International
IOR Rectifier

APPLICATION NOTE

AN-1060

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BARE DIE:
HANDLING AND STORAGE

By Richard Clark

Introduction

International Rectifier supply a range of power devices in a variety of packages and in Bare Die form. The Bare Die products are available in a variety of formats from whole wafers to ChipPak. All of these products, whether packaged or unpackaged, require best storage and handling practices to be adopted.

The purpose of this guidance note is to look specifically at the handling and storage of Bare Die products. A few precautions in the storage, handling, die mounting and wire bonding should help to minimise product introduction time and minimise production losses.

Some International Rectifier Bare Die products are unpassivated. These products may be more susceptible to handling damage on the top surface of the die. The pick-up tools and collets used by automatic handling equipment may need to be optimised in terms of design (shape) and materials of composition.

Note that: it is not the intension of this document to 'specify' or 'recommend'; it is only a means of presenting some basic guidance. However, where a statement has been extracted from an IR document or International Standard it will be appropriately identified and cross-referenced.

Packing/ Carrier Type

Bare Die are available in several formats to accommodate the customer's prototype or production requirements. These include:

- Whole wafer
- Sawn wafer on film and frame,
- ChipPak or Waffle pack – individual die picked from sawn wafer and placed into waffle tray.
- Pocket tape, tape and Reel – individual die on continuous feed reel.

All containers and carriers for Bare Die products are labelled and sealed to protect the die from damage or contamination. It is important that these seals are only broken when the package is in a suitable clean environment, such as a lamellar flow station of FS 209 Class 1000 (ISO 14644 Class 6) or better. All receipt and inspection operations must be performed under clean conditions optimised for handling Bare Die products.

Storage

All Bare Die products sold on film or tape will have a limited shelf life due to the deterioration of the adhesive used on the film/ tape, i.e. typically the adhesion strength increases in time. These products are 'built to order' in order to minimise the risk to the customer. Therefore, it is recommended that these products are purchased, stored and used in a controlled manner within three months, to prevent loss of yield or productivity.
Note that this is a property of the adhesive and not the wafer or die.

Bare Die products need to be stored in a temperature, humidity and contamination controlled environment. The optimum storage conditions for Bare Die products are:

- Particle count: Class 1000 or better.
- Temperature: 65ºF to 75ºF (18ºC to 24ºC)
- Humidity: <30%
- Nitrogen: Dryness < 4 ppm ~ -114ºC dew point.

The above storage conditions were extracted from JEDEC Standard JESD 49 "Procurement Standard for Known Good Die".

All die products should be stored in this environment when not in use. This includes the 'as received' product still in its sealed packaging and partly used 'work in progress' product. It may, however, be wise to separate the 'as received' stock from 'work in progress' to avoid any potential for cross contamination and to minimise the disruption of the controlled environment in the 'work in progress' compartment or cabinet.

Bare Die products that are stored for longer periods of time than recommended by the 'due date' or warranty period should be inspected on a routine basis to verify the condition of the die to look for signs of contamination, oxidation or corrosion. Bare Die on film or tape should also be checked for ease of removal.

Handling and Transfer

Bare Die products are electronic components and as such should be regarded as static sensitive, in the same as any other electronic component. Full ESD precautions should be followed during all operations.

Bare Die products should be handled with great care at all times and should remain secure in their carriers except during unloading or inspection operations at dedicated workstations. Exposure of wafers or Bare Die to the general working environment, even in a cleanroom, can results in contamination or damage.

Singulated die in a ChipPak tray or waffle pack will not rotate or flip provided that the paper and lid are in place. Without the lid, the slightest disturbance could cause mis-orientation of die.

For low volume and engineering runs it may not be cost effective to use specialised automated die handling equipment. In these situations manual handling may be employed.

It is imperative in these situations that tweezers, of any form, are not used to pick up, transfer or place bare die. Tweezers often cause mechanical damage to the die, whether to the top surface in the form of scratches, or to the bulk silicon in the form of chip-outs, micro-cracks and cracks.

This damage is sometimes visible during subsequent inspection but often does not manifest until electrical testing. For example, a scratch causing a bridge between metal tracks may be visible at inspection and if tested should cause a short. But, a crack in the bulk silicon may effectively introduce an area of insulation that may manifest itself as high RDSon failure at test. Sometimes the damage may be latent, presenting a reliability hazard.

