Thermal Expansion of Electronic Components

Introduction

Electronic components are used in the automotive, communication, aerospace and other industries. Miniaturization, higher package density and accelerated development processes have a great impact on the reliability of electronic components.

Rapid changes of ambient temperature or internal production of heat may occur during operation. This may create high thermal stresses due to the mismatch of the thermal expansion coefficients of the different materials in electronic components.
The electronic components used in cars are exposed to high stress due to vibrations and extreme temperature changes. If a car is started the temperature of the electronic cards might pass a value of minus 0°C to a value beyond 140°C in a few minutes. Today, a big amount of the car recalls by the manufacturers are due to electronic malfunctions.
The thermal expansion is very important for the durability of electronic components. Joining of different materials exposed to variations of temperature generates the strain mismatch which can be locally strong. These strains might cause cracks which initiate malfunctions.
Strain mismatch occurs by the following process:

- During the production process (soldering conditions, heat production during curing, …)
- During the operation due to local production of heat (Resistant loses microprocessors, diode laser, …)
- Changes of ambient temperature

On the other side simulations (FEM, …) are used in the electronic industry, but the material parameters (coefficient of thermal expansion, young's modulus, …) have to been known. A validation of results is necessary. In some cases simulations are not possible, than the measurement precise deformation is necessary.

DANTEC DYNAMICS

The 3D-ESPI Sensor Q300 is a very powerful tool to investigate the thermal expansion of electronic components. Due to the full field measuring technique combined with a high resolution the determination of critical areas and hot spots in electronic components is very easy.

Deformation of yaw sensor due to power consumption

The measurement set-up is shown in fig. 1. The optical sensor head of the Q-300 is placed above the yaw sensor and the PLC44 housing is connected to the power supply. Applying a voltage of 5 V the surface deformation has been monitored during heating up. The power consumption was 1,35 mW. In fig. 3 the resulting displacement fields are shown. The maximum displacement in the in-plane direction is the range of ± 0,6 µm and in the range of ± 0,3 µm for the out-of plane displacement. The displacement field in z-direction shows the place of the sensor (light blue) an the ASIC itself (red)

