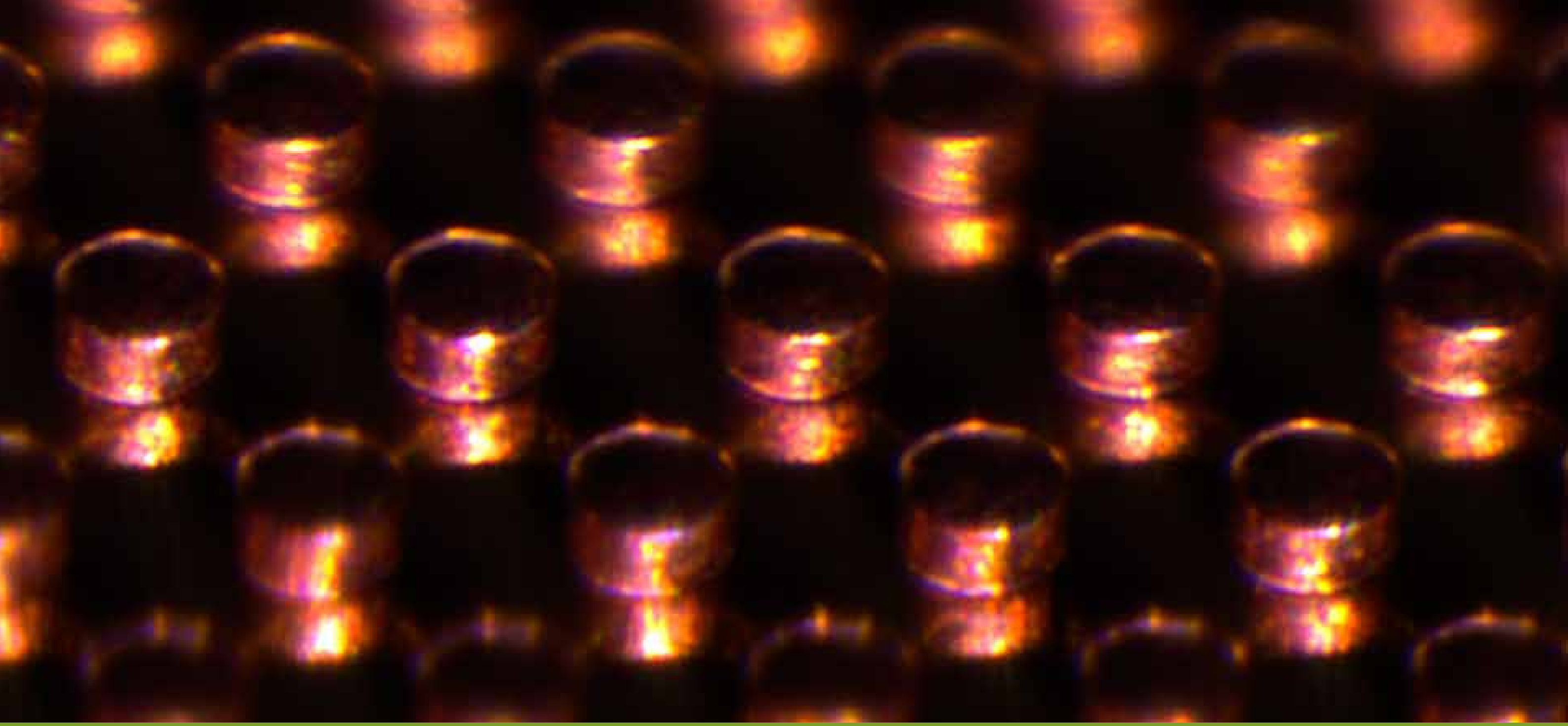


Cu Pillar

Application Note

Copper is increasingly becoming one of the preferred materials for semiconductor interconnects. Copper's physical properties enable it to be used at smaller geometries providing similar performance to traditional interconnect materials such as solder. Copper interconnects are becoming increasingly common in flip chip devices, the main driving force behind this shift is the silicon industry.

A current common interconnect platform to the silicon die is achieved using wirebonds, bonded to the die and then to the carrier substrate, typically using gold as the wirebond. The carrier then has an interface medium to where the chip will be attached to the mainboard. This interface medium usually consists of solder balls, such as on a BGA device.

The ever shrinking geometries of interconnect mediums, driven by the silicon industry means that other methods of interconnect have been introduced, including direct solder bumping of the silicon die.

This interconnect method provides a great reduction in package geometry, as the whole package is the area of the silicon die, often referred to as a wafer level package. A wafer level package has many advantages over traditional packaging, it allows much greater interconnect density, by utilising the whole surface area of the die, compared to wirebond interconnects where the outer edges of the die were used to locate the bond sites. This has greatly improved the IO capabilities of processors and memory devices.

Nordson DAGE

What is Cu Pillar?

Solder has restricted and limited use when the requirement is for higher density, it has a optimal height to width ratio which cannot be reduced easily. Increasing the IO count on a solder bumped device would mean shrinking the solder to its limits and then reducing the pitch to a minimum. This can work to some extent but not without hitting some major risks such as risk of shorting of the bumps during reflow.

