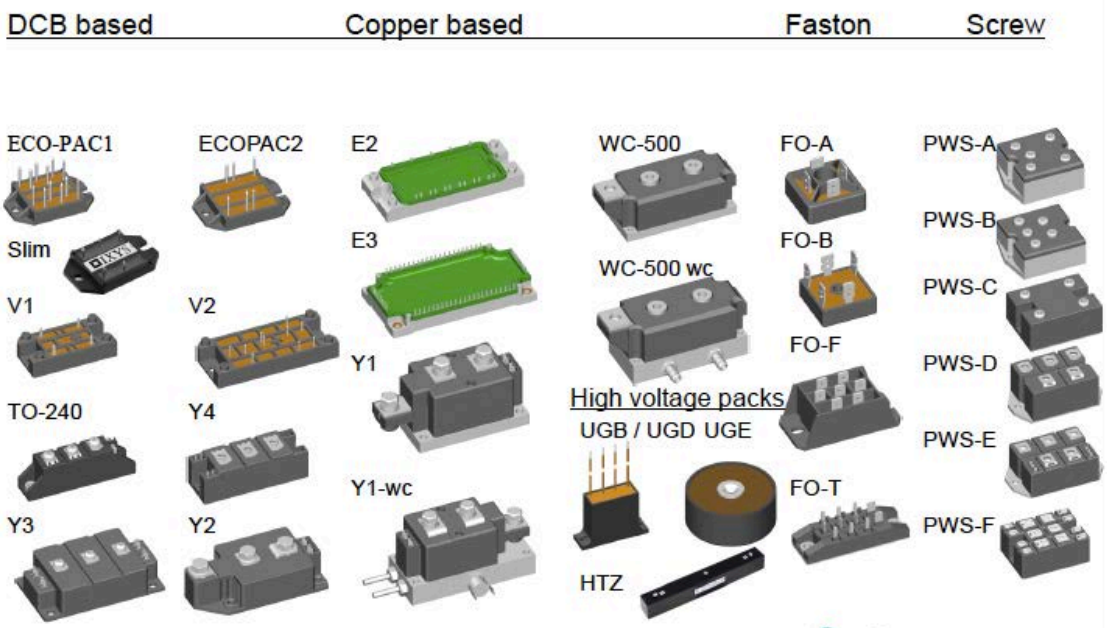


Fig. 1. DAB substrate with chip assembled.

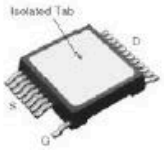
This paper deals with newly developed direct aluminum bonded (DAB) substrates which are proposed as an alternative to conventional DCB.

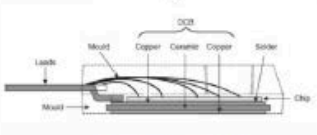
Bipolar Products – Package Overview



I. PROPRIETARY PACKAGING TECHNOLOGIES

- ISOPLUS™ Technology
- Surface Mount Power Device (SMPD) Packages
- High Voltage Packages





IXYS PACKAGING TECHNOLOGIES

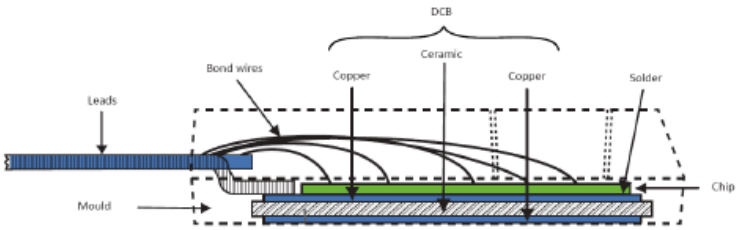
Package Technology	Features/Advantages
ISOPLUS™ Technology	▪ Low thermal resistance ▪ Space savings ▪ Increased power and temperature cycling ▪ Reduced EMI ▪ High reliability ▪ 3, 4, or 5 lead configurations available ▪ 3500V electrical isolation ▪ Low parasitics
Surface Mount Power Device (SMPD) Packages	▪ Ultra-low and compact package profile (5.3mm height x 24.8mm length x 32.3mm width) ▪ Surface mountable via standard reflow process (Available in Tape & Reel packaging) ▪ Low package weight (8g) ▪ Up to 4500V ceramic isolation (DCB) ▪ Low package inductance ▪ Excellent thermal performance ▪ High power cycling capability ▪ High frequency performance
High Voltage Packages	▪ Increased distance between leads ▪ Arc-prevention in high voltage applications ▪ Electrical isolated tab for heat sinking ▪ Excellent thermal performance ▪ Best-in-class power and temperature cycling capabilities