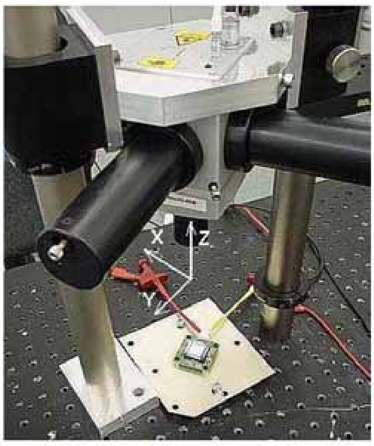


Fig. 1: Set-up of 3D ESPI

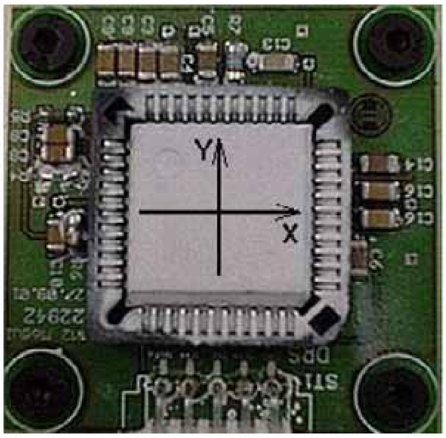


Fig. 2: Sensor in a PLC44 housing

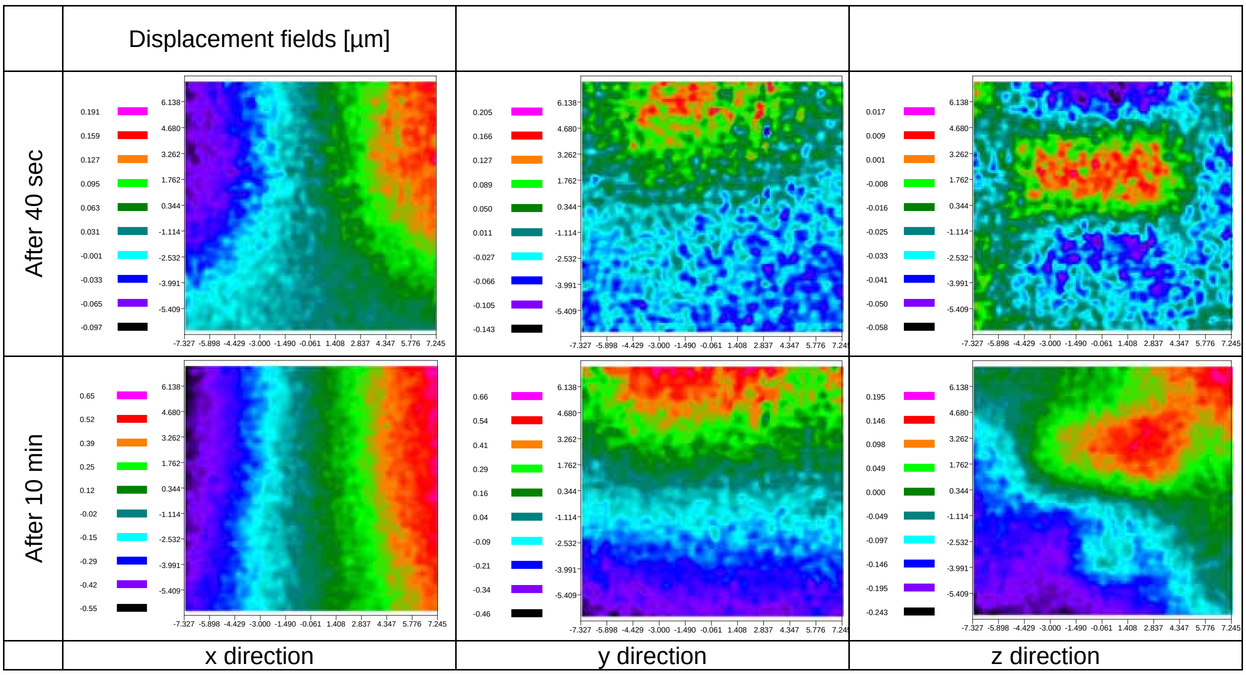
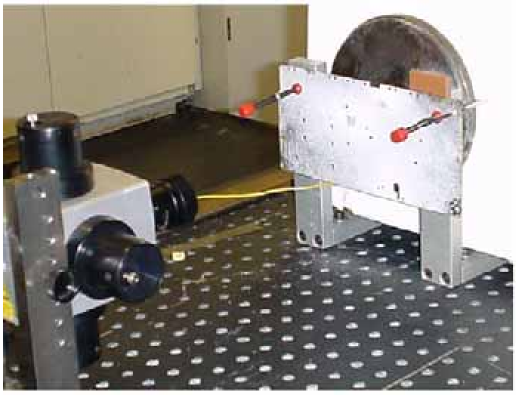


Fig. 3: Displacement fields after switching on the power supply voltage of 5V (Power= 1,35mW)

Thermal expansion of an electronic board

In fig. 4 the set-up for the test of a electronic board is shown. No components are mounted on the board but some internal layers are inserted in order to reduce the thermal expansion locally. The board is heated from the backside by thermal radiation.

The board has been heated from room temperature up to 60° C. Fig. 4 shows the displacement fields in the two in-plane directions and the related strain fields. In the strain field ε_{yy} the effect of reducing the thermal expansion is clearly seen.



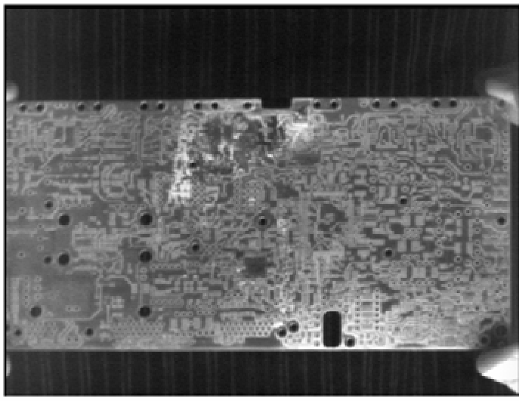


Fig. 4: Test set-up
left image: Q300 with the board and heating plate, right image: electronic board as seen by the sensor