The drive for even greater IO capabilities and higher performance processors within the same die footprint has led to another interconnect medium migration. Copper, is the preferred material for next generation interconnects. It can be formed into pillars, bumps and studs. These pillars allow greater ratios of height to width and ultimately allow for greater density interconnects on a die compared to solder.

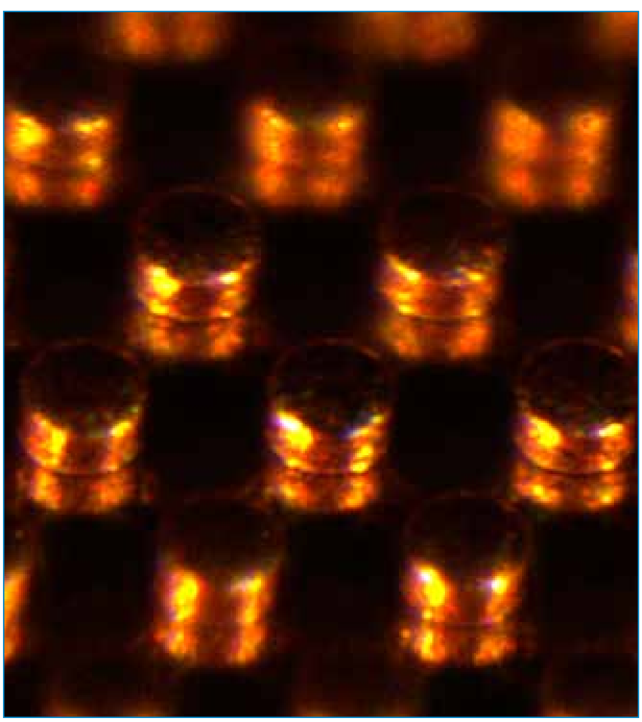
Copper meets the demand for shrinking geometries and higher IO counts, by providing better thermal and electrical performance compared to solder interconnects in smaller geometries and at tighter pitches.

Flip chip refers to the method of interconnect of the die to the carrier, done by placing a conductive bump directly on to the die surface, this die is then flipped over and bonded face down onto a carrier directly. The flip chip connection can be formed by conductive adhesive or by the more popular method with solder as the interconnect medium.

Copper pillars and bumps are the next generation flip chip interconnects providing many features and benefits over traditional solder interconnect methods.

Features include:

- Ultra fine pitch down to 40um
- Bump geometries down to 20um diameter and 30um height
- Cost reduction
- Reduced signal impendence
- Better thermal conductivity



Trinocular view of 80um copper pillars

Testing the mechanical integrity of these copper interconnect pillars is an important part of manufacturing quality assurance and ultimately ensures product longevity.

There are a number of test methods to gauge the quality of copper pillar interconnects, these include:

Shear testing: A common test method for interconnect bonds has been shear testing, where the bond is sheared off the bond pad. This is regarded as a very accurate and reliable test to establish bond integrity.

