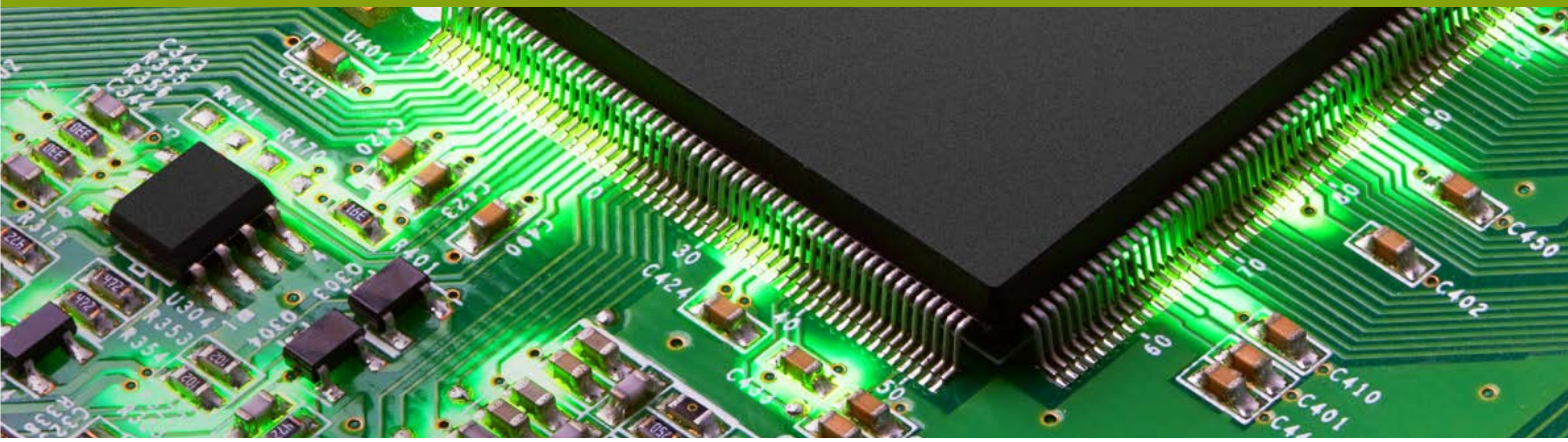
BondTesting of Memory Devices

Application Note



New test software is required to achieve virtually zero landing force when testing the bond strength of ball bonds on overhanging die within semiconductor packaging. This article looks at the challenges and solutions to performing bond shear on overhanging die surfaces.

Rapid advances in semiconductor packaging technology continue to drive bondtesting capability. The testing of interconnections within stack die commonly found in system-in-package (SIP) devices presents a number of new and exciting challenges. Overhanging die in particular can be difficult to bond test because of complications such as thin spacing between die and low profile wire bonding. An industry wide solution for the shearing of ball bonds underneath overhanging die has yet to be perfected. However with the aid of new software the traditional problem of die surface deflection associated with the load tool landing on an overhanging die surface has been solved.

Ball Shear on Overhanging Die

One of the problems in performing ball shear on overhanging die is the possible deflection of the die surface during load tool landing and setting the required step back. In this case step back is defined as the distance between the tip of the load tool and the surface adjacent to the bond. Alternative terms are step up or shear height. This complication can be overcome by the use of an oscillating load tool in combination with new test software which controls the sequence of operations during bondtesting.

Test Sequence

The first step is the normal touch down, where the shear tool lands on and detects the overhanging die surface. (Figure 1 shows a typical alignment of the shear tool during touch down.)

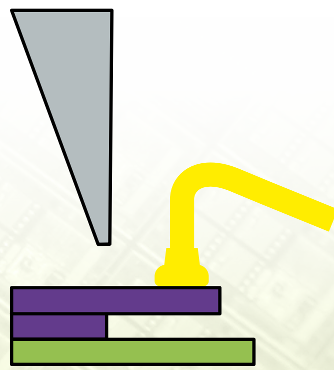


Figure 1. Alignment of shear tool with ball bond

Next, following tool landing, the Y-axis is oscillated with a small amplitude to induce an oscillating force that is detected by the transducer. (Figure 2 shows tool landing and oscillating a small amount to produce a measurable force.)

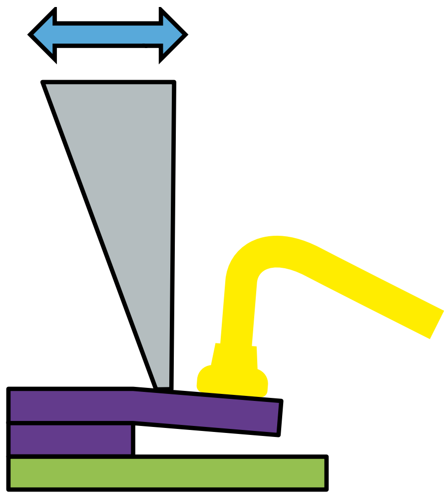


Figure 2. Shear tool lands and oscillates producing a measurable force on the transducer

The Z-axis is then raised a small step for each oscillation until no output is measured by the transducer. This position represents the point of contact between the shear tool and the overhanging die surface at which there is zero or minimal landing force. (Figure 3 shows shear tool being raised until the oscillating force is reduced to zero.)

