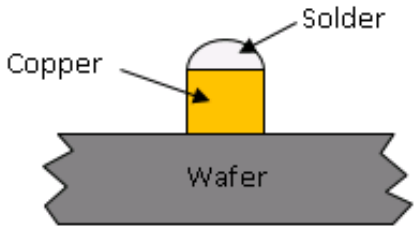
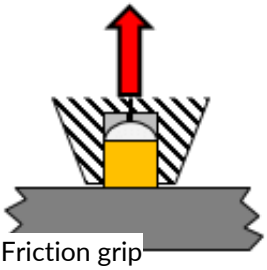


The Condor Sigma can test copper pillars down to 35µm diameter

Copper pillar testing

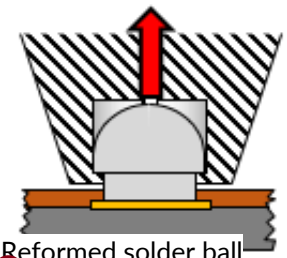
- Copper to pad interconnect
  - Pull testing
  - Shear testing
- Solder to copper interconnect
  - Cold bump pull testing
  - Shear testing
- Sensor accuracy ±0.075%
- Down to 35µm diameter copper pillars



Friction grip

Introduction

Copper Pillar is rapidly being adopted as a bumped wafer interconnect. The construction is that of a Copper cylinder around 50µm in diameter and height, topped with a dome of solder.



Reformed solder ball

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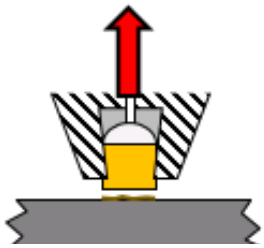
As with any interconnect the quality of the bonding process between the different parts is vital for the reliability of the finished product. The bond between the copper and its pad on the wafer are of particular interest as this is seen as the most likely failure mode. In a bond test a failure mode between the copper and wafer is then the “Failure mode of interest”. If you are more interested in the solder to copper interconnect, click here.



Pull test copper pillar gripped with two tapered cavities

Copper to pad interconnect

Pull testing

This failure mode can be produced by either a pull or a shear test and the measured bond strength used for your process control. In many other applications pull testing is typically preferred because the bond is subjected to a simple tensile load, distributed over the bond area. The bond separation is clean making failure mode analysis of the surfaces relatively easy. Unlike solder bumps, Copper is relatively hard and gripping it therefore easier.

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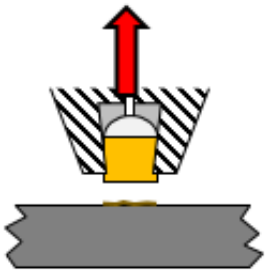
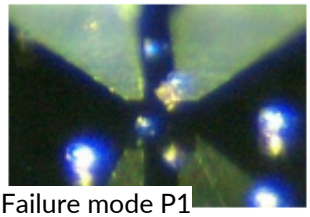
Constant Closing Force 220g Step back 25µm		
Sequence	Result (g)	Failure mode
1	30.8950	P1
2	28.7756	P1
3	38.5604	P1
4	39.8527	P1
5	28.8891	P1
6	34.6535	P1
7	38.7797	P1
8	42.4205	P1
9	33.4713	P1
10	39.9420	P1
Average	35.6240	
StdDev	4.9610	

Example of typical pull test results for Copper pillar

Solder balls require precise reforming in order to be able to apply a meaningful test load on to the bond. Copper also has to be reformed in order to be able to grip it but this takes the form of well know gripping methods such as plain surfaces and friction, a few serrations that slightly reform the copper in order to get a mechanical grip or a slight tapper.



Failure mode P1



Failure mode P1

Shear testing

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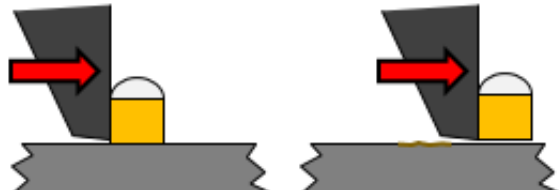
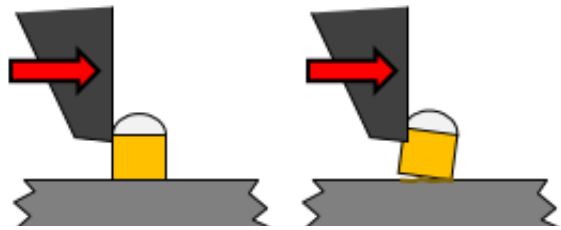
An alternative to pull testing is a shear test. If this is done with a very low shear height the bond is subjected to mostly shear. If a high shear height is used the bond is loaded by shear and a bending moment. It is though the bending loads, and in particular the tension side of the bending moment, that typically cause the bond to fail. The pillar tends to pivot on its edge furthest from the shear tool, making the failure mode very similar to that of a pull test.