ISOPLUS™ Technology

FEATURES

- Incorporates a DCB ceramic isolator
- Provides UL recognized 3500Vrms isolation
- Isolation continues above 4000V
- DCB substrate provides lower thermal resistance and higher load cycling capability
- JEDEC TO-247,PLUS220, & TO-264 compatibility
- Low thermal resistance (Up to 40% lower (R_{thJS}) than std. packages w/same die & external isolation)
- Reduced EMI/RFI emissions due to low coupling capacitance between die & heat sink
- Space & weight savings
- Transfer molded housing for low cost
- Allows creative circuit configurations

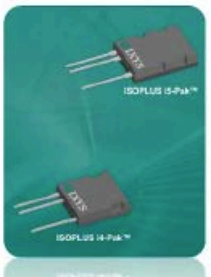
IXYS ISOPLUS US Patents: 420,983,
6,534,343B2
6,583,505B2
6,710,463B2
6,727,585B2
6,731,002B2
7,005,734B2
6,404,065B1



ISOPLUS™ Packages

Highest power density and reliability

- ISOPLUS i4-Pak™
- ISOPLUS i5-Pak™
- ISOPLUS DIL™



Features

- Low thermal resistance
- Increased power and temperature cycling
- High reliability
- Reduced EMI
- 3, 4, 5 lead configurations available

Applications

- Full diode bridges
- Phase leg configurations
- Buck converters
- Boost converters
- Electric and hybrid electric vehicles applications

Surface Mount Power Device (SMPD) Packages

Ultra-low profile SMPD package

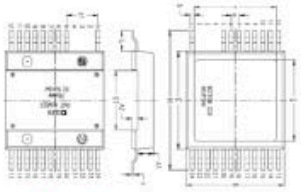
SMPD	SOT-227	TO-264	PLUS247
Height=5.3mm	Height=8.92mm	Height=4.8mm	Height=4.8mm

The above accentuates the compact and low profile nature of the device. Compared to a conventional high power package such as the SOT-227, the IXYS SMPD features ¼ the weight and 1/3 the volume and provides similar electrical and thermal characteristics.

SMPD ADVANTAGES
- Ultra-low and compact package profile (5.3mm height x 24.8mm length x 32.3mm width)
- Surface mountable via standard reflow process (Available in Tape & Reel packaging)
- Low package weight (8g)
- Up to 4500V ceramic isolation(DCB)
- Low package inductance
- Excellent thermal performance
- High power cycling capability

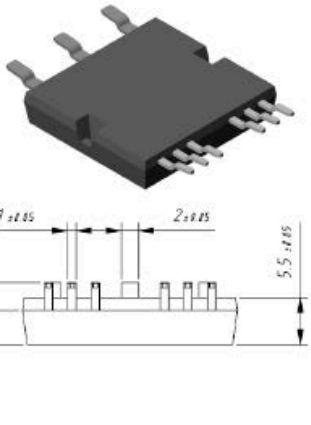
CONFIGURATIONS
- Buck
- Boost
- Full-bridge
- Half-bridge
- Phase leg
- Single

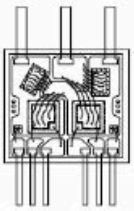
APPLICATIONS
- DC-DC converters
- Battery chargers
- Switching and resonant power supplies
- DC choppers
- Temperature and lighting controls
- Motor drives
- E-bikes and electric and hybrid vehicles
- Solar inverters
- Induction heaters



IGBT INTRODUCTIONS

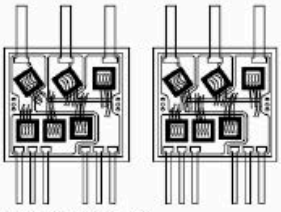
- **XPT IGBT -> 10 – 50A, 1200V**
- **ISOPLUS SMPD -> Surface Mount Power Device**





