Utilizing SCHOTTKY Rectifier Die In Assembly

by Bret Daniels

Introduction

This application note describes the Schottky rectifiers 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.

Characteristics

Schottky die sizes presently available from International Rectifier are summarized in Table 1. These sizes range from 43.3 (1.100) to 275 (6.985) mil/side (mm/side). Sizes 43.3 and 66.1 are available only in wafer form while all others are available in both wafer and die forms. The evolution of International Rectifier Schottky diodes has resulted in four unique processes and six voltage grades. The *OR'ing, Low V_F Efficient, Standard,* and *"830" processes* have each been optimized to minimize power dissipation based upon the electrical and thermal requirements of various applications and operating modes. The *six voltage grades* available are 15V, 30V, 45V, 60V, 100V, and 150V.

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, high temperature characteristics, surge capability (I_{FSM}), thermal resistance (R_{thJC}), series inductance (L_S), and avalanche (E_{AS} and I_{AR}). 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

Schottky 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®-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, IR reserves the right to make design or processing changes without prior notice.

Visual Inspection of Die

International Rectifier Schottky rectifier 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 Schottky die have a 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 Schottky 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 preforms or solder paste, cleaning must always be performed afterwards.

The furnace zone setting will depend upon hybrid mass, material, fixturing, and belt speed. The Schottky die temperature must not exceed 400°C, nor be in the range of 350 to 400°C for greater than one minute. 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.

International Rectifier offers standard options of molybdenum tabs soldered to the anode, cathode, or both. These are available in both round and square configurations and various sizes appropriate for a particular die size. These options are listed in Table 2. To order die with molybdenum tabs add the suffix number of the option required to the end of the die part number.

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 Schottky barrier.

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

Note: Teflon is a trademark of DuPont.

Table I

Schottky Rectifier Die

Wafer(1) Part Number	Die(2) Part Number	Die "A" Length/Side (in.) mm	Bond Pad "B" Length/Side (in.) mm	Anode Metallization (topside)	Process	Tray Quantity
SC043H100SWB	N/A	(0.0433) 1.10	(0.0362) 0.92	Silver	830	N/A
SC043S040SWB	N/A	(0.0433) 1.10	(0.0362) 0.92	Silver	Standard	N/A
SC043S060SWB	N/A	(0.0433) 1.10	(0.0362) 0.92	Silver	Standard	N/A
SC066H100AWB	N/A	(0.0661) 1.68	(0.0591) 1.50	Aluminum	830	N/A
SC066H100SWB	N/A	(0.0661) 1.68	(0.0591) 1.50	Silver	830	N/A
SC066S040AWB	N/A	(0.0661) 1.68	(0.0591) 1.50	Aluminum	Standard	N/A
SC066S040SWB	N/A	(0.0661) 1.68	(0.0591) 1.50	Silver	Standard	N/A
SC066S060AWB	N/A	(0.0661) 1.68	(0.0591) 1.50	Aluminum	Standard	N/A
SC066S060SWB	N/A	(0.0661) 1.68	(0.0591) 1.50	Silver	Standard	N/A
SC090H045AWB	SC090H045A	0.0900 (2.29)	0.0700 (1.78)	Aluminum	830	196
SC090H150AWB	SC090H150A	0.0900 (2.29)	0.0700 (1.78)	Aluminum	830	196
SC090S045AWB	SC090S045A	0.0900 (2.29)	0.0700 (1.78)	Aluminum	Standard	196
SC125R015SWB	SC125R015S			Silver	OR'ing	100
SC125H045AWB	SC125H045A	0.125 (3.18)	0.105 (2.67)	Aluminum	830	100
SC125H045SWB	SC125H045S	0.125 (3.18)	0.105 (2.67)	Silver	830	100
SC125H100AWB	SC125H100A	0.125 (3.18)	0.105 (2.67)	Aluminum	830	100
SC125H100SWB	SC125H100S	0.125 (3.18)	0.105 (2.67)	Silver	830	100
SC125H150AWB	SC125H150A	0.125 (3.18)	0.105 (2.67)	Aluminum	830	100
SC125S030AWB	SC125S030A	0.125 (3.18)	0.105 (2.67)	Aluminum	Standard	100
SC125S045AWB	SC125S045A	0.125 (3.18)	0.105 (2.67)	Aluminum	Standard	100
SC125S045SWB	SC125S045S	0.125 (3.18)	0.105 (2.67)	Silver	Standard	100
SC125S060AWB	SC125S060A	0.125 (3.18)	0.105 (2.67)	Aluminum	Standard	100
SC150H045AWB	SC150H045A	0.150 (3.81)	0.130 (3.30)	Aluminum	830	49
SC150R015AWB	SC150R015A	0.150 (3.81)	0.130 (3.30)	Aluminum	OR'ing	49
SC150S045AWB	SC150S045A	0.150 (3.81)	0.130 (3.30)	Aluminum	Standard	49
SC175H045SWB	SC175H045S	0.175 (4.45)	0.155 (3.94)	Silver	830	49
SC175H100AWB	SC175H100A	0.175 (4.45)	0.155 (3.94)	Aluminum	830	49
SC175H100SWB	SC175H100S	0.175 (4.45)	0.155 (3.94)	Silver	830	49
SC175S045AWB	SC175S045A	0.175 (4.45)	0.155 (3.94)	Aluminum	Standard	49
SC175S045SWB	SC175S045S	0.175 (4.45)	0.155 (3.94)	Silver	Standard	49
SC175S060AWB	SC175S060A	0.175 (4.45)	0.155 (3.94)	Aluminum	Standard	49
SC200E045SWB	SC200E045S	0.200 (5.08)	0.180 (4.57)	Silver	Efficient	36
SC200H045SWB	SC200H045S	0.200 (5.08)	0.180 (4.57)	Silver	830	36
SC200H100AWB	SC200H100A	0.200 (5.08)	0.180 (4.57)	Aluminum	830	36
SC200H100SWB	SC200H100S	0.200 (5.08)	0.180 (4.57)	Silver	830	36
SC200R015SWB	SC200R015S	0.200 (5.08)	0.180 (4.57)	Silver	OR'ing	36
SC200S030SWB	SC200S030S	0.200 (5.08)	0.180 (4.57)	Silver	Standard	36
SC200S045SWB	SC200S045S	0.200 (5.08)	0.180 (4.57)	Silver	Standard	36
SC275H045SWB	SC275H045S	0.275 (6.99)	0.255 (6.48)	Silver	830	25
SC275H100SWB	SC275H100S	0.275 (6.99)	0.255 (6.48)	Silver	830	25
SC275S030SWB	SC275S030S	0.275 (6.99)	0.255 (6.48)	Silver	Standard	25
SC275S045SWB	SC275S045S	0.275 (6.99)	0.255 (6.48)	Silver	Standard	25