For these reasons it is recommended that any manual die handling operation use suitably designed tools such as vacuum pencils with carefully selected tips for sawn-edge pick-up. There are a number of suppliers of such instruments. One recommended supplier is Research Instruments Limited (http://www.research-instruments.com).

Where automated die pick and place equipment is used a soft silicon/ rubber tip or 4-sided inverted pyramid collet of suitable size should be used. This is particularly important for unpassivated die where mechanical damage may occur causing device failure. Routine inspection and cleaning of the tips or collets is recommended to avoid 'die to die' contamination or mechanical damage. The pick and place pressure should also be minimised to prevent physical damage that may cause failure or performance degradation

Mounting (Die Attach)

International Rectifier wafers, and hence die, are coated with metal on the back side. Details of the metallization scheme are shown on the Bare Die product datasheet. The purpose of the back metallization is to provide a good thermal and electrical interface between the die and die attach material. The back-metal is also solderable, therefore providing customers with the widest possible choice of die attach options from conductive epoxies to specialised lead-free solders. The final choice of die attach or solder material will depend on the performance requirements of the device. All Bare Die product datasheets show device performance based on the die assembled in a specific package. The die attach commonly used for this assembly is a lead-free solder.

Whichever die attach material is used it is important that the die are placed with sufficient precision to produce a uniform, void free, secure attachment. For solder die attachment there should be minimal fillet on all sides and must not encroach onto the top surface. For epoxy die attach there should be a fillet of at least 50% of sidewall height on at least three side of the die, but no encroachment to the top surface.

The presence of voids in the die attach or solder may restrict thermal and electrical flow between the die and circuit board. This may result in a general performance degradation or catastrophic failure where localised hot spots occur at the void resulting in thermal avalanche.

Wire Bonding

International Rectifier cannot recommend bond wire selection or bonding conditions to customers of Bare Die products. Information regarding the bond wire and arrangement used by International Rectifier for the package identified in the specific die datasheet can be made available but this will not imply any recommendation or liability.

It is recommended that all customers select bond wire and arrangement to best suit their needs and that the bonding operation is optimised by careful design of experiments (DOE) using their own specific equipment base.

General precautions to take during bonding include:

- Monitoring of bond wire properties, particularly hardness.
- Clean wire bond workstation to minimise contamination.
- Pre bonding inspection of die to verify condition of bond 'pad'.
- Careful selection (DOE) of bonding parameters in conjunction with bond wire properties for optimum device performance and reliability.
    - A common bonding defect is cratering
    - The level of cratering is influenced by bond wire hardness and ultrasonic energy.

Appendix A demonstrates how a DOE, in its simplest form, could be used to find improved operating conditions for a process. The attached example uses wire bonding parameters. However, any process where a number of factors (parameters) can be adjusted to produce an improved or optimum response, could be achieved using this technique.

Appendix A: DOE Title

Aluminium Wire Bonding using Bertie Bonder

Note: All results and comments in this guidance note have been contrived for demonstration purposes only.

Synopsis:

The aim of this experiment was to determine the optimum aluminium wire bonding to a new device, MOSFET5, using the Bertie Bonder. The results showed that a bond force of X3 and ultrasonic power of Y1 gave the best combination of bond pull and aged bond pull results.

Team Members:

Process:

- *Wire bond with 20mil Al wire using Bertie Bonder*

Objectives:

- *The objective of this experiment is to identify the optimum bonder settings to produce strong reliable bonds consistently.*
- *New device - MOSFET5*
- *Bond wire must be 20mil aluminium.*
- *Bond wire loop height must not exceed ZZmil.*

Responses:

- *Bond pull*
- *Bond pull after simulated aging of the bond (combination of temperature cycle and high temperature storage)*

Factors and Factor Settings:

Three factors will be considered in this experiment at two levels, above and below current bonding settings for similar device. Factors are:

- *Bond force*
- *Ultrasonic power*
- *Time*

Experimental Design:

Sample size: Each run will consist of – 10 strips, 10 devices per strip and three bonds to source pad per device. For this experiment all devices will be taken from the same wafer.

Run Number	Bond Force	Ultrasonic Power	Time
5	X1	Y1	T1
3	X1	Y1	T3
8	X1	Y3	T1
2	X1	Y3	T3
9	X3	Y1	T1
6	X3	Y1	T3
1	X3	Y3	T1
4	X3	Y3	T3
7	X2	Y2	T2

Experimental Results:

Samples of strips from each run inspected and confirmed to conform to visual inspection criteria and bond loop height constraints.

