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ANALYSIS OF TEMPERATURE-CURRENT RISE IN MODERN PCB TRACES BY MEANS OF THERMOGRAPHY

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Higher functionality of today's electronic products demands high density integration of electronic components. In this field, printed-circuit-board (PCB) are the perspective technology to build a variety of electronic systems for different applications. Two types of boards were investigated: high current for power applications and high density boards for modern electronic equipment. The set of IR images and temperature-current diagrams for different substrate materials were investigated. Current and temperature limits for all test boards were defined to provide high level of board reliability.

Introduction

The global trend in the electronic industry driven by automotive, aerospace, computer, telecommunication, hand held equipment and other products is showing up in improved performance and better human interface. So the electronic equipment is demanding miniaturization and function integration. In this field, printed-circuit-board (PCB) embedding technology has the potential to play the important role with the possibility to build a variety of electronic modules and systems for different applications. However, