Q-300 TCT

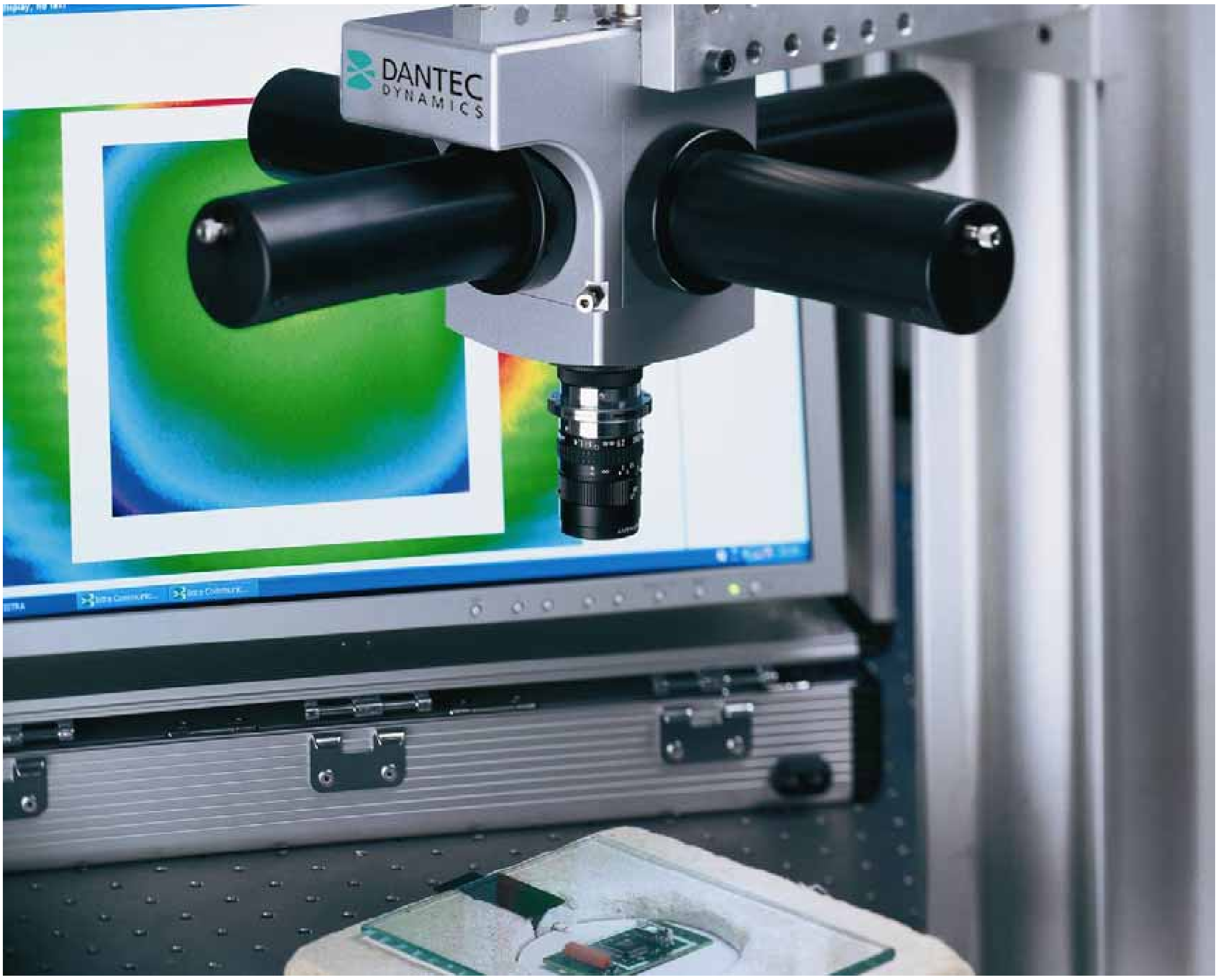
Application Note - A-Q-300TCT-BallGridArrays-001a-EN

Thermal expansion of Ball grid arrays

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. For example the thermal expansion coefficients for typical materials, used in a BGA assembly are shown in the table below.

Gold:	$\alpha = 14{,}2 \cdot 10^{-6}/K$
95 Sn-5Ag:	$\alpha = 23{,}2 \cdot 10^{-6}/K$
Silicon:	$\alpha = 2{,}6 \cdot 10^{-6}/K$
FR4:	$\alpha = 13{,}0 \cdot 10^{-6}/K$
Dexter Hysol FP4401:	$\alpha = 22{,}0 \cdot 10^{-6}/K$
Ablebond 965-1L:	$\alpha = 50{,}0 \cdot 10^{-6}/K$



The variation of the thermal expansion coefficient can be up to a factor of 25. The 3D-ESPI Sensor Q300 is a very powerful tool to investigate the thermal expansion of BGAs 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.