Inverter V12

Vce monitoring, small high voltage diode integrated in this version



Eingangsbrücke V3

Surface Mount Power Device (SMPD) Packages

Light and compact Mini SMPD package

Mini-SMPD	SMPD	SOT-227	TO-264	PLUS247
Height=5.3mm	Height=5.3mm	Height=8.92mm	Height=4.8mm	Height=4.8mm

The figure above illustrates a comparison of the Mini-SMPD with other industry standard packages. The volume of it (1.8cm³) is only at 60% of that of the SMPD (3cm³). But the Mini SMPD is able to maintain a high voltage isolation of 4.5kV and weighs just 5g.

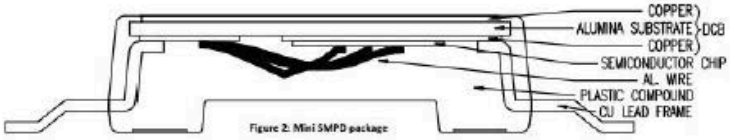
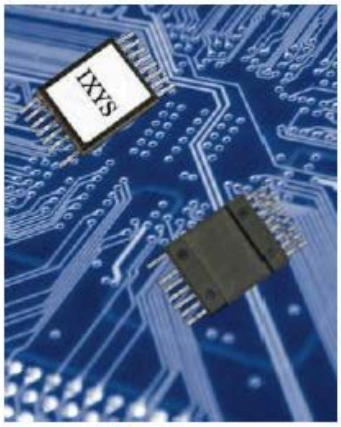


Figure 2: Mini SMPD package

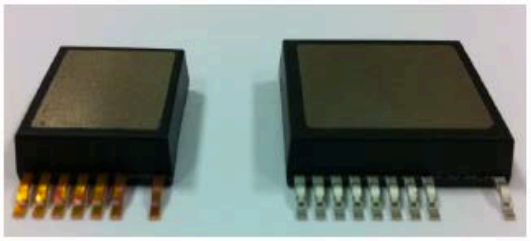


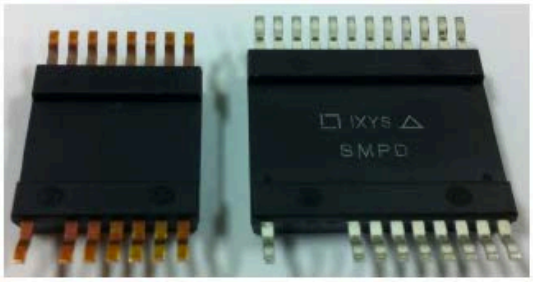
Mini SMPD ADVANTAGES

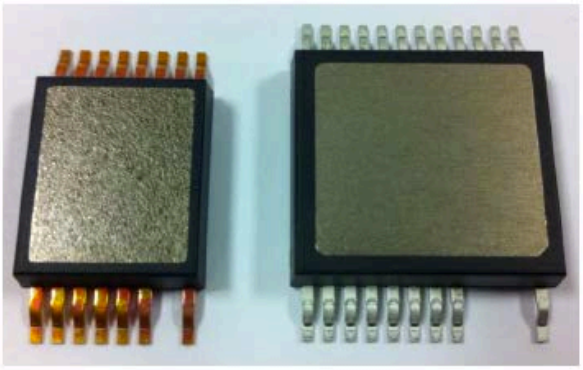
- High-voltage electrical isolation (4500V)
- Lower thermal resistance compared to standard packages (TO-247, TO-264, SOT-227B)
- High component density/flexible configurations (H-bridge, half-bridge, boost, buck, phase-leg)
- High current carrying capability
- Low parasitic capacitances and inductances
- Low package weight (5g)
- Better protection against vibrations and g-forces

Applications: Electric and hybrid vehicles, E-bikes, battery chargers, DC-DC converters

Compact Small Die SMPD Package



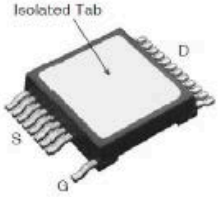




Volume Comparison	
Mini SMPD	SMPD
0.102 cubic inches	0.183 cubic inches

GigaMOS™ TrenchT2™ MOSFETs in SMPD Package (40V - 150V / 235A - 600A)