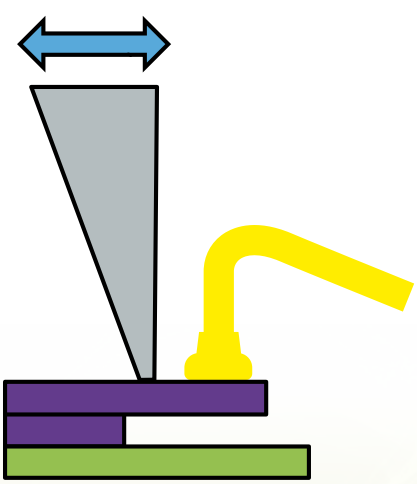


Figure 3. Shear tool being slowly raised until oscillating force is reduced to zero

Normal step back is applied to the shear tool at this point. Although step back is controlled, shear height may vary if vertical thrusts occur during the actual bondtest. Such thrusts can be minimized using a cavity shear tool. This will be described later. (Figure 4 shows the step back of the shear tool followed by bond shear.)

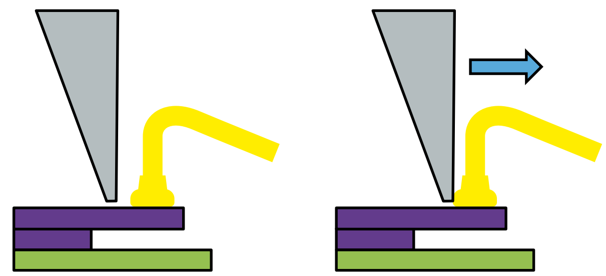


Figure 4. Step back of the shear tool followed by bond shear

This new test procedure has a slightly longer duration as the system finds the zero landing force condition prior to actual bondtesting. The additional time is generally dependent upon the amount of deflection exhibited by the overhanging die surface.

Bondtester Requirements

Coping with the problem of overhanging die deflection is just one aspect of bondtesting these type of packages. In the following other requirements are considered.

Bonds on overhanging die are small and pitches tend to be fine, so the bondtester needs to be highly accurate and repeatable and this can only be achieved using advanced technology. This requires that the system have frictionless, air-bearing, ball shear load cartridges with sub-micron step back and +/- 0.25 micron step back accuracy.

New load tool designs need to be optimized, such as cavity shear for small bonds with passivation layers.

A high magnification optical system is required to achieve tool alignment and bond failure mode grading; for example using a Borescope imaging system.

Due to the low forces involved, it is essential that the bondtester is equipped with a built in self-leveling, self-damping, anti-vibration system. Precision control for accurate sample manipulation is also important.

Borescope Imaging System

Traditional stereomicroscopes have large diameter object lenses which give a long working distance (typically 140mm) and inadequate depth of focus for small geometry ball or bump shear applications. (Figure 5 shows a typical view through a stereomicroscope.)

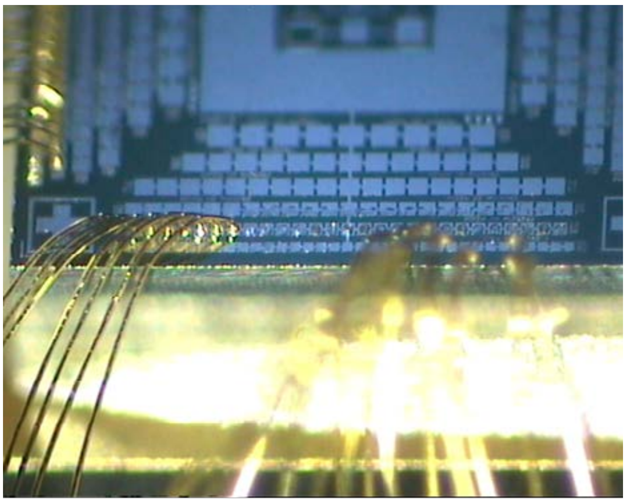


Figure 5. Typical view as seen through a stereomicroscope with 128X optics and 0.2mm FOV

Operators carrying out ball shear typically find it more convenient to align the load tool to the ball bond by viewing the package on a screen with a monocular image provided by a Borescope. The shorter working distance of the Borescope provides the higher magnification not achievable with conventional stereomicroscopes. The higher magnification improves the grading process following a shear test. (Figure 6 shows a view as seen through a Borescope.)

