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Issue 47

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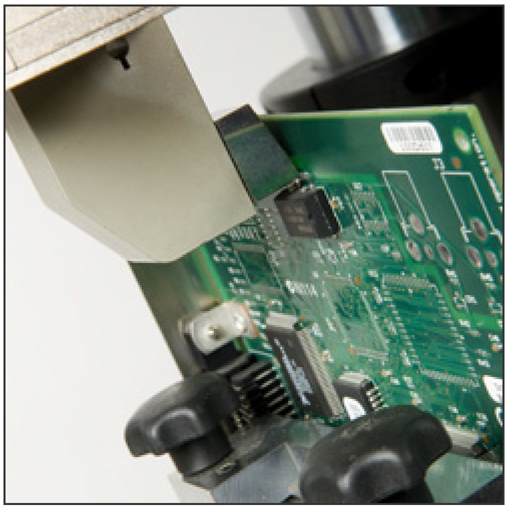
Importance of Testing in an Ever-Changing World



For many years, tin and lead solder has been the accepted material for securing electrical components and wiring to circuit boards. Recently, environmental concerns have led to legislation in many countries to outlaw the use of lead and other hazardous materials in consumer goods and other industries. In Europe, the Restriction of Hazardous Substances Directive (RoHS) has either banned or restricted the use of lead along with five other elements or compounds. This has forced the development of lead-free alternatives to tin/lead solder. Furthermore, the rapid rate of miniaturization of consumer goods has driven the development of novel production techniques. These changes have opened the door to a wave of research and testing for the new materials and techniques.

Solder, along with its higher temperature counterpart, brazing, has been in use for thousands of years as a medium for forming a robust joint between metals. Solder has a lower melting temperature than the metals to be joined. Simply put, the melted solder flows between and around the items to be joined, then hardens to form a conductive bond between them. It is similar to a hot glue bond, but more complex in that the solder material forms a molecular bond with the materials of the pieces to be joined.

A major advantage of tin/lead solder in the proportions of 63% tin and 37% lead is that it is a eutectic alloy; that is, the melting and solidifying point of both materials in the alloy are identical. In non-eutectic alloys, one of the materials will solidify at a different temperature to the other. Between these two temperatures exists a range where the alloy appears solid, but is soft, and movement between the surfaces to be joined is still possible. This movement can seriously weaken the final joint.

There are, of course, disadvantages to tin/lead solder. Its low melting temperature of around 183°C (361°F) makes it unsuitable for use at anything much above ambient temperatures. It cannot be used where load bearing is required. Most importantly, lead is recognized now as a hazardous material, particularly for young children.

On July 1, 2006 in Europe, the RoHS came into effect to require many new printed circuit boards (PCBs) to be free of lead. This legislation, along with similar pressures in other regions, has led to the development and testing of many new solder alloys using tin, copper, silver, gold, and bismuth in different combinations and proportions. Many questions remain regarding the chemical and mechanical characteristics of the new lead-free alloys.

The ongoing miniaturization of electronic components has also driven the development of many new techniques for soldering components to PCBs. An example is the Flip Chip or Controlled Collapse Chip Connection known as C4. In this technique, the integrated circuit has a grid of metal pads rather than wire terminals. Blobs of solder are deposited onto the metal pads. The chip is turned over and placed into its location on the PCB with matching metal pads and the solder balls are re-melted and solidified to form the bond between the pads.

These modern production techniques also require extensive testing to ensure that the resulting products meet their requirements for performance and reliability. Therefore, a worldwide research effort has been underway for years to characterize lead-free solder alloys and to mechanically test the strength of the bonds formed using the alloys and the new production techniques.

Because of the large variance in materials and construction – the different solder alloys, surface finishes, substrates, process conditions, and geometries – no industrial standards currently exist. However, there are several typical mechanical tests that manufacturers and researchers carry out on the bonds between the solder balls and the metal chip pads, such as low and high speed shear tests, cold and hot pull tests, impact tests, and fatigue tests. These tests are useful for obtaining comparative data, but some of them, particularly the pull tests, do not reproduce real-world conditions very well. The need to grip the solder ball either deforms the ball or requires the insertion of a pin by re-melting the solder ball.