FEATURES
- Silicon chip on Direct Copper Bond (DCB) Substrate
- Excellent thermal transfer
- Increased temperature and power cycling capabilities
- 175°C operating Temperature
- Very high current handling capability
- Fast intrinsic diode
- Avalanche rated
- Very low $R_{DS(on)}$



MMIX1T600N04T2
MMIX1T550N055T2
MMIX1F520N075T2
MMIX1F360N15T2

MMIX1F520N075T2
"MMIX" denotes SMPD Package
"F" denotes HiPerFET™
"T2" denotes TrenchT2™

SMPD Advantages:
- Ultra-low and compact package profile
- 5.3mm height x 24.8mm length x 32.3mm width
- Surface mountable via standard reflow process
- 4500V ceramic isolation (DCB)
- Very high power cycling capability
- Excellent thermal performance
- Low package weight (8g)

APPLICATIONS
- DC-DC converters, off-line UPS, primary-side switch, high speed power switching applications

Q3-Class HiPerFET™ Power MOSFET in SMPD Technology (1000V, 30A)

More Power, Less Package (ultra-low profile, energy efficient, and rugged)
MMIX1F44N100Q3

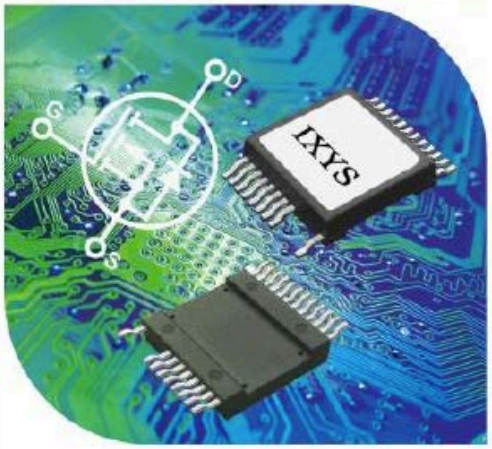
Features:
- Low $R_{DS(on)}$ and gate charge Q_g
- Low intrinsic gate resistance
- Fast intrinsic rectifier
- Excellent dv/dt performance
- High avalanche energy rating
- High power density

Applications:
- DC-DC converters
- Battery chargers
- Switching and resonant power supplies
- DC choppers
- Temperature and lighting controls

SMPD Advantages:
- Ultra-low and compact package profile
- 5.3mm height x 24.8mm length x 32.3mm width
- Surface mountable via standard reflow process
- 4500V ceramic isolation (DCB)
- Very high power cycling capability
- Excellent thermal performance
- Low package weight (8g)

Reduce The Size of Your High Power Design

1000V Q3-Class HiPerFET™ Power MOSFET in SMPD Package Technology



Q3-Class HiPerFET™ Features:
- Low $R_{DS(on)}$ & Q_g
- Low Intrinsic Gate Resistance
- Fast Intrinsic Rectifier
- Excellent dV/dt Performance
- High Avalanche Energy Capabilities
- High Speed Switching Capabilities
- High Noise Immunity

SMPD Package Features:
- Compact, Ultra-low Package Profile (5.3mm height x 24.8mm length x 32.3mm width)
- 2500V Ceramic Isolation (DCB)
- Very High Power Cycling Capability
- Excellent Thermal Performance
- Low Package Weight (8g)
- High Power Density

Applications:
- DC-DC Converters
- Battery Chargers
- Switch-Mode and Resonant-Mode Power Supplies
- DC Choppers
- Temperature and Lighting Controls

Part Number	VDSS Max (V)	ID(cont) TC=25°C (A)	RDS(on) max TJ=25°C (Ω)	Ciss Typ (pF)	Qg Typ (nC)	trr Max (ns)	PD (W)	RthJC Max (°C/W)	Package Style
MMIX1F44N100Q3	1000	30	0.245	13600	264	300	694	0.18	SMPD