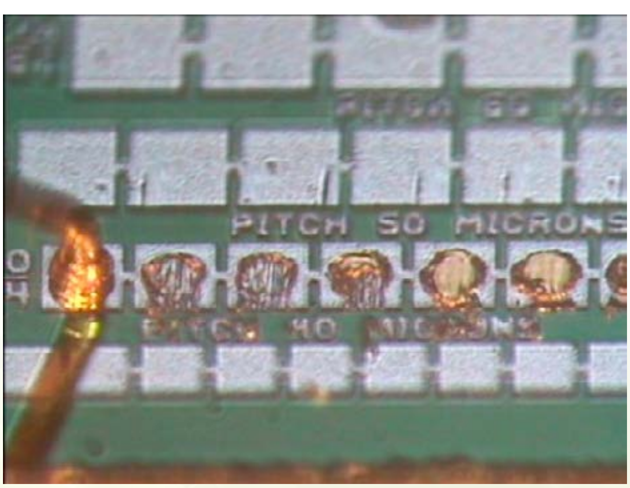


Figure 6. Typical view as seen through a Borescope with 330 micron FOV

Cavity Shear

Cavity shear tools have many advantages for the testing of ultra fine pitch bonds on overhanging die. Overall, using cavity shear tools improves the accuracy and quality of the bond strength test data. This improvement is achieved in several ways. A cavity shear tool helps to overcome the sensitivity to minimum step back height which occurs when the load tool lands on a passivation layer. Compared with a conventional shear tool, a cavity shear tool evenly distributes the force over the surface of the bond substantially increasing the load applied to the bond area.

Anti-Vibration System

As geometries reduce, the influence of ambient vibration on accurate bondtesting becomes more significant. This depends on the location of the bondtester within a test laboratory or manufacturing facility. Therefore provision should be made to isolate the machine from vibration.

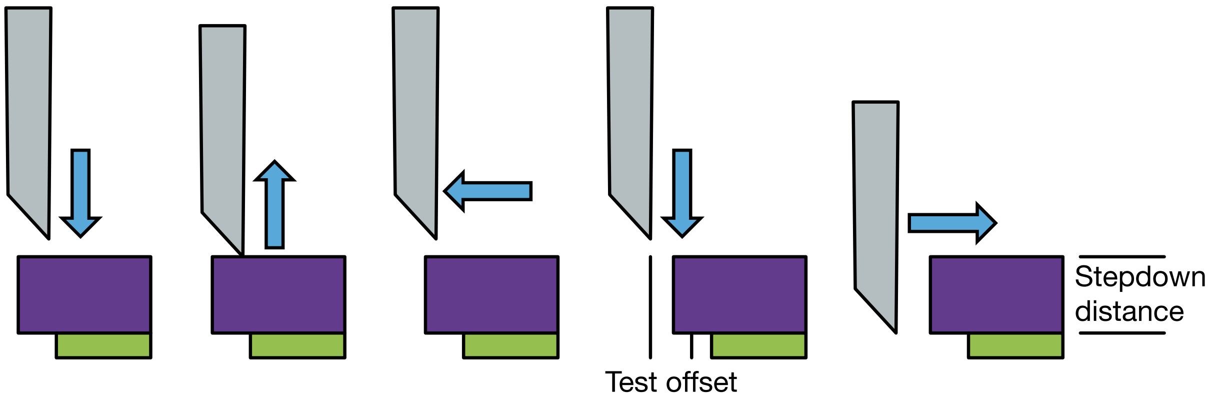
Unchecked vibration will adversely affect instrument calibration, test results and the optical image quality at high levels of magnification. As described earlier, an oscillating load tool technique is used during the overhanging die ball shear cycle and in order for this technique to be effective it is important that the machine is immune from unwanted ambient vibration. This may be achieved using a system of antivibration mounts that are self-leveling and self-damping.

Precision Control

The final feature necessary for bondtesting on overhanging die is high precision sample manipulation. Precise alignment of the shear tool to the ball bond during setup and test is critical. Precise X and Y-axis movements are necessary for easy manipulation through coarse and fine alignments by the operator. The Z-axis motion control of the bondtester needs a sub-micron resolution. The landing force of the shear tool must be reduced in proportion to the smaller landing area of the tool tip. For example, if the width of the load tool face is halved then the landing force must be reduced by a factor of four.
Sequential testing of bonds may at the correct shear height be achieved in two ways; joystick step and repeat automation, where the co-ordinates of the first and last bonds are entered together with the pitch, or auto pitch testing where the pitch is entered and the tool pauses before shearing the next bond to allow grading. This level of automation in ultra fine pitch applications is only possible with the appropriate precision in XY table manipulation.

Step Down Shear

Shearing the overhanging die poses an immediate problem with shear height due to inconsistent and non-planar surfaces. In order to overcome this problem the step-down shear sequence can be used in conjunction with soft land.



Conclusion

Further developments in semiconductor packaging will foster the use of overhanging die for the foreseeable future. Testing the bond strength integrity on the various surfaces of these complex packages remains an industry challenge. However, use of a proper test sequence, combined with new test software, a special toolset and a self-damping anti-vibration system all enable effective bondtesting on overhanging die surfaces.

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