Capitalizing on the Advantages of ISOPLUS Products

Introduction

IXYS Corporation offers unique power packages with internal isolation, and performance and reliability advantages. The IXYS isolated packages include ISOPLUS220™, ISOPLUS247™, ISOPLUS i4-PAC™, ISOPLUS264™ as well as the new ISOPLUS-DIL™ modules. The ISOPLUS advantages relative to the standard power packages include:

- Better electrical isolation
- Larger and multiple die
- Multiple circuit configurations
- Lower thermal resistance
- Higher reliability
- UL recognition has been granted to the ISOPLUS220, ISOLPUS247 and ISOPLUS i4-PAC
- Higher component density
- Easy clip assembly

This article will describe and quantify the ISOPLUS advantages and focus on mounting techniques and materials that optimize the ISOPLUS performance and capitalize on their inherent advantages. The focus will be on the ISOPLUS220 and ISOPLUS247 examples, but quantitative tools will be provided for the designer to apply the approach to all ISOPLUS packages.

Electrical Isolation

Electrical isolation between the power die and heatsink is provided by Direct-Copper-Bonded (DCB) ceramic substrates, which are integrated into the ISOPLUS packages as shown in Figure 1. The ceramic substrate provides superior isolation to most interface materials with isolation greater than 6,000 Vrms, which is higher than the isolation voltage to the leads based on creepage paths. The rated isolation for all products to date is 2,500V. The electrical isolation from leads to backside tab and leads to top of the plastic package where the clips apply force is 100% tested at 3,000 V for 10 seconds.

The ceramic in the DCB is alumina for standard products, but aluminum nitride can be substituted where extremely low thermal resistance is required and economically justified.

The integrated and molded DCB eliminates exposed electrically active cases, pads and tabs, which may need to be isolated from adjacent traces, components or mounting screws and hardware.

The DCB ceramic is immune to dielectric puncture and partial discharge, which can be troublesome with many external interface materials. This immunity to damage and AC wear-out further enhances the reliability of the ISOPLUS packages.

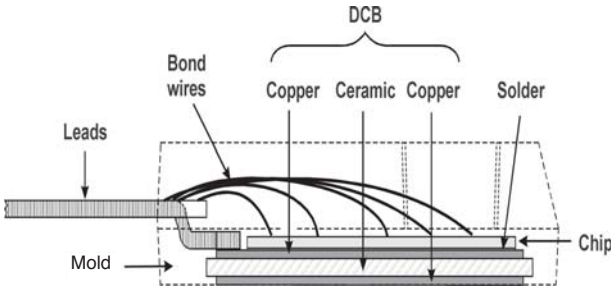


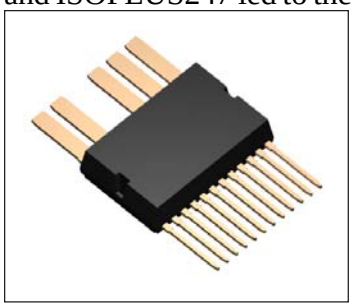
Fig. 1. Cross sectional view for the discrete ISOPLUS packages.

Larger and Multiple Dice

The ISOPLUS packages use the full package body for die attach area by extending the DCB substrate into the areas used for tabs and holes in the standard power packages. This allows larger and higher power die with a direct heat path to the bottom of the package. For example, the die in the ISOPLUS220 IXFC30N60P requires a larger TO-247 standard package to accommodate it and likewise, the die in the ISOPLUS247 must go into a TO-264 standard package. However, it should be noted that 'hole-less' non-isolated versions of the TO-220 and TO-247 packages, the PLUS220™ and PLUS247™, are also offered for very large die product. The use of smaller packages can increase board density and reduce board size and cost.

IXYS Corporation - www.ixys.com
3540 Bassett Street; Santa Clara, CA 95054; Ter: (408) 982-0700; Fax: (408) 496-0670

The ISOPLUS packages provide more internal space for multiple die and the DCB provides a natural technique for isolated metallization for multiple die attach pads and interconnecting traces. The multi-chip discrete power packages like the ISOPLUS220 and ISOPLUS247 led to the larger 4-lead and 5-lead



ISOPLUS264 and ISOPLUS i4-PAC as well as the ISOPLUS DIL modules, shown in the illustration with 5 power leads and 12 signal leads. Additional circuit configurations are now available in ISOPLUS package options. Examples include AC switches, buck and boost configurations with either MOSFETs or IGBTs, common anode or series connected diodes, half-bridge and new 3-phase, Trench MOSFET bridges in the ISOPLUS-DIL package.

Clip Assembly

The ISOPLUS packages eliminate the mounting hole to allow a large DCB substrate, which improves isolation, reduces thermal resistance and allows a larger internal die area. The elimination of the mounting hole has become another advantage of the ISOPLUS package, because it allows the use of component clips without special tab or hole isolation, and excessive isolation spacing.

