

## APPLICATION NOTES

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AN-993

# Utilizing HEXFRED<sup>®</sup> Ultra-Fast Recovery Diode Die In Assembly

(HEXFRED is a trademark of International Rectifier)

by Keith Weinrich

## Introduction

This application note describes the HEXFRED<sup>®</sup> Ultra-Fast Recovery Epitaxial Diode available from International Rectifier in die and wafer form. These epitaxial diode die feature a proprietary, high reliability planar technology utilizing a guard ring structure for maximized ruggedness. Hybrid packaging of these die results in substantial savings in weight and volume compared to standard packaging, as well as significant improvements in electrical performance, particularly lead inductance. Most of the same parts are available in finished packages; thus, development work and evaluation can be easily performed before converting the design for die application. A cross reference of packaged product to die part numbers is included in this application note. HEXFRED die sizes presently available from International Rectifier are summarized in Table 1. Sizes less than or equal to 1.68 millimeters (0.066 inches) square are available in wafer form while all others are available in both wafer and die forms.

## Probing

Because of limitations when electrical probing in die form, some of the specifications of equivalent packaged devices cannot be tested or guaranteed in die form. Typically, these are high current forward characteristics and  $t_{rr}$ , high temperature characteristics, surge capability ( $I_{FSM}$ ), thermal resistance ( $R_{thJC}$ ) and series inductance ( $L_S$ ). However, each wafer is 100% probed at room temperature for maximum reverse voltage ( $V_R$ ), maximum reverse leakage current ( $I_R$ ), and low current forward voltage drop ( $V_F$ ).

During electrical probing, the rejected die are inked for identification. The wafer is then cut and the die mechanically separated. The rejected die are discarded and the remaining die are 100% visually inspected, loaded into waffle pack trays, and packed for shipment.

## Handling and Shipping

HEXFRED die from International Rectifier are classified as non-static sensitive devices but are packaged in conductive trays for convenience. The chip tray capacities for each die size are shown in Table 1. These trays are then sealed in electrostatic shielding bags for shipment. Wafers are shipped in non-conductive, polyethylene wafer carriers.

Once opened, the die must be stored in a dry, inert atmosphere, such as nitrogen, prior to assembly. Die should be handled with DuPont Teflon<sup>®</sup>-tipped vacuum pencils to prevent mechanical damage. Any non-conformance to the electrical or visual inspection specifications in this application note must be reported in writing to International Rectifier within 30 days after shipment of the lot. International Rectifier assumes no responsibilities for die which have been subjected to further processing, such as mount-down, wire-bonding, or encapsulation. In the interest of product improvement, International Rectifier reserves the right to make design or processing changes without prior notice.

## Visual Inspection of Die

International Rectifier HEXFRED die are designed to meet the visual inspection criteria of Mil-Standard 750, Method 2072, and are visually screened to a 0.04% AQL level.

## Mounting Backside (Cathode) of Die

The HEXFRED die have a aluminum/titanium/nickel/silver cathode metallization which is suitable for either solder paste or solder preform mounting using solders such as 92.5%/5%/2.5% Pb/In/Ag solder. It is recommended that solders containing silver are used due to silver dissolution of the backside metal in the absence of silver in the solder.

Any of the commonly used header or substrate materials, such as copper and copper-plated beryllia or alumina, are acceptable. The substrate must be free of oxides prior to assembly either by chemical cleaning or hydrogen pre-firing techniques. Mounting of HEXFRED die is generally accomplished in a profiled belt furnace or by using a hotplate reflow technique. Infrared or vapor phase reflow are also acceptable methods for die mounting. If using solder paste, cleaning must always be performed afterwards.

The furnace zone settings will depend upon hybrid mass, material, fixturing, and belt speed. HEXFRED die characteristics are sensitive to maximum temperatures during the die attach process. The maximum temperature and duration above 300°C is critical for its performance. The suggested profile is 345°C (+15°, -5°C) peak with the duration above 300°C to be no more than 7.0 minutes (+/-0.5). See Profile 1 and 2 for typical profiles of the die and furnace ambient temperatures during die attach. Trade-offs of higher temperatures are 1) decreasing the  $V_F$  and  $I_R$  and 2) increasing the  $t_{TR}$ ,  $I_{RRM}$ , and  $Q_{TR}$ . A clean furnace of hydrogen atmosphere is recommended, although an atmosphere of nitrogen or forming gas (nitrogen-hydrogen, 85%-15%) is acceptable.

It is also possible to mount the die using conductive adhesives, although this is not currently used in production at International Rectifier.