Masurements of Ball Grid Arrays (BGA)

Fig. 1 shows the scheme of the principle of the assembly of a BGA. The measurement set-up is shown in fig 2. The component is placed in the heating chamber.

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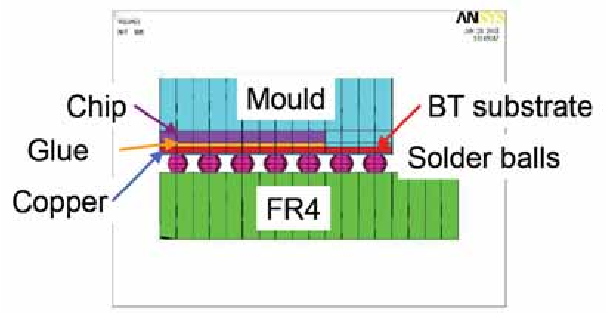


Fig. 1: Different components of a BGA assembly

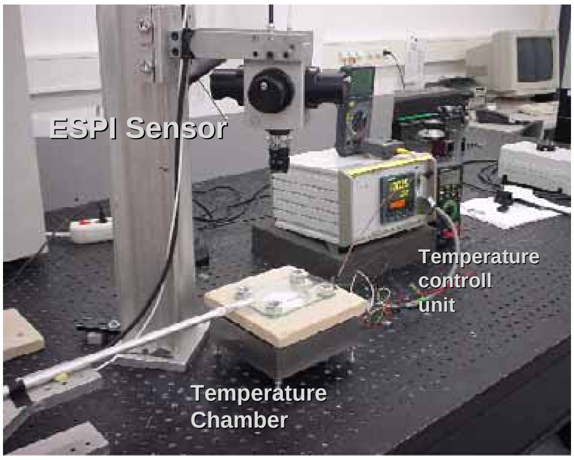


Fig. 2: Measurement set-up

Measurement of BGA with and without defect

Fig. 3 shows the sample as seen by the sensor. The thermal expansions of two BGA's (one without and one with defect) are measured from room temperate up to 140 °C. The result of the thermal loading is shown in fig 4 – good sample and fig. 5 – bad sample at three different temperatures. The in-plane displacement fields are quite similar. The bending in z-direction of the sample B shows a different behaviour than the good sample. At approximately 120 °C the middle of the BGA bends in the opposite direction.

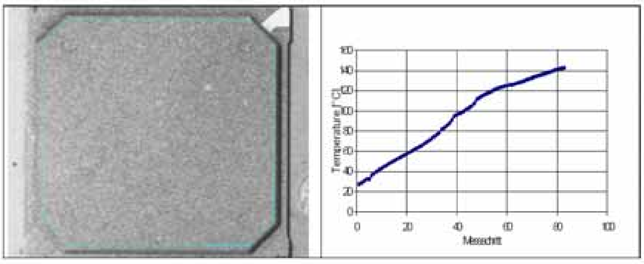


Fig. 3: 1" BGA as seen by the sensor (left image) and thermal loading curve (right image)

