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Why test bonds? » shear testing

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Shear Testing

A good example of this is shear testing of a gold ball bond and wire bonds within a semiconductor device (Figure 1). A good gold ball bond will be stronger than the ball so the failure mode of a strong bond will be gold ball shear. It is not uncommon for production engineers to use this failure mode alone as an indication of bond strength but it does represent a limit to the capability of the test. A better test would produce a bond failure and record a higher force that corresponds with the bond strength. One of the prime objectives of a bond test designer is to try to produce the failure mode of interest.

Figure 1: shear testing of gold ball bonds within a semiconductor device

As mentioned peak force is by far the most common metric for measuring bond strength. This is very often all that is needed but a force-displacement graph conveys a lot more information. Traditionally force time was recorded because this is relatively easy to obtain but it is far less interesting. If the test is done at constant speed the difference between a force-time and force-displacement graph is only one of scale on the X-axis typically denoting time or displacement.

However, when testing with small bond deflections, high forces or at moderate test speeds maintaining a constant test velocity can be extremely difficult. In these cases a velocity-time graph may lead to a misinterpretation of the test results. Using displacement one can visualize the force increasing and falling as the bond yields relate directly to the geometry of the sample. In addition the area of the force-displacement graph equals the energy absorbed by the bond which in itself is an alternative bond strength metric that is particularly valuable when testing resistance to mechanical shock.

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Figure 2: impact measurement unit testing chip capacitor mounted on printed circuit board

As previously mentioned, obtaining an accurate force-displacement graph can be challenging. In rigid bonds such as a die attach the deformation of the bond to failure is extremely small and typically less that the deformation that occurs in a well designed test machine performing the test. The best way to overcome this is to use an external displacement sensor that directly measures the deflection of the tool applying the load to a datum point on the sample synchronously with the force measurement. Such a system typically requires nanometer resolution. The good news is that peak force is often all that is needed for this type of test and this is not affected by the types of errors that are typically seen in a displacement measurement.

Another use of the force-displacement graph is in bond strength modeling. This is of growing interest driven by the possibility that the strength and reliability of a bond may be virtually guaranteed during the design process. Given the massive range of geometries, materials and processes used this is no small undertaking. However, particular designs can be modeled and the model qualified by a bond test. The assumption being that if the model successfully predicts the failure mode and force-displacement of a given bond test, there is a very good chance it will also make an accurate prediction modeling of a reallife loading condition. We should be aware that no bond test exactly replicates the real thing. For example when a chip capacitor bond breaks it is not because a shear tool has subjected it to a load (Figure 2).

Like any experiment the act of the measurement process can potentially change the measurement. Bond testing is typically a strength analog or comparator but none the less is an essential control tool in assuring product quality in electronic assemblies.

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