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Accelerating long-term durability testing

New mechanical method for quality testing of material joints in the nm to cm range – quick, efficient, reliable & proven method

Many industrial components consist of a wide variety of materials and layers: electrically conductive and insulating, ductile and brittle; made of metal, ceramics, glass or polymers. They are all used for specific functions, but are not ideally suited to each other from a materials point of view: They are often difficult to join together, or expand to different degrees when heated. Subsequently, during electrical switching or thermal stress, high internal mechanical stresses may result, which in the course of time can lead to defects, breakage and delamination. How long a component withstands its operating stresses is a key quality feature for the customer. At present, temperature or alternating current tests are commonly used in the quality assessment of electrical devices and electronic components.

However, those tests often require a great deal of equipment and, above all, a great deal of time: even with a short cycle of only 5 seconds, a test may take almost 6 days to fail after, for example, 100,000 cycles.

The problem of the durability of components over the course of long-term operations is the same across many product segments and industries. Those who have fast, reliable durability tests have clear advantages both in the development of their products and in customer satisfaction.

Objective

The Mechanical Response of Materials Research Group at TU Wien has developed a high-frequency testing system for chip and electronics manufacturing that is already being successfully used at Infineon. The underlying methodology can also significantly accelerate the testing of other bonds and multi-material components. It is applicable for punctual joints as well as for large area bonds ranging from nm to cm. The new method is now ready for application in other industries.

Approach

The basic idea is to replace the thermomechanically-induced stresses which would normally occur in a material joint during its operation with equivalent cyclic

mechanical loads, and to significantly shorten the time required for the test by drastically increasing the load frequency.

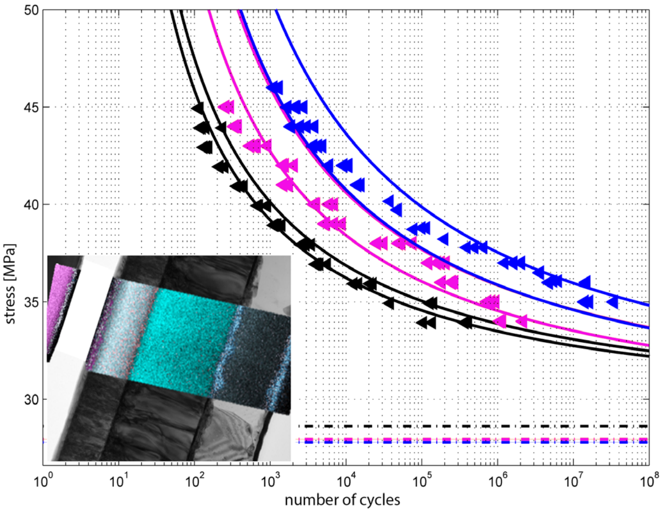
Our novel high-frequency test system is specially adapted to each particular application in such a way that the damage patterns actually occurring in the course of use correspond exactly to those caused by the high-frequency test. FEM simulations and careful qualitative and quantitative material analyses are used to better understand the prevailing failure mechanisms during operation and thus to quickly but realistically replicate the degradation processes.

The testing system

Our system for highly accelerated durability testing - for example, to test the long-term reliability of material connections, chip contacts or multilayer structures (contact or delamination testing) - consists of an excitation source that subjects components to a specific vibration load in a wide frequency range, between 100 Hz and 60 kHz.

Changing the configuration of the setup allows testing of both model test structures and real components. This enables the uniform evaluation of varying material inter-faces and joining techniques in a given application area - whether in the production of electronics, thin films, or composites.

Application of this unique test method in the electronics industry has already shown that it is 1,000 times faster than previous test methods. It is a highly efficient tool for screening, for the rapid detection of component weaknesses, and for the identification of failure modes - as required in the development and production of multilayer systems. Due to these excellent qualities it accelerates optimal material selection and process design. It is also destined to become an all-purpose tool for the efficient quality control of incoming and outgoing products.



Determination of the service life of multilayer materials in a very short time - by means of very high cycle numbers - and chemical analysis of damaged areas

Notes

Life curves up to the highest number of load cycles can be determined in a very short time. Depending on the application, the degree of damage can be tracked over time using optical methods, vibrometry or acoustic sensors and determined in situ. This data is used to create validated models for reliably predicting the service life of a component

Target groups and applications

- Automotive, aerospace industry, medical technology, mechanical engineering, toolmaking, plant design
- Manufacturers of measuring and testing equipment for the above-mentioned industries
- Production and development of or laboratories for:
  - soldered, sintered, welded, bonded joints
  - functional coatings, thin-film coatings, paints
  - laminates, composites
  - semiconductor materials, electronic components

Your Benefit

- extreme time savings compared to conventional test methods (factor of 1,000 and more)
- available for a wide range of material combinations with joint areas or layer thicknesses from nm up to cm
- realistic failure modes of expected long-term damage in the shortest possible time
- precise time-dependent degradation process as a function of material and production parameters
- rapid substitution of environmentally harmful materials and auxiliary materials
- considerable shortening of the “time to market”
- quick improvement of sustainability, customer confidence and profitability by reducing scrap and waste rates, as well as by avoiding complaints
- already proven in practice - successfully being used for chip testing at Infineon

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