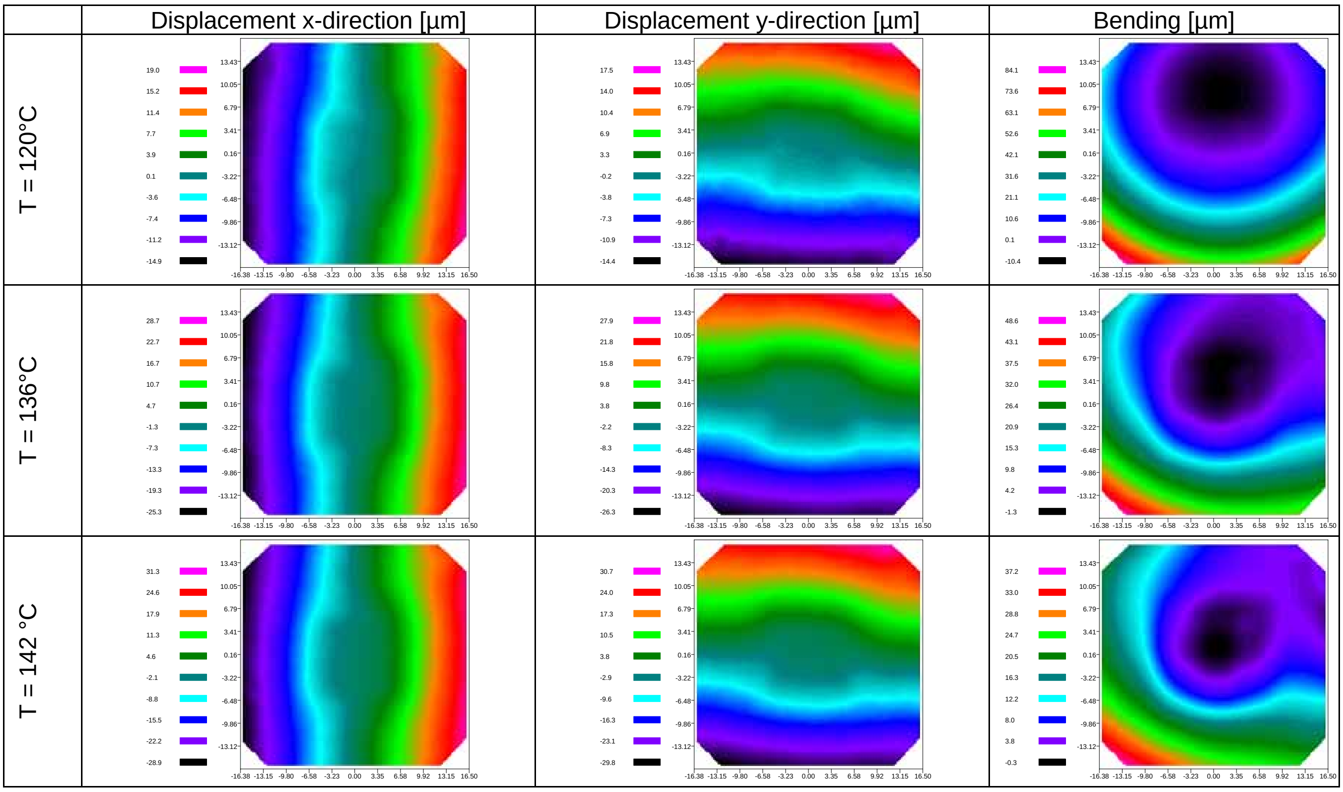


Fig. 4: Thermal expansion of a BGA without defect. Measurement started at room temperature.