Copper pillar low shear height and bond fails in shear

The advantages of a high shear test are that the tool and test are much simpler. Making pull tweezers with 50µm cavities is difficult and costly. Aligning them to the pillar takes time and requires skill. A shear test is no different to that commonly used when testing wire bonds. The only difference being the shear height is bigger. The tools cost a lot less and its alignment to the pillar is not so critical, making it less skilled and faster.



Copper pillar high shear height and bond fails in tension

Variations in shear height will cause variations in the test result but with the Condor Sigma accuracy of ±1µm these affects are likely to be less than those caused by the grip reforming and operator misalignment in a pull test. It is though beneficial to test with the highest possible shear height as this reduces any effect from the small variations in height and assures that the bending moment dominates the failure mode.

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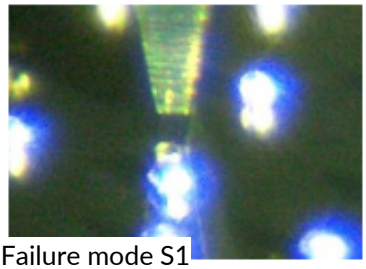
Shear Test Step back 35µm		
Sequence	Result (g)	Failure mode
1	18.5413	S1
2	17.9513	S1
3	19.0650	S1
4	19.3856	S1
5	21.8356	S1
6	17.0694	S1
7	19.3770	S1
8	17.3289	S1
9	15.7519	S1
10	16.9914	S1
Average	18.3297	
StdDev	1.7081	

Example of typical shear test results for Copper pillar

For a solder ball a Cold Bump Pull test is known to be better than shear. A 1st bond Gold ball test is best done with a low shear height. The reason for both of these comes from our "Golden rules of bond testing" ©, they both produce the highest number of failure modes of interest or the highest possible test force.

Failure mode S1



Failure mode S1

In the case of Copper pillars we should be guided by these same rules. Shear is the simplest test

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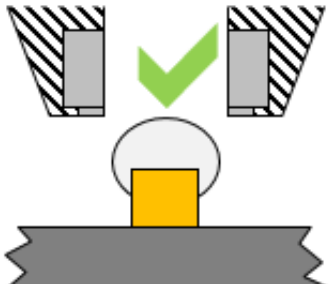
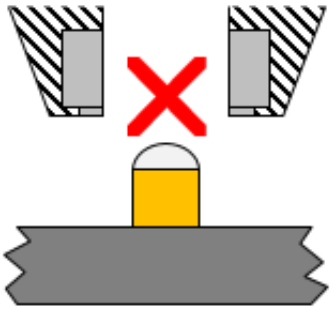
and it does produce the failure mode of interest. The optimum shear height will be the one that maximises this or produces the highest test force.



This shape of solder is possible to test similar to regular Cold Bump Pull (CBP)