Component clips can simplify assembly by eliminating mounting screws with their associated hardware like screws, threaded holes, washers and insulators. Furthermore, clips do not require controlled torque and clamping force as clips are pre-designed for a given clamping force for a given package thickness..

Interface materials like silicone grease and thermal pads are often use with lower force clamps, and such materials and clamps can be used with the ISOPLUS packages. New high performance phase change materials often require much higher clamping forces to achieve the lowest possible thermal resistance. Kunze Folien offers a number of high force clamps for power packages.

- The Power Clip KU4-498 is an excellent clip for the ISOPLUS220 or ISOPLUS247 providing clamping force of 23 lbs, or 90 lbs per square inch for these two packages.
- The Power Clip KU4-499 is an excellent clip for the ISOPLUS247, ISOPLUS264 and ISOPLUS i4-PAC providing for providing a mounting force of 29 lbs.for these packages.
- The KU4-495 is a dual clip for mounting either two ISOPLUS220 or ISOPLUS packages side-by-side.

The clamping force for the KU4-498 and KU4-499 power clips is shown in Figure 2 and is a function of clip displacement.. These clips are available in Multi Transistor Clip configurations, which can further simplify assembly, and multi transistor clips are easier to use with the ISOPLUS packages where all isolation is internal. Table 2 provides a Cross Reference between Kunze Power Clips and Power Semiconductor packages, both ISOPLUS and standard packages.

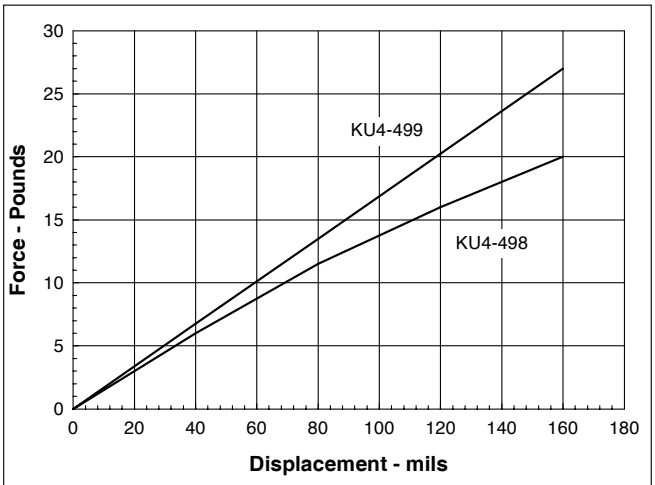


Fig. 2: Clamping force for the Kunze clips KU4-498 and KU4-499.

Thermal Resistance

The primary advantage of the ISOPLUS packages is that their exceptionally low thermal resistance

IXYS Corporation - www.ixys.com
3540 Bassett Street; Santa Clara, CA 95054; Tel: (408) 982-0700; Fax: (408) 496-0670

Table 1: Thermal Resistance Junction-to-Case Comparison of ISOPLUS Package Types to Standard Package Types

Package Type	ISOPLUS220	PLUS220*	ISOPLUS247	PLUS247*
Part Number	IXFC30N60P	IXFV30N60P	IFR64N60P	IXFX64N60P
Die Size (mm)	8.9X7.4	8.9X7.4	14.2x10.6	14.2x10.6
Clip Type	KU4-498	KU4-498	KU4-499	KU4-499
Interface-Conductive	KU-ALF 5	(NA)	KU-ALF 5	(NA)
Interface-Isolated	(NA)	KU-KG 2.5	(NA)	KU-KG 2.5
$R(th)_{JC}$ (max)	0.75 K/W	0.25 K/W	0.35 K/W	0.12 K/W
$R(th)_{CS}$(max)	0.07 K/W	1.74 K/W	0.05 K/W	0.93 K/W
$R(th)_{JS}$ (max)	0.82 K/W	1.99 K/W	0.40 K/W	1.05 K/W

* 'Hole-less' versions of the ISOPLUS220 and ISOPLUS247 packages respectively.

($R_{(th)js}$) from device junction to case, for power devices requiring isolation from the heatsink. The ISOPLUS packages can provide 10 to 50 percent lower $R_{(th)js}$ than standard packages with the same die and external isolation. The greatest thermal advantages occur with larger die products, which are the focus of the ISOPLUS products.

The ISOPLUS packages are already isolated allowing direct mounting to heatsinks. However, the use of silicone grease, thermal pads, or one of the high performance conductive phase-change materials be used to reduce contact resistance. Kunze Folien offers state-of-the-art conductive phase change material, like the KU-ALF 5. Its thermal resistance is plotted versus applied pressure in Figure 3. Kunze Folien also provides state-of-the-art isolated, phase change materials, like KU-KG 2.5 for standard power packages. However, their thermal resistance per area can be more than ten times greater as evidenced in Figure 4.

The product examples shown in Table 1 are representative of the improvements that can be achieved with in the ISOPLUS220 and ISOPLUS247 packages with larger die products and with the recommended interface materials shown above.