High-speed shear, impact, and fatigue testing of solder balls come much closer to reproducing the same failure modes seen in manufacture and end use. They offer a measure of the overall resilience to mechanical shock. An impact pendulum tester using precision high-speed sensors measures the force and position of the impact tool enabling accurate force v. displacement graphs of the test.

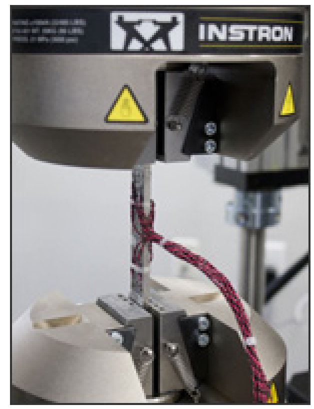
Brittle fracture is a typical failure in the intermetallic layer between the solder ball and the PCB metal pad, and pad crater, a fracture on the PCB that leaves a "crater" on the surface. These failure modes are common causes of weak and unreliable joints.

The pendulum tester can also provide useful fatigue data with repeated low-load or high-rate impacts or both on the solder ball. These tests can simulate many fatigue loading conditions with the advantage that the load, energy, and strain can be selected and recorded for every load cycle.

If the product is not performing to requirements, these tests may help determine if design or process changes are likely to result in an improvement. Conversely, if the product is performing to requirements, continued testing can provide a fast, cost-effective, and real-time assessment of product quality.

The accelerating rate of innovation in consumer goods such as computers, cell phones, and touch pads is astonishing with smaller and increasingly capable products being released to the market almost weekly. This demand, along with increasing national requirements for safety and environmental awareness, drives continuous improvements in design, development, and production. In this rapidly changing and competitive environment, the role of testing has never been more important.

Importance of Accurate Alignment



Your testing system represents a major capital investment for your organization. You make sure it is regularly calibrated for load, strain, and displacement, and that it is regularly serviced. But when did you last make sure that the alignment was correct?

Misalignment takes two forms: concentricity misalignment, in which the centerline of the upper grip or fixture is offset from the centerline of the lower grip or fixture; and angularity misalignment, in which the two centerlines are at different angles to each other. Both impose unwanted bending stresses into a test piece under load and can therefore affect the behavior of the material.

Load frame alignment can change for a number of reasons, including:

- Changing grips
- Installing new or replacement load string components, such as load cells, adapters, and fixtures
- Repositioning the fixed crosshead
- Wear or damage to load string or load frame components

The importance of accurate alignment is recognized more and more by accreditation bodies, aerospace corporations, and others. You must be able to demonstrate that your systems meet the alignment requirements specified in many ASTM standards that reference tolerances for either bending stresses or alignment.

ASTM has produced ASTM E1012, which outlines the requirements and calculations for assessing load frame alignment. This standard is frequently quoted as an acceptable method for checking and quantifying materials testing machine alignment.

So, consider requesting an alignment check during your next service visit. You never know when you may need to show that your system is ready for everything.

Q. In these days of increased awareness of the environment, why does Instron still use “standby” modes on your systems?

A. Strain gauge load cells convert the load acting on them into electrical signals. The gauges themselves are bonded onto a structural member that flexes when weight is applied. Temperature effects on the modulus of elasticity of the flexure materials are compensated, using carefully trimmed temperature-sensitive resistors. But it is still necessary when starting a system from a full shutdown state to allow a 15 - 20 minute “warm-up” period that allows the load cell temperature to stabilize and ensures consistent measurements.

Standby mode is provided to permit the automatic shutdown of the energy-consuming components of a testing system after a period of inactivity, but it retains the power supply to the load cell to ensure that it remains temperature stable.

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