The solder interconnect is very difficult to test. Shear is the best test

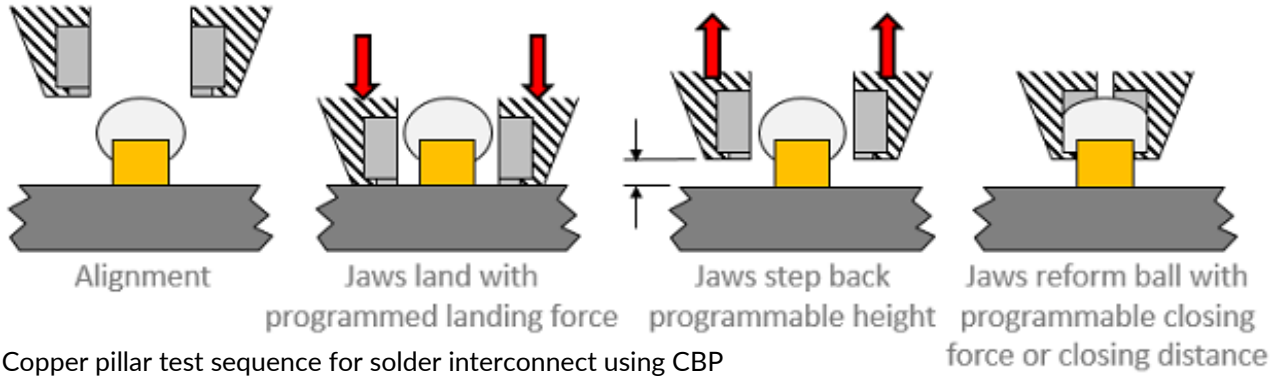
Solder to copper interconnect

Cold bump pull testing

If you are interested in the interconnect between the solder and the copper, it depends on the shape of the construction whether a Cold Bump Pull (CBP) type test is feasible. If not, a shear may be the only effective test to qualify your process.

More on CBP can be found in our how-to.

The test sequence for the CBP-approach is as follows:



Copper pillar test sequence for solder interconnect using CBP

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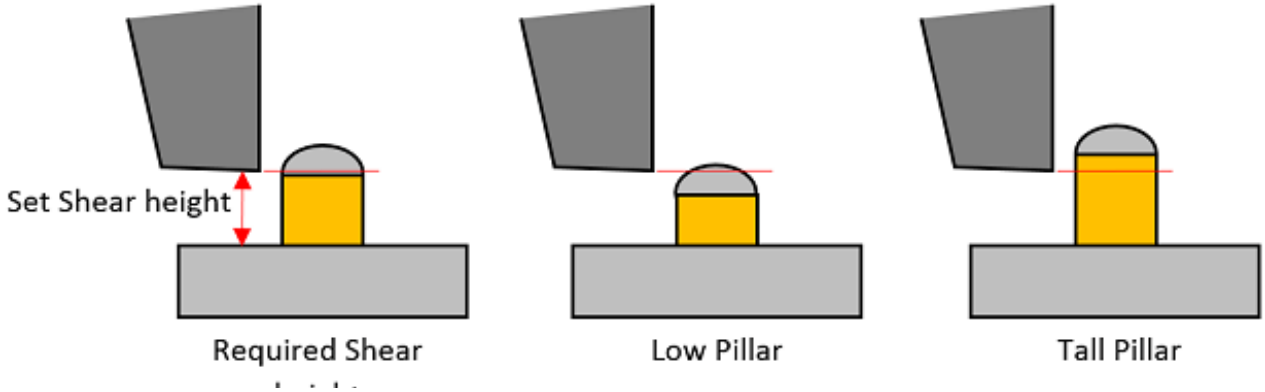
Shear testing

As with any shear test, testing the solder to copper interconnect requires accurate alignment of the shear tool to the bond line. When the height of the bond line from the substrate varies due to tolerance build up conventional shear height methods can be a problem.



Tolerance build up can cause problems when shear testing the copper bump using conventional methods

A solution is XYZTEC's unique top landing shear method. The tool lands on the top of the solder, then moves back and down programmable amounts to guarantee a shear height relative to the top of the pillar rather than its base.