Table showing summary (mean) results.

Run Number	*Bond Pull*	*Aged Bond Pull*
5	*11*	*12*
3	*10*	*11*
8	*7*	*9*
2	*7*	*8*
9	*20*	*13*
6	*17*	*12*
1	*12*	*10*
4	*12*	*9*
7	*12*	*9*

Data Analysis:

[Include key graphs and tables]
For example:

	Run Number:	5	3	8	2	9	6	1	4	7	Ave BP	Ave ABP
Bond Force	X1	5	3	8	2						8.75	10
	X2									7	12	9
	X3					9	6	1	4		15.25	11
Ultrasonic Power	Y1	5	3			9	6				14.5	12
	Y2									7	12	9
	Y3			8	2			1	4		9.5	9
Time	T1	5		8		9		1			12.5	11
	T2									7	12	9
	T3		3		2		6		4		11.5	10

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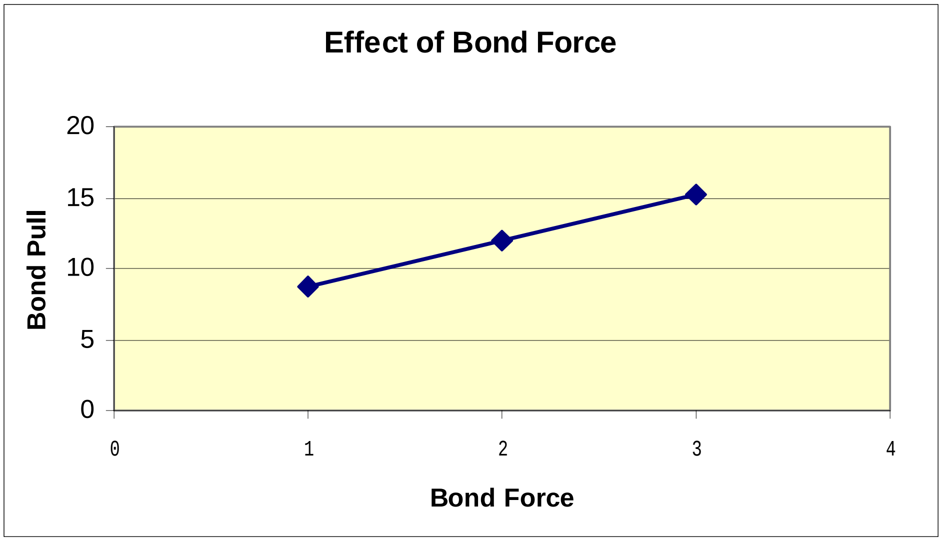

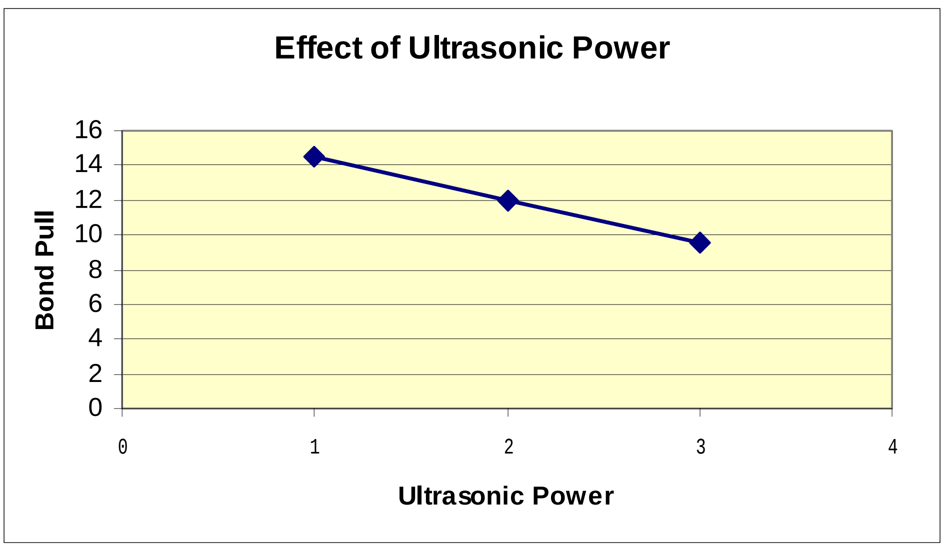

Conclusions and Recommendations:

- *Bond force X3 and Ultrasonic power Y1 gave the highest bond pull and aged bond pull results.*

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