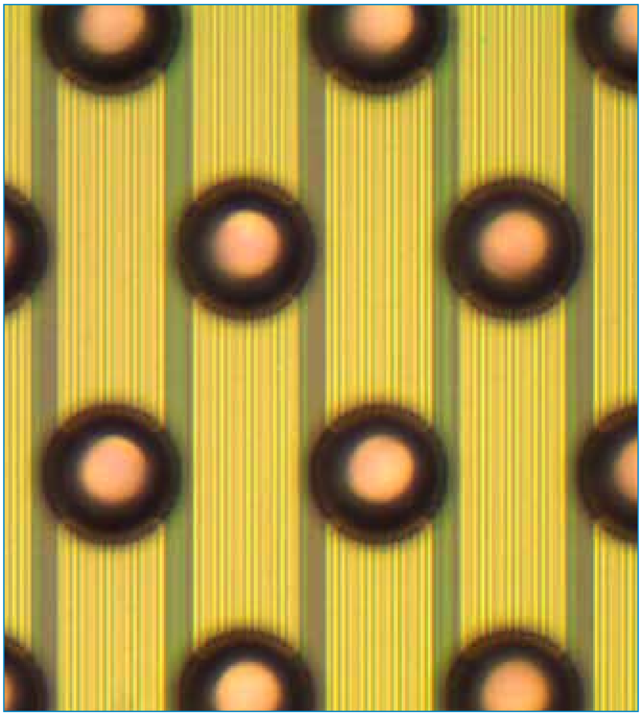


Image capture view of 80um pillars

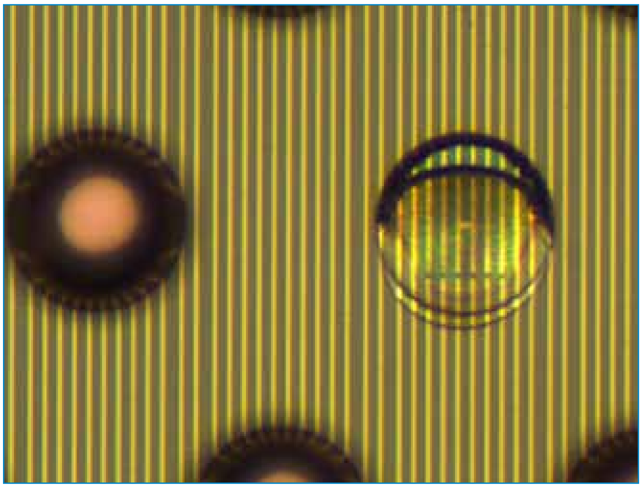
Tensile pull: Another test method which can be introduced, is tensile loading. In the case of copper bonding this can be more representative of the loads to which the bonds would be subjected to. This has not been a feasible option with solder bumps, due to the higher ductility and low width to height ratios, making it very difficult to grip and apply a given load successfully. Tensile pull is an ideal solution for very densely populated dies, where shear testing would become challenging to test a particular bond where the geometrical constraints can prevent successful shear testing

Hot Bump Pull: Most copper requires a bonding method to the carrier substrate, in this case traditional solder can be used. Solder caps are normally deposited on top of the copper pillars to allow for a bond medium. This solder cap can be used to perform a tensile pull. HBP allows a fine probe to reflow the solder cap and bond to the probe, then perform a tensile pull to gauge the quality of the copper pillar.

The tough material nature of copper is an advantage for bond test techniques, as it can be gripped mechanically without the high risk of damaging the bond compared to a solder bond. A challenge is posed when trying to grip the bond successfully, with accurate and consistent pressure. Controlling the tool clamping pressure on a copper bond is important, as too much pressure could deform or break the jaw tool, which previously was not a major issue with more compliant materials such as solder, which reformed during clamping, posing less risk to the jaw tool. Any deformation in the jaw tool can lead to degraded and unreliable results. Too little pressure will lead to tool slippage potentially damaging both the tool as well rendering the results void.

The superior electrical and physical properties of copper compared to solder means that the bond geometries can be decreased. This decrease in size equates to an increase in bond density, finer pitch devices and more complex bond arrangements. The challenge this trend poses is successful positioning, alignment and inspection techniques for bond test machines.

With the decreasing size of bonds, tooling techniques are of very high importance. The correct tooling technique, with correct material selection aids successful bond gripping as well as easier alignment in more densely populated test samples.



Failure mode analysis after test

In anticipation of this shift in material choice, Nordson DAGE have introduced the 4000*Plus*. This advanced multipurpose bondtester caters to copper interconnect bond testing such as copper bond, pillar, stud and bump pull and shear, offering an industry unique solution. The solution combines a number of unique technologies including:

- High precision XY table: Provides high resolution control and accuracy which is critical when testing fine pitch devices such as copper bonded ICs.
- Advance tooling: Shear tools and cavity jaw tools designed to specific geometries allow optimum test techniques.
- Multi camera system: Provides multiple live images of tool tip and sample under test in two planes, allowing fine operator visual control and adjustment on screen.
- Paragon™ software: Innovative new bond test platform software, which provides a user friendly interface to enable fast setup and customisable test environment. The live camera imaging is integrated into Paragon allowing multiple displays to be active and provide unique features such as snap images and video clip of tests.

The new bond testing system enables software control of air pressure, allowing accurate gripping of the feature under test as well as spreading the load with selected clamp pressure. This consistent pressure is maintained during a test providing reliable clamp pressure, in order not to deform the bond or let it slip during a test.

The copper bond is mechanically gripped by specially designed jaws that allow optimum force to be transferred to the bond to allow tensile pull to be performed. The jaws are designed so that the surrounding pillars are not damaged and the pressure is transferred wholly to the bond under test only.

The next generation shear cartridges allow highly repeatable step back accuracies, performing shear testing of a copper feature as accurate as ±0.25um. Precise shear tooling provides shear tool face widths down to 20um.

Current copper test solution geometries achievable are 40um height bond and 40um bond diameter. These geometries are achievable for all copper interconnects, including, stud bumps and pillars as well as ball bonds.

For copper bond interconnect solutions please contact Nordson DAGE for further information.

For more information, please contact your Nordson DAGE regional office or speak with your Nordson DAGE representative, all of which are listed on www.nordsondage.com.

Americas
+1 510 683 3930 **Phone**
sales@nordsondage.com **Email**

China
+86 512 6665 2008 **Phone**
sales.ch@nordsondage.com **Email**

Germany
+49 7021 950690 **Phone**
sales.de@nordsondage.com **Email**

Japan
+81 432 995851 **Phone**
sales.jp@nordsondage.com **Email**

South East Asia
+65 655 27533 **Phone**
sales.sg@nordsondage.com **Email**

United Kingdom
+44 1296 317800 **Phone**
globalsales@nordsondage.com **Email**

Nordson DAGE
25 Faraday Road
Rabans Lane Industrial Area
Aylesbury, Buckinghamshire HP19 8RY, UK

+44(0)1296 317800
www.nordsondage.com

AN-BT-CuPillar-211011.