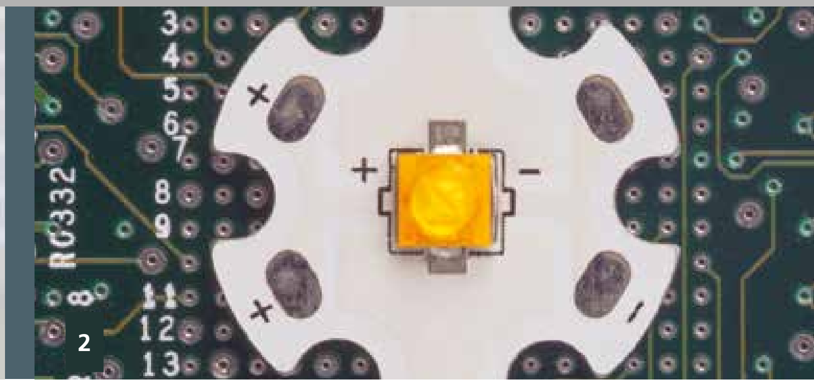
FRAUNHOFER INSTITUTE FOR PHYSICAL MEASUREMENT TECHNIQUES



1 *Fraunhofer IPM's ESPI system allows both spatially and temporally resolved measurements of even minimal deformations.*
2 *State-of-the-art high-power LEDs are subject to high stress, both thermal and mechanical, as the result of substantial electrical load cycling.*

FAST AND IMAGING DEFORMATION MEASUREMENT

State-of-the-art electronic components with high power densities heat up strongly in use. This leads to deformation and thus to mechanical strains inside the components. Fast switching and load changes may cause strain peaks that are transient, spatially confined and lead to micro-cracks or broken connections. This is one of the main causes of component failure.

Quality inspection by spatially resolved, highly accurate surface measurement

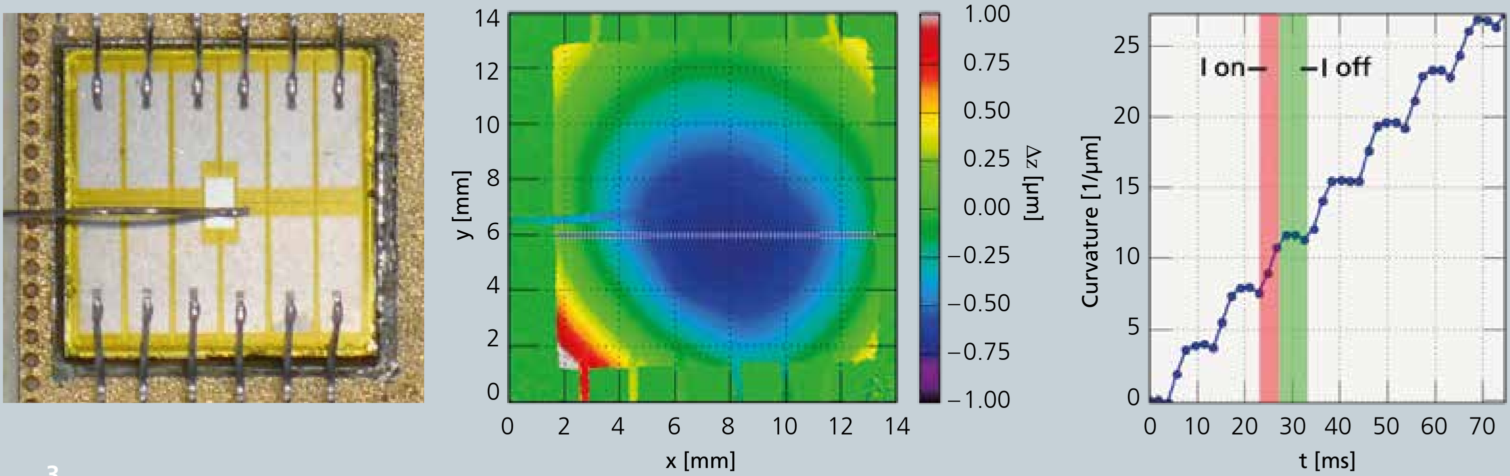
To date, analysis of such failure modes has been restricted to indirect measurements by measuring heat distribution. However, measuring mechanical deformations directly supplies important data to avoid defects and thus premature failure.

A new Fraunhofer IPM system for measuring micro-deformations measures minimal changes to the component topography quickly, spatially resolved and down to the nanometer range – even in-line. The system measures very small deformations of the component surface, e.g. those caused by mechanical or thermal loads, resolving fast and transient changes to the electrical components. The method is suitable for inspecting critical production steps but also supplies important information for component development, circuit design and process development: for example, distortion of electrical components can be measured under operating conditions with accuracies down to 30 nanometers or less, after the soldering or bonding process. Recognizing and understanding the dynamics of the distortion in the millisecond range are necessary for component development and design in order to prevent short-term or local over-stressing of the component during subsequent operation. Component and PCB design which has been optimized in this way guarantees constant product quality and a long service life despite high component stress.

Fraunhofer Institute for Physical Measurement Techniques IPM
Georges-Köhler-Allee 301
D-79110 Freiburg, Germany

Contact
Andreas Hofmann
Business Development Manager
Production Control
Phone +49 761 8857-136
andreas.hofmann@ipm.fraunhofer.de

www.ipm.fraunhofer.de/en



3 *Measurement of a power transistor: Left: power transistor (11 x 11 mm²) Center: spatially resolved measurement of the transistor during operation; deformation as the result of the electrical power loss. Right: temporal characteristic of the measured curvature along the profile; dynamic change in buckling in pulsed operation (3 A, 50 Hz); the diagram shows the first seven pulses after power-on.*

Shape and expansion measurement for more precise simulations

Thermal expansion creates mechanical strains in the component. The resultant distortions may lead to irreversible deformations and to structural failure through cracks or fractures – caused by high peak strains or cyclical strains. The challenges when designing electrical components or circuits are not limited to individual component design, they also encompass ensuring the reliability of the entire electronic system. Simulation tools assist in this but require precise, spatially and temporally resolved input data. Besides stationary deformation, dynamic deformation, e.g. during switching operations, plays an important role. This requires two-dimensional deformation and expansion measurements with adequate spatial and temporal resolution. Mechanical loads can already be detected by measuring minute deformations in the nanometer range, well before a failure occurs.

Electronic speckle interferometry for measurement with nanometer precision

The Fraunhofer IPM system for fast measurement of micro-deformations identifies minute changes to the shape of a component on the basis of electronic speckle pattern interferometry (ESPI). This method involves illuminating the surface with an expanded laser beam. This produces a speckle pattern. This speckle pattern changes as the result of deformations in the surface of the component amounting to fractions of the wavelength. Special computer algorithms allow quantitative determination of surface deformations at high speed and with high accuracy.

Classical ESPI methods use temporal phase-shifting methods. These involve recording a sequence of camera images to detect the current deformation condition. This makes the method very sensitive to vibration. Fraunhofer IPM's ESPI system uses an adapted spatial phase-shifting method which obtains all required information from a single camera image. This makes it very fast and robust.

Horizontal and vertical measurement

The system combines ESPI and high-speed speckle correlation, thus allowing highly precise measurement of deformation in all spatial directions: 500 times per second – with a resolution of more than one million pixels. The system detects surface deformations of less than 30 nanometers. This allows measurement and evaluation of even minute deformations, such as those which occur on power transistors, integrated circuits or light-emitting diodes, in real time (see Fig. 2). Even higher measuring frequencies can be achieved by reducing resolution, so that the mechanical load of even high-frequency components can be examined, with a smaller measuring field.