IXYSPOWER *Efficiency Through Technology*

EUROPE	USA	ASIA
IXYS GmbH	IXYS Power	IXYS Taiwan/IXYS Korea
marcom@ixys.de	sales@ixys.com	sales@ixys.com.tw

www.ixys.com

IXYSPOWER NEW PRODUCT BRIEF

1000V Q3-Class HiPerFET™ Power MOSFET in SMPD Technology

August 2012

OVERVIEW

FEATURES
- Low $R_{DS(on)}$ and gate charge (Q_g)
- Low intrinsic gate resistance
- Fast intrinsic rectifier
- Excellent dv/dt performance
- High power density
- High avalanche energy rating

SMPD ADVANTAGES
- Ultra-low and compact package profile (5.3mm height x 24.8mm length x 32.3mm width)
- Surface mountable via standard reflow process
- Low package weight (8g)
- 2500V ceramic isolation (DCB)
- Low package inductance
- Excellent thermal performance
- High power cycling capability

APPLICATIONS
- DC-DC converters
- Battery chargers
- Switching and resonant power supplies
- DC choppers
- Temperature and lighting controls

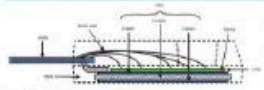
SMPD Q3-Class HiPerFET Power MOSFET Summary Table

Part Number	V_{DSS} max (V)	$I_{D(cont)}$ T_C=25°C (A)	$R_{DS(on)}$ max T_J=25°C (Ω)	C_{iss} typ (pF)	Q_g typ (nC)	t_{rr} max (ns)	P_D (W)	R_{thJC} max (°C/W)	Package Style
MMIX1F44N100Q3	1000	30	0.245	13600	264	300	694	0.18	SMPD

Ultra-low profile SMPD package

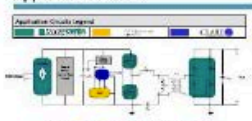
The above figure accentuates the compact and low-profile nature of the device. Compared to a conventional high power package such as the SOT-227, the IXYS SMPD features 1/10 the weight and 1/3 the volume and provides similar electrical and thermal characteristics.

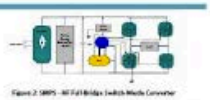
Direct Copper Bond (DCB) isolation

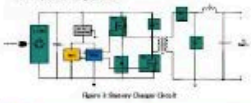


- Provides 2500V ceramic isolation
- Improves temperature and power cycling capabilities
- Reduces $EAS/RF1$ due to low coupling capacitance between die and heat sink
- Lowers thermal resistance (R_{thJC})
- Allows new circuit configurations

Application Circuits

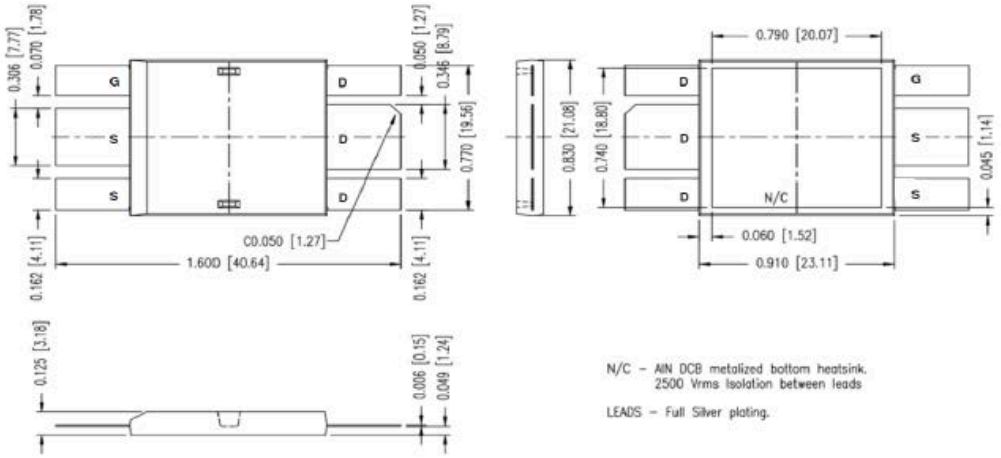






DE-Series Packaging (DE475)

- IXYS DE-Series packages offer 10 times the speed, 3 times the power dissipation, with ½ the volume, 1/3 the weight and greatly reduced die stress, of comparable conventional device packages