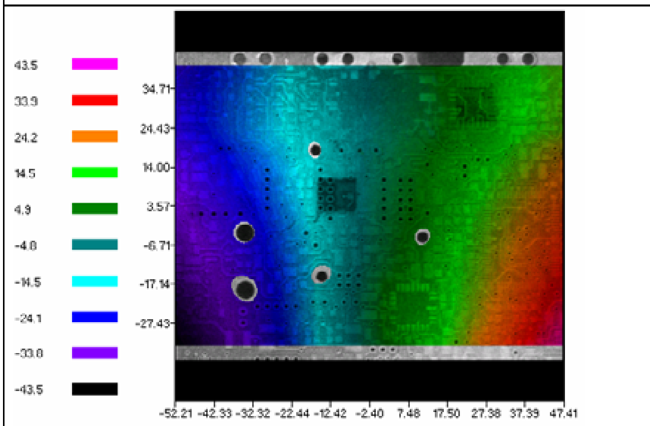
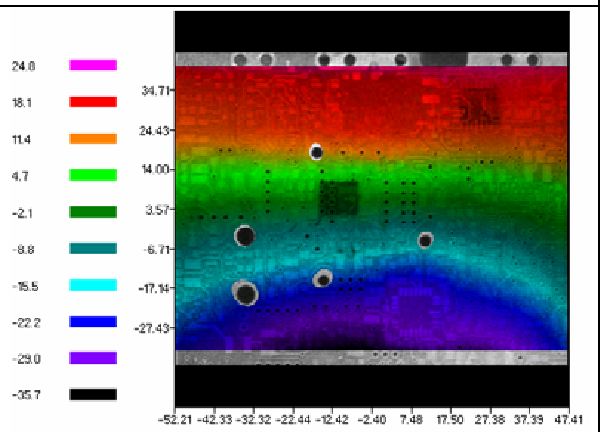
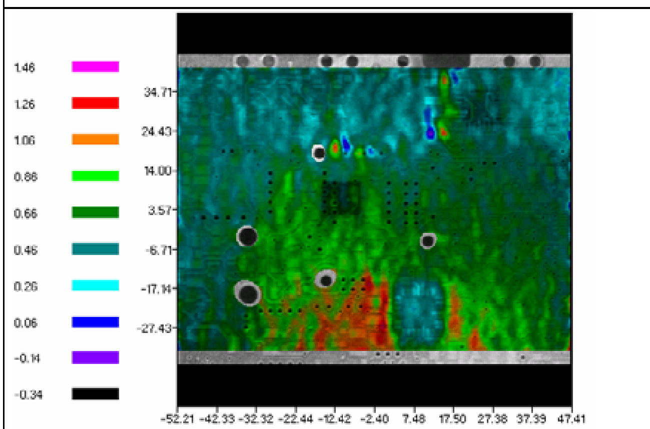
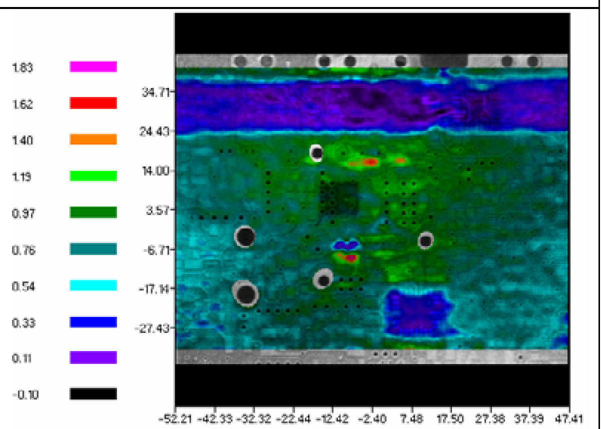
Displacement x-direction [µm]	Displacement y-direction [µm]
	
Strain ε_{xx} [µm/mm]	Strain ε_{yy} [µm/mm]
	

Fig. 5: In-plane displacement and strain fields after heating from room temperature up to 60°C

Conclusion

Measurements with the Dantec Dynamics laser optical measuring system Q-300 enable us to characterize thermal loading not only of electronic components. Thermal stresses can be easily detected, defects will be found. The sensitivity and spatial resolution is quite well adapted to the application. Due to the variability of the sensor, it can be easy adapted to the measurement problem.

For more information please contact:

Dantec Dynamics GmbH
Kaessbohrerstrasse 18
89077 Ulm
Germany

Tel.: +49-731-933-2200
Fax: +49-731-933-2299

E-mail: product.support@dantecdynamics.com
Internet: www.dantecdynamics.com

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