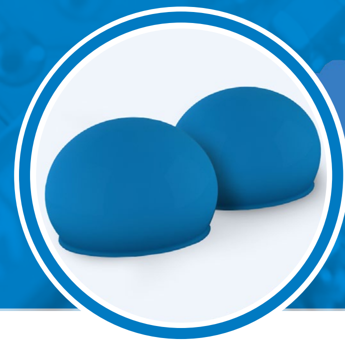
Application Note

How to carry out mechanical testing on very small components



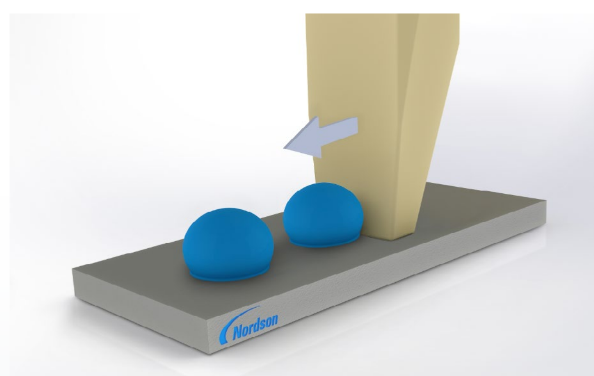
The traditional method of testing the strength and other properties of materials is performed using tensile testing coupon, typically with a total length of 165-246 mm long (ASTM D638 dimensions). When high reliability is required, such as in turbine discs, the component is forged and machined to final shape; the properties of this component could be accurately determined by making testing coupons that were also forged and machined to a similar finish. Technologies such as powder metallurgy have made it possible to make far smaller and more complex components without having to use the traditional forge-machine route, or compromising the microstructure of the material. Fibre-reinforced materials also present a challenge to conventional testing, as localized issues such as resin rich areas around complex features can dramatically change the real properties of a material in critical regions.

How Can a Structure be Tested When it is too Small for Conventional Grips?

One of the main issues of testing small components is that it can be very difficult to grip the component so that it can be pulled in tension, without damaging the gauge length and therefore compromising the results.

In the world of micro-electronics, this issue was solved by shearing small components instead of pulling them.

The original driving force to develop shear testing was to enable solder connections to be mechanically tested on circuit boards. These solder balls are typically 0.8 mm in diameter, but can be as small as 0.02 mm. While the electrical connection of a soldered joint can be determined by a simple continuity test, defects such as cracks or voids along with residual stresses can cause premature failure of the joint in service, so a mechanical test is required to prove reliability. In the micro-electronics industry, which is heavily dependent on component reliability and large volume manufacture, these machines, referred to as ‘bond testers’ are commonly used for quality assurance work.

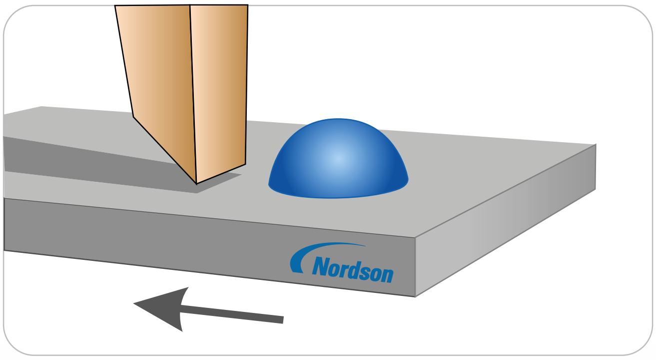


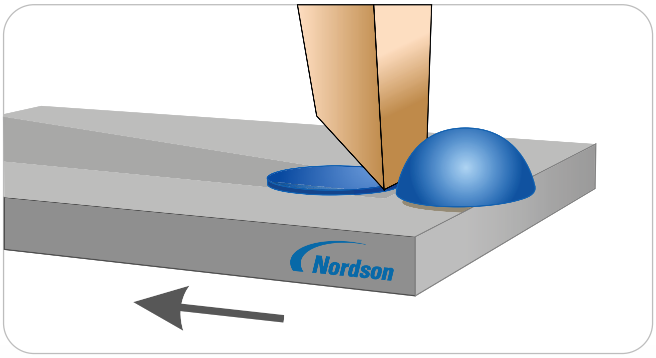
How Does a Micro-Shear Test Work?