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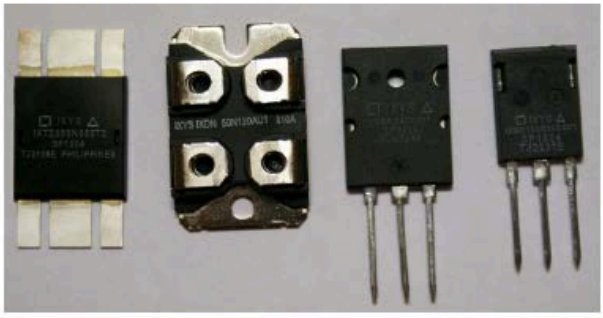
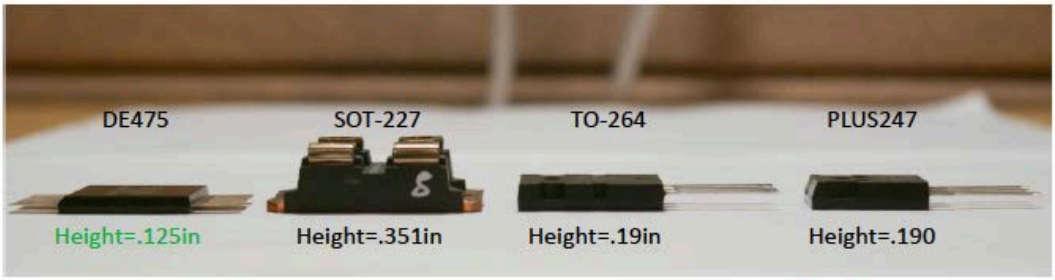
DE-Series Packages (DE475)

Visual comparison of DE475 vs. Conventional High Power Packages





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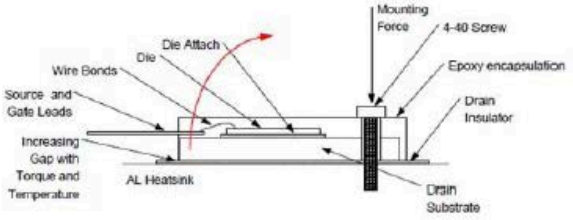
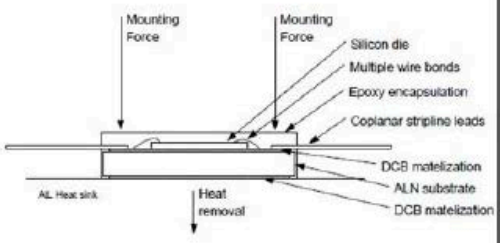
DE-Series Packages

Thermal and Mechanical Advantages



Cross sectional view: TO-247



Cross sectional view: DE475

- Conventional packages warp as indicated by the red arrow above, leading to a loss of thermal contact, a lower power handling capability, and an increase in mechanical die stress.

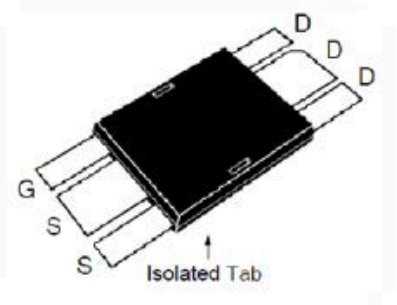
- Less cumbersome mounting technique.
- Direct Copper Bond (DCB) isolation
- Low thermal impedance and die stress

IXYS

GigaMOS™ TrenchT2™ MOSFETs in DE475 Package (55V – 75V / 465A – 550A)

TrenchT2™ MOSFETs in the ultra-low profile DE-Series package!

FEATURES
- Silicon chip on Direct-Copper Bond (DCB) Substrate
- Isolated substrate
  - excellent thermal transfer
  - increased temp and power cycling capabilities
  - high voltage isolation (2500V~)
- 175°C operating temperature
- Very high current handling capability
- Fast intrinsic diode
- Avalanche rated
- Very low $R_{DS(on)}$



ADVANTAGES
- Easy to mount, space savings, high power density

APPLICATIONS
- DC-DC converters,
- Off-line UPS,
- Primary-side switch,
- High speed power switching applications

IXTZ550N055T2
IXFZ520N075T2
"Z" denotes DE475 package
"F" denotes HiPerFET™ MOSFET
"T2" denotes TrenchT2™