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

(2) Die in probed waffle pack form

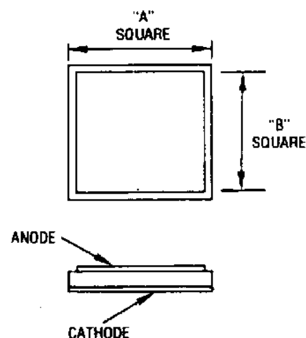
(3) All die and bond pads are square (see diagram next page)

Table II Schottky Molybdenum Tab Suffixes and Descriptions

Suffix Number	Applicable Die Size	Top Moly (Anode)	Shape	Bottom Moly (Cathode)	Shape
J01	0.200 (5.08)	0.150 (3.81) dia.	Round	N/A	—
J02	0.200 (5.08)	0.150 (3.81) dia.	Round	0.283 (7.19) dia.	Round
J03	0.200 (5.08)	0.150 (3.81) dia.	Round	0.215 (5.46) dia.	Square
J04	0.200 (5.08)	N/A	—	0.283 (7.19) dia.	Round
J05	0.200 (5.08)	N/A	—	0.215 (5.46) dia.	Square
J06	0.200 (5.08)	0.150 (3.81) dia.	Square	N/A	—
J07	0.200 (5.08)	0.150 (3.81) dia.	Square	0.283 (7.19) dia.	Round
J08	0.200 (5.08)	0.150 (3.81) dia.	Square	0.215 (5.46) dia.	Square
J09	(These suffix numbers are for future use.)				
J10					
J11					
J12	0.175 (4.45)	0.125 (3.18) dia.	Round	N/A	—
J13	0.175 (4.45)	0.125 (3.18) dia.	Round	0.250 (6.35) dia.	Round
J14	0.175 (4.45)	0.125 (3.18) dia.	Round	0.190 (4.83) dia.	Square
J15	0.175 (4.45)	N/A	—	0.250 (6.35) dia.	Round
J16	0.175 (4.45)	N/A	—	0.190 (4.83) dia.	Square
J17	(These suffix numbers are for future use.)				
J18					
J19					
J20	0.275 (6.99)	0.190 (4.83) dia.	Round	N/A	—
J21	0.275 (6.99)	0.190 (4.83) dia.	Round	0.295 (7.49) dia.	Square
J22	0.275 (6.99)	N/A	—	0.295 (7.49) dia.	Square

NOTES:

1) All dimensions are inches (mm)
2) Solder joints are 0.002 (0.508) thick typical
3) Die thickness is 0.0145 (0.3683) +/-0.0005 (0.0127)
4) Die length and width tolerance is +/-0.003 (0.0762)
5) Top moly is 0.010 (0.254) thick and bottom moly is 0.020 (0.508) thick
6) Moly thickness tolerance is +/-0.002 (0.0508)
7) Moly length and width tolerance is +/-0.002 (0.508)



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