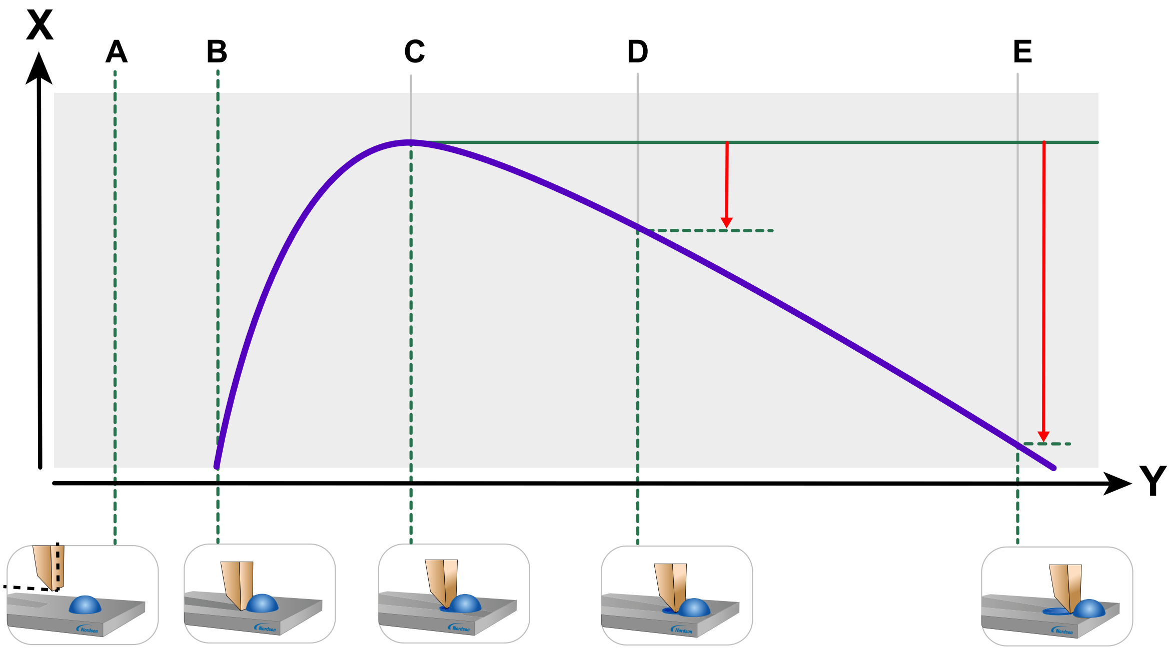
A shear test is carried out using a flat sided shear tool, typically made from tool steel, that is held inside a calibrated load-cell cartridge. The whole sample is held in a vice, which in turn is mounted on a stage that can move precisely in the X and Y axis.

The key to repeatable measurement of shear loads is ensuring that the shear height is carefully controlled. To achieve this the shear tool is gently lowered onto a surface adjacent to the feature to be tested (or the shear height can be measured from the top of the component to be sheared) and then positioned to ±0.25 µm of the desired testing height.

The stage that holds the sample is then moved to press the sample against the shear tool to produce a shear load (in either load or displacement control). The shear tool will either cut through the feature being sheared at the bottom of the tool, or if the bond between the feature and the substrate is weaker, then the failure may occur in the interface or within the substrate itself.



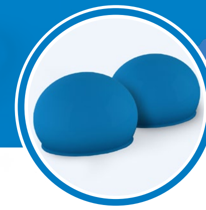


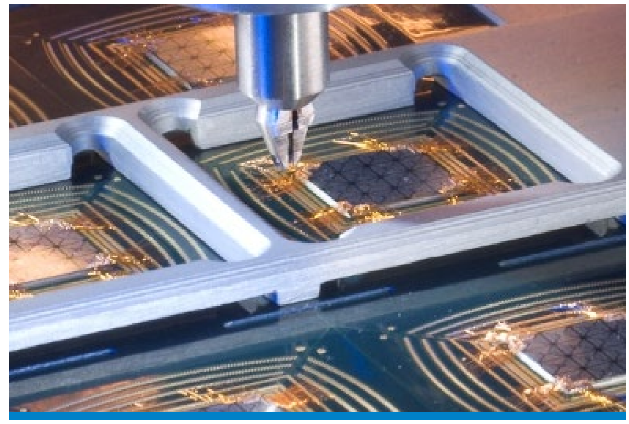


The shear tool will provide a shear failure force and the stage provides displacement information, so a load versus displacement curve can be plotted and therefore a measure of rigidity. High quality bond testers are fitted with an optical microscope so that the failure mode can be determined, and the bond area can be measured to provide a shear strength measurement. High Strain rate testing, with shear rate of up to 4 metres per second, can also be carried out in a similar way.

How can structures be tested when they are too small to be seen?

As features in micro-electronics have shrunk, they become more difficult to see and position shear tools. The simplest way of positioning shear tools is to use a trinocular microscope (binocular microscope, for depth perception, fitted with a video camera to film testing). The trinocular is set to view the test site at an angle. If the feature density at the test site is very high, then a side alignment camera can be used to ensure that there are no clashes between the sample and the test machine. Unlike in a large scale uni-axial test machine, the load cell is constantly active, so if the sample is navigated into the path of the tool, the stage stops at a low load to prevent damage of the sample or tool.





What materials can be tested?

Bond testers were originally conceived as mechanical testing devices for solder and ultrasonically welded joints, but over the years they have developed to cover a range of testing possibilities, such that the largest shear force that can be achieved is above 200 kg, so as long as the material to be tested is no stronger than the shear tool, it can be tested.

The smallest shear tool is only 25 µm wide, which fits to a 25 g load cell that can measure down to 0.25 g.

While the loading of the material is more complex than a typical tensile test, the opportunity to quickly and reliably test the actual feature on real components can provide far more useful information on performance.

Micro pillar

Low profile bump

Large area die

High density wire

Solder mount device

High strength ribbon

Nordson
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