### Molybdenum Tabs

In solder applications, due to thermal expansion stresses exerted on the larger die sizes (200 mil/side and greater), International Rectifier recommends the use of molybdenum or other thermally matched tabs on the anode and cathode. The selection of tab material and/or plating must be such that it can be soldered to the silver metallization of the top and bottom metals.

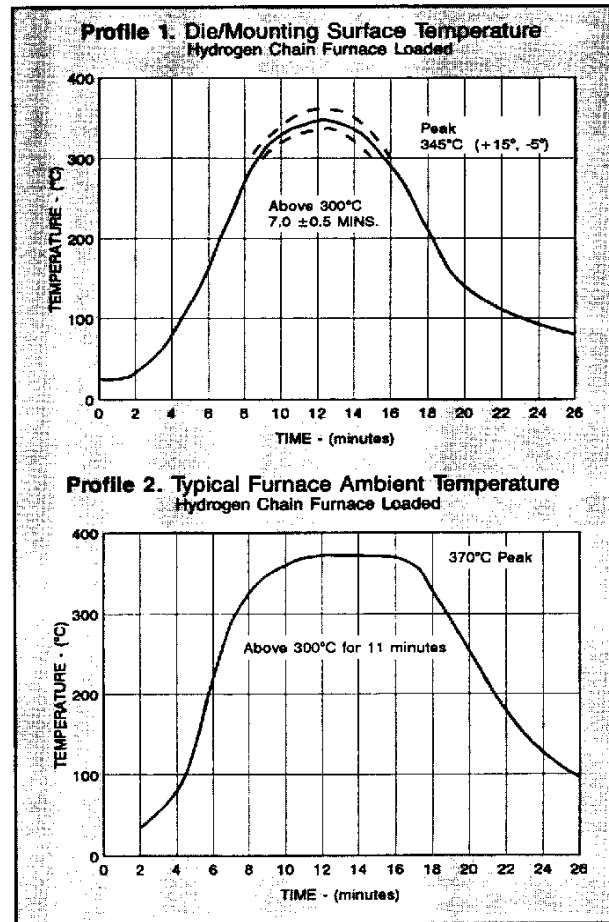
### Anode Connection

Electrical connection to the anode should be a solder connection for all devices with silver top metallization. For all parts with aluminum top metallization, electrical connection to the anode is by ultrasonic bonding with aluminum wire. The wire diameter and number of wires should be chosen to suit the current requirements. For enhanced reliability, all copper piece parts that come into contact with the anode metallization must be nickel-clad or nickel-plated to eliminate copper contact with the anode.

Caution must be exercised during wire bonding to ensure that the bonding footprint remains within the bonding pad area; otherwise, device failure can result. The bonding pad area is centered on the die and the outside edges of the die are not part of the bonding area so neither solder, in the case of silver metallization, nor wire, in the case of aluminum metallization, may make contact with the perimeter or oxide passivation. The bonding pad area is different for each die size and the dimensions of each are listed in Table 1.

Likewise, wire bonding equipment settings should be optimized and a wire pull test performed (e.g., see Method 2037, Mil Standard 750) to monitor wire bond strength

Note: Teflon is a trademark of DuPont.



uniformity. Destructive sample testing and 100% non-destructive testing is recommended. Re-bonding of wire bond rejects can be performed although decreased yield can be expected from such reworks.

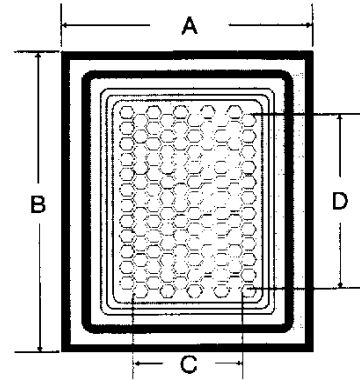
### Encapsulation

Prior to encapsulation, the die or assembly should be kept in a moisture-free environment. For non-hermetic packaging, a semiconductor grade silicone elastomer may be applied. Cleaning of the die or assembly prior to coating is recommended. Immediately prior to encapsulation, especially for hermetic packages, a 150°C, two-hour bake should be performed to remove any surface moisture. Capping of hermetic packages should be performed in a dry-nitrogen atmosphere.