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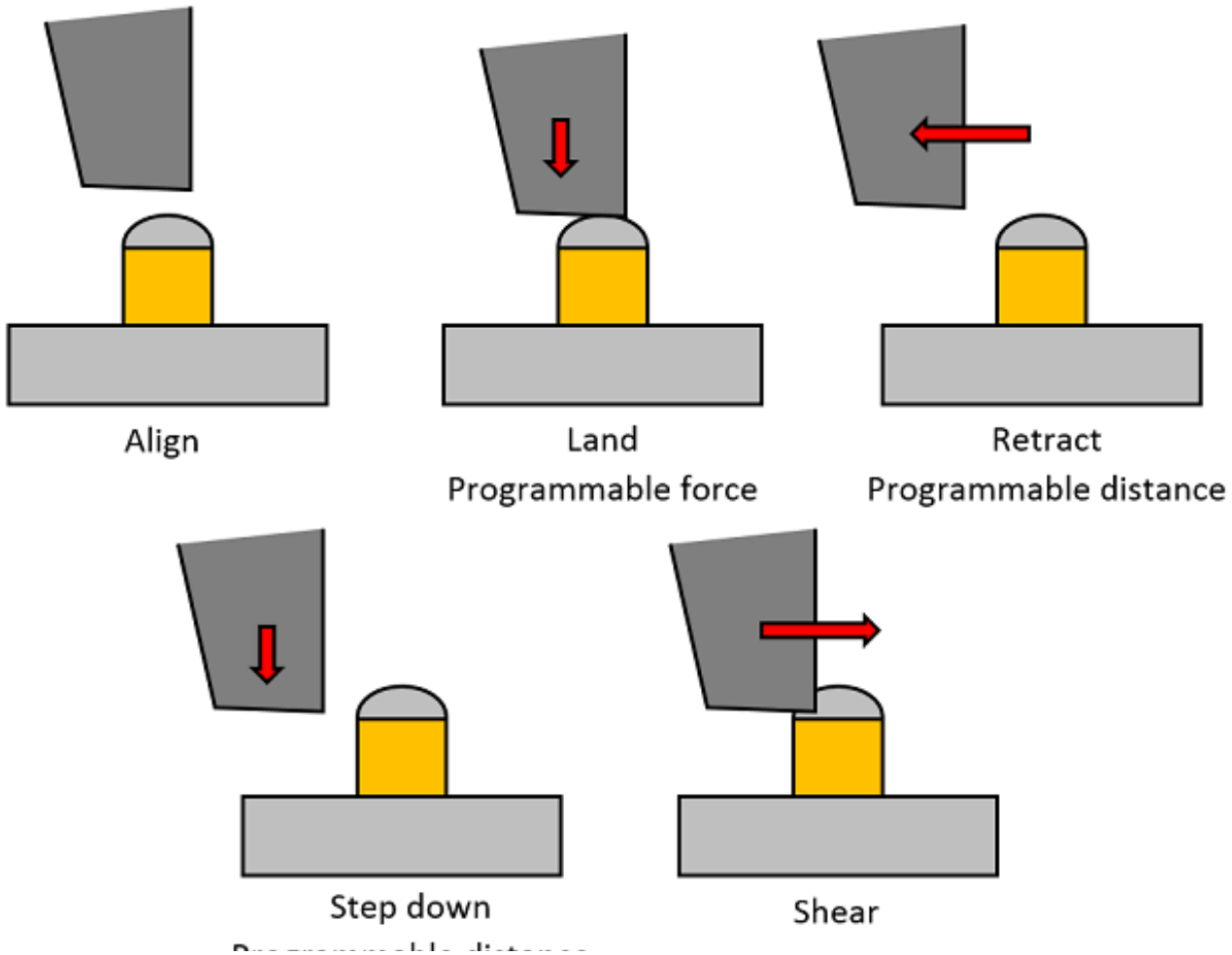

The test sequence using XYZTEC's unique top landing shear method

The video below shows a test. The programmed landing force is 5gf. As the landing contact is initially a point, even with a low landing force, a small amount deformation occurs on the top of the solder. The loads on the pillar bond though are small and compressive and have no detrimental effect on the measurement. The Condor Sigma is the only bond tester in the world with a programmable landing force and is capable of lower landing forces than any other tester.

[Video not included in PDF: click here to view online]

Choose between pull and shear testing

The choice between pull or shear testing depends on the application and the test objectives. XYZTEC has a lot of experience with different types of copper pillar products and can advise you on how to test in order to get the best information for your quality assurance process. If you are interested to find out more please contact us for more information, to request an application report, a demonstration or a quotation.

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Relevant products

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- Condor Sigma W12
- Condor 150HF
- Revolving Measurement Unit
- Sensors
- Tweezers
- Vision
- Software
- Calibration
- Work holders

Increase your bondtesting throughput

The Condor Sigma is not only the most accurate bondtester in the world, but also the fastest. Click here to read the study that proves the Condor Sigma is up to 39% faster than the competition.

Special applications

Please contact us if you have any questions or special bond testing requirements.

Condor Sigma brochure

Click here to download the Condor Sigma brochure, the Condor Sigma W12 brochure or the Condor Sigma Lite brochure or the Condor Sigma Vision brochure (PDF).

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