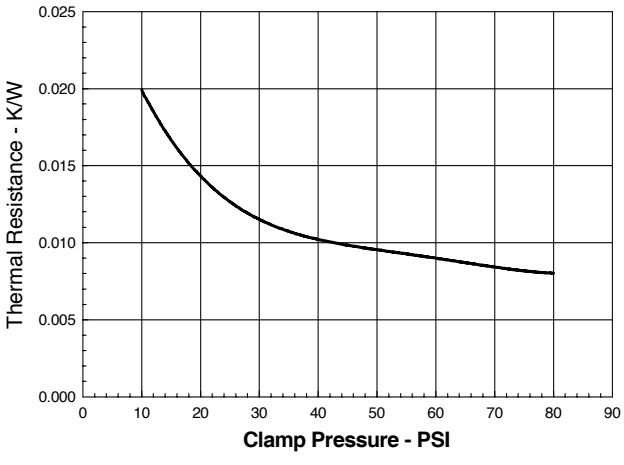


Fig. 3: KU-ALF 5 Thermal Resistance per Square Inch vs. Clamp Pressure.

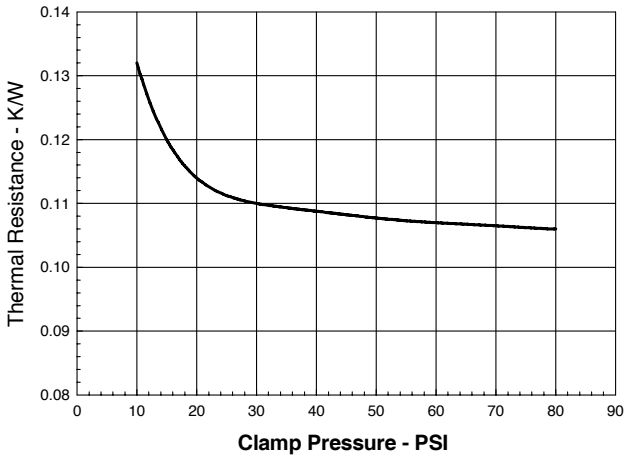


Fig. 4: KU-KG 2.5 Thermal Resistance per Square Inch vs. Clamp Pressure.

IXYS Corporation - www.ixys.com
3540 Bassett Street; Santa Clara, CA 95054; Ter: (408) 982-0700; Fax: (408) 496-0670

The above comparisons are based on ISOPLUS products with DCB alumina substrates. If the DCB alumina is replaced by DCB aluminum nitride, the thermal resistance can be reduced significantly because the thermal conductivity of aluminum nitride is 7 times higher than alumina.

Reliability

Power Semiconductor products are always limited by the Coefficient of Thermal Expansion (CTE) mismatch between the die and copper case. The CTE mismatch limits both die size, load cycle capability and temperature cycling reliability. In the ISOPLUS package, the die is attached to the DCB ceramic substrate, and CTE mismatch between the die and substrate is much less than between die and copper. This increases the ISOPLUS package reliability in temperature cycling, and allows the package to withstand larger temperature excursions and number of cycles without damage. The DCB substrate also allows the use of larger power die than can be used directly on copper.

Higher Component Density

A secondary advantage of the ISOPLUS packages is that they provide higher board densities.

The ISOPLUS packages accommodates larger die in a smaller package outline, and the isolated packages can be placed closer together. In some cases, groups of multiple isolated packages can clamped by single multiple fingered clips. Semicustom, cost effective configurations can be developd for qualified opportunites.

Table 2: Package Cross Reference for Kunze Power Clips

Package Type	Kunze Clip Model*
TO-3P	KU3-392, 3-396/24, 3-397, 3-399, 4-440/3.1, 4-440/4.0, 4-441, 4-443, 4-450, 4-453, 4-490
TO-3P Double	KU4-445
TO-220	KU3-381, 3-386, 3-387, 3-388, 3-389, 3-399, 4-440/3.1, 4-440/4.0, 4-441, 4-443, 4-450, 4-453, 4-490
TO-220 Double	KU4-430, 4-445, 4-495 Gull Wing Clip
TO-220 Multiple Transistors	KU4-498/X (X = number of transistors)
ISOPLUS220	KU4-498/X (X = number of transistors)
TO-247	KU3-392, 3-396, 3-397
TO-247 Double	KU4-495 Gull Wing Clip
TO-247 Multiple Transistors	KU4-499/X (X = number of transistors)
ISOPLUS247	KU4-499/X (X = number of transistors)
TO-247AD	KU3-393
ISOPLUS DIL	KU4-501
ISOPLUS i4-PAC	KU3-393, 3-395
TO-264 Multiple Transistor	KU4-499/X (X = number of transistors)
ISOPLUS264	KU4-499/X (X = number of transistors)

* Go to <www.heatmanagement.com> for clip and interface material data sheets.

IXYS Corporation - www.ixys.com
3540 Bassett Street; Santa Clara, CA 95054; Tel: (408) 982-0700; Fax: (408) 496-0670