### Conclusion

The use of HEXFRED die for hybrid assemblies can result in significant reduction in overall package size and significant improvements in performance and efficiency. In addition, several HEXFRED die can readily be mounted on the same heatsink to form circuit configurations or to parallel devices. The operational advantages of International Rectifier HEXFRED Ultra-Fast Recovery Epitaxial Diodes, thereby, can be realized in very compact, custom package configurations. □

**FIGURE 1. HEXFRED Die Outline (shaded area simulates the passivation).**



**NOTES:**

- 1) All dimensions correspond to TABLE 1.
- 2) Dimensions are referenced from die center.
- 3) Die thickness is (0.0145) 0.3683 +/- (0.0005) 0.0127
- 4) Die length and width tolerance is +/- (0.003) 0.0762

**TABLE 1. HEXFRED Die**

Wafer (1) Part Number	Die (2) Part Number	Die Size	Die "A x B" Length/Side (in.)mm	Bond Pad "C x D" (in.)mm	Anode Metallization (topside)	Tray Quantity
HFAW06-60A	N/A	06	(0.066x0.066) 1.68x1.68	(0.037x0.037) 0.94x0.94	Aluminum	N/A
HFAW06-60S	N/A	06	(0.066x0.066) 1.68x1.68	(0.037x0.037) 0.94x0.94	Silver	N/A
HFAW10-60A	HFAC10-60A	10	(0.090x0.090) 2.29x2.29	(0.062x0.062) 1.58x1.58	Aluminum	196
HFAW10-60S	HFAC10-60S	10	(0.090x0.090) 2.29x2.29	(0.062x0.062) 1.58x1.58	Silver	196
HFAW20-60A	HFAC20-60A	20	(0.107x0.130) 2.72x3.30	(0.056x0.080) 1.42x2.03	Aluminum	100
HFAW30-60A	HFAC30-60A	30	(0.115x0.155) 2.92x3.94	(0.064x0.104) 1.63x2.64	Aluminum	100
HFAW40-60A	HFAC40-60A	40	(0.169x0.220) 4.29x5.59	(0.117x0.169) 2.97x4.29	Aluminum	35
HFAW40-120A	HFAC40-120A	40	(0.169x0.220) 4.29x5.59	(0.112x0.163) 2.85x4.14	Aluminum	35
HFAW42-40A	HFAC42-40A	42	(0.200x0.200) 5.08x5.08	(0.170x0.170) 4.32x4.32	Silver	49
HFAW42-40S	HFAC42-40S	42	(0.200x0.200) 5.08x5.08	(0.180x0.180) 4.57x4.57	Aluminum	49

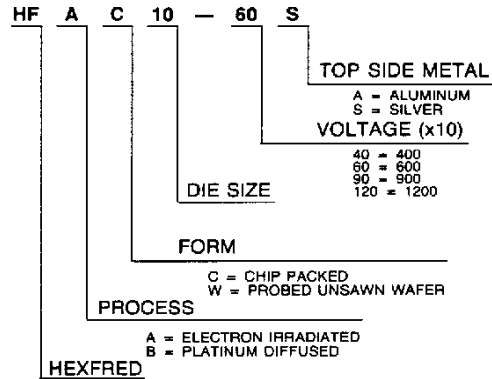
- (1) Die in probed un-cut, wafer form
- (2) Die in probed wafer pack form

**TABLE 2. HEXFRED Die**

Die Number	Wafer Probe Limits			Cross Reference Part Number (1)
	V <sub>RRM</sub> 100µA min. (V)	I <sub>R</sub> @ V <sub>RRM</sub> max. (µA)	V <sub>FM</sub> @ 1.0A max. (V)	
HFAC06-60A	600	5	1.3	HFA04TB60 HFA08TA60C
HFAC06-60S	600	5	1.3	HFA04AC60
HFAC10-60A	600	5	1.1	HFA08TB60 HFA16TB60C
HFAC10-60S	600	5	1.1	HFA06AD60
HFAC20-60A	600	10	1.1	HFA08SD60
HFAC30-60A	600	10	1.1	HFA15TB60 HFA30TA60C
HFAC40-60A	600	20	0.85	HFA25TB60
HFAC40-120A	1200	20	1.2	HFA20TB120
HFAC42-40A	400	20	0.85	NA
HFAC42-40S	400	20	0.85	NA

- (1) Cross reference to packaged devices for general information only.

**Chart 1. Nomenclature Code for HEXFRED Die**



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**WORLD HEADQUARTERS:** 233 KANSAS ST., EL SEGUNDO, CA 90245, U.S.A. (310) 322-3331, FAX (310) 322-3332, TELEX: 66-4464  
**EUROPEAN HEADQUARTERS:** HURST GREEN, OXTED, SURREY RH8 9BB, ENGLAND TEL: (0883) 713215, FAX (883) 714234, TELEX 95219