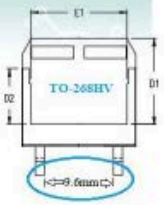
High Voltage Packages

Proprietary high-voltage versions of international standard size packages

- TO-247HV
- TO-263HV
- TO-264HV
- TO-268HV

Increased creepage distance between leads

- Prevents arcing in high voltage applications
- 2 times greater creepage distance of TO-263HV (4.28mm) and TO-268HV (9.6mm), compared to the standard version packages

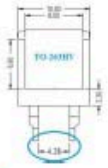


Elimination of multiple series-connected lower-voltage devices

- Simplification and reduction in grate drive circuitry
- PCB space savings
- Parallel operation possible thanks to positive temperature coefficient of $R_{DS(on)}$

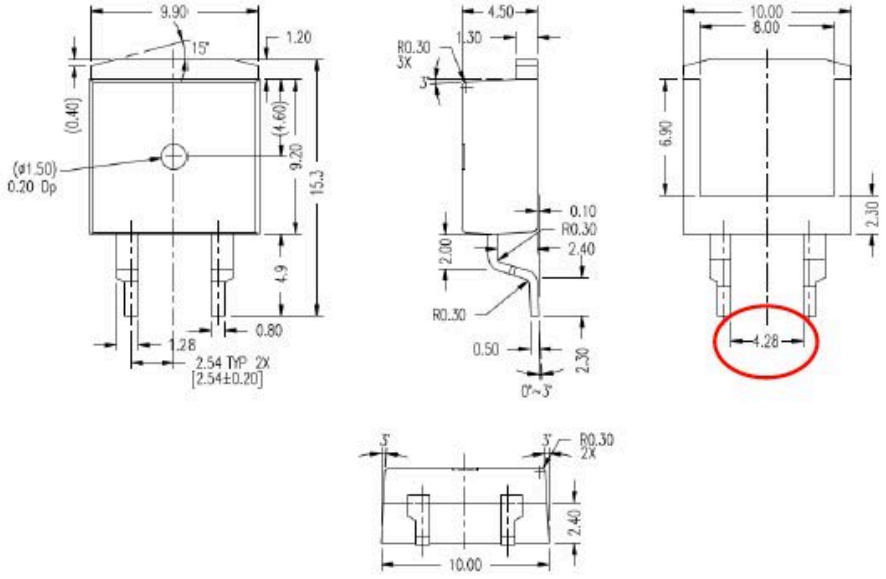
Up to 4500V Direct Copper Bond (DCB) isolation

- Electrically isolated tab for heat sinking
- Provides excellent thermal performance
- Best-in-class power and temperature cycling capabilities



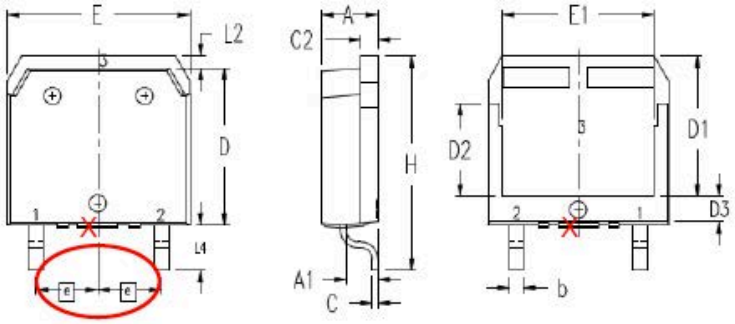
TO-263HV: High-Voltage 2-Lead TO-263

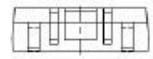
2 times greater creepage distance (4.28mm) for high voltage applications!



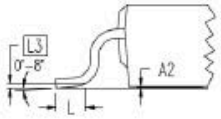
TO-268HV: High-Voltage 2-Lead TO-268

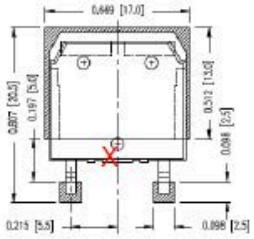
2 times greater creepage distance (9.6mm) for high voltage applications!





1 – GATE
2 – SOURCE (EMITTER)
3 – DRAIN (COLLECTOR)





[slide 13 was a video, not included here]