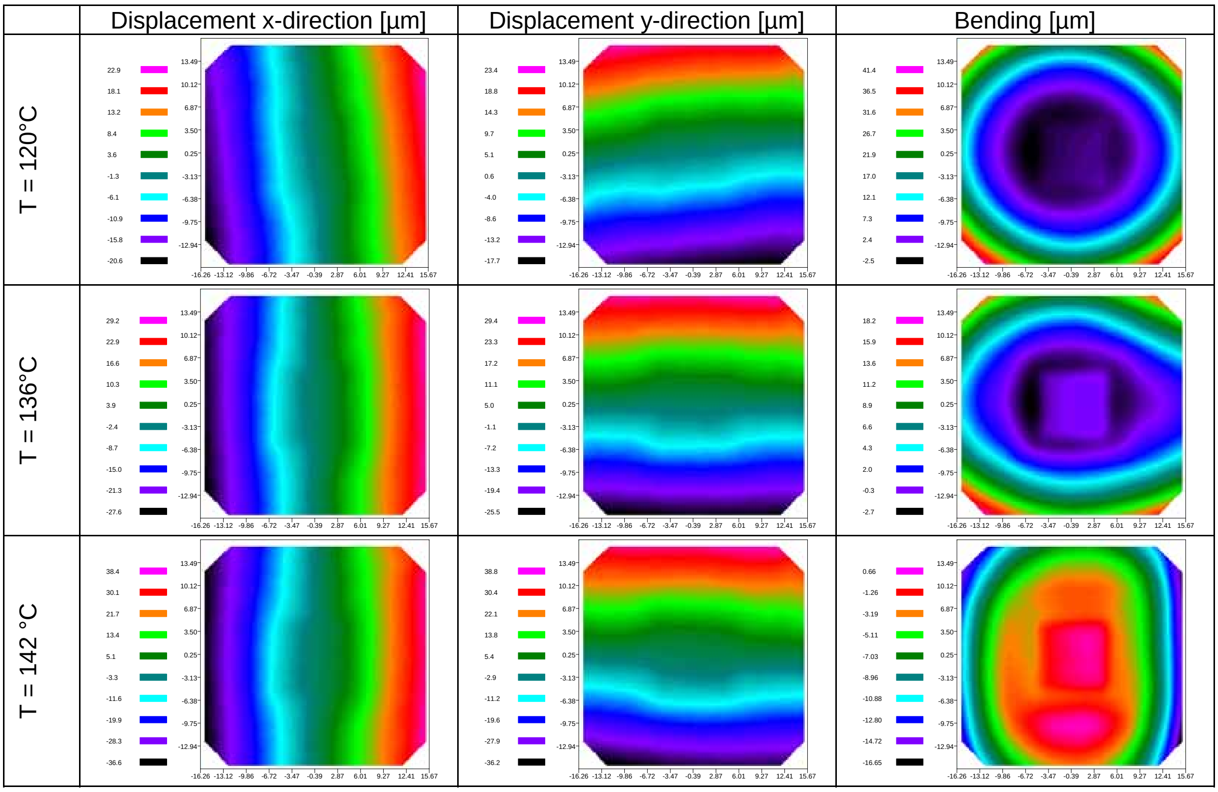


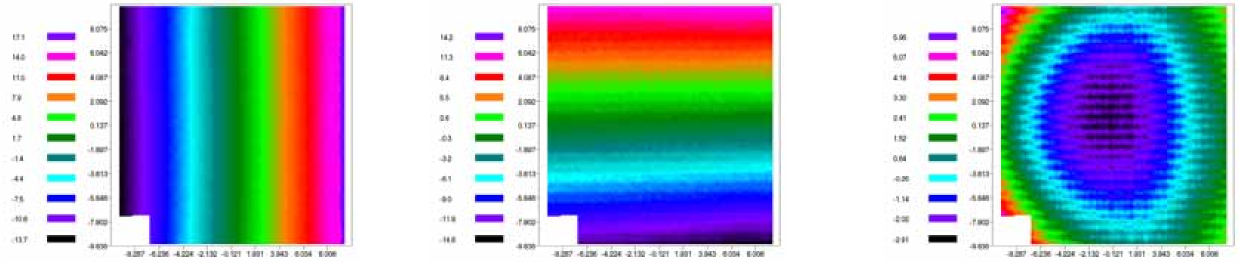
Fig. 5: Thermal expansion of a BGA with defect. Measurement started at room temperature.

Measurement of the fiber reinforced substrate

FR4

The measurements are performed with the same setup and the same thermal loading as the measurements of the BGA's above. Fig. 6d shows the FR4 sample as seen be the sensor.

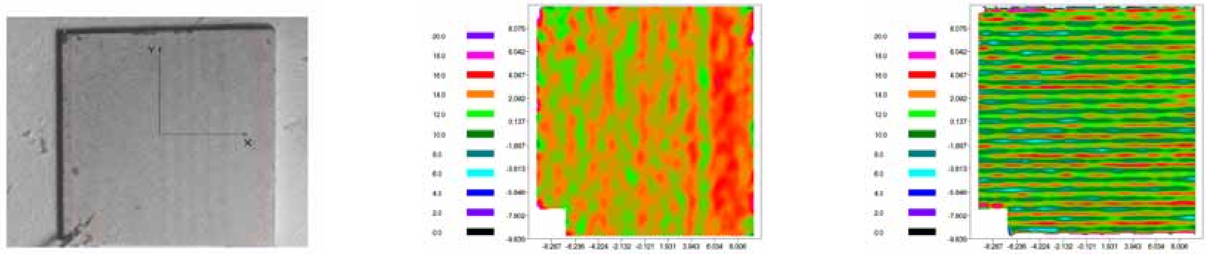
The results for the in-plane and out-of-plane displacement as well the spatial distribution of CTE's are shown in the same figure. The upper fiber layer is seen in fig. 6c and fig. 6f. Fig. 7 shows the difference of the CTE in due to the fiber orientation.



a) displacement field x-direction [µm]

b) displacement field y-direction [µm]

c) displacement field z-direction [µm]



d) Sample

e) CTE for x-direction [10^{-6} 1/K]

f) CTE for y-direction [10^{-6} 1/K]

Fig. 6: Sample, displacement fields and spatial distribution of CTE for a FR4 sample

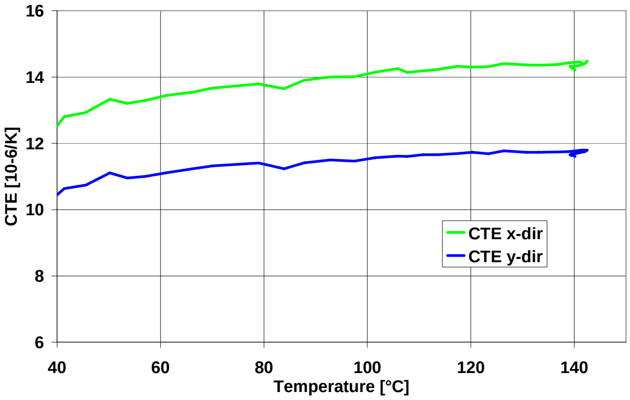


Fig. 14: Temperature dependence of the CTE of FR4

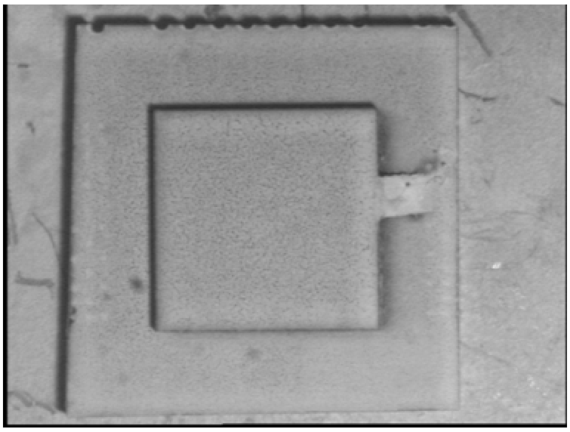
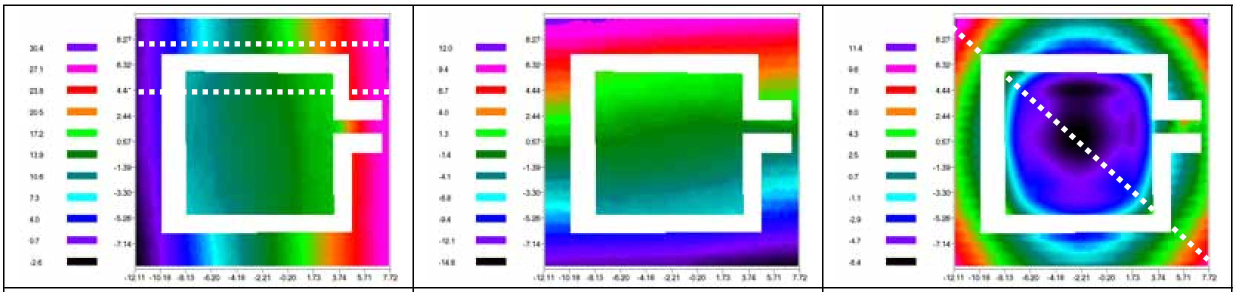


Fig. 15: BGA assembly

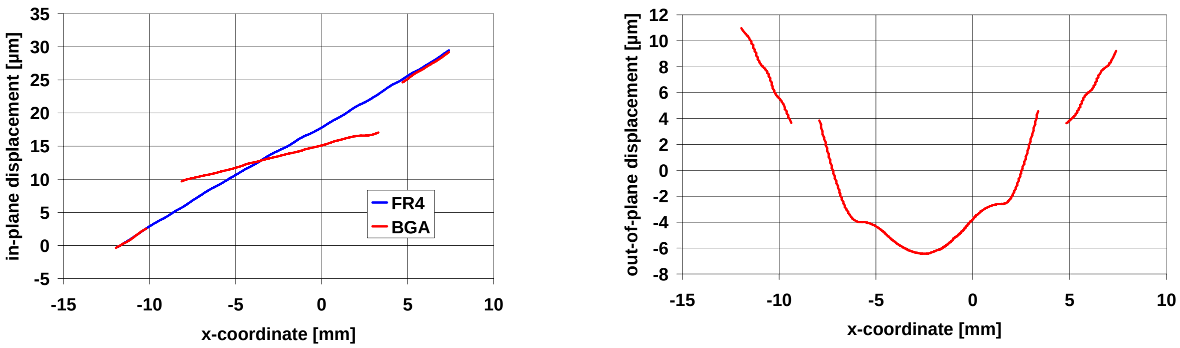


a) x-displacement [µm]

b) y-displacement [µm]

c) z-displacement [µm]

Fig. 9: In-plane and out-of-plane displacement fields of a BGA assembly after thermal loading.



a) x-displacement on the FR4 and the BGA
(dashed lines in fig 9 a)

a) z-displacement on the FR4 and the BGA
(dashed lines in fig 9 c)

Fig. 10: variation of the in-plane and out-of-plane displacement vectors along the dashed line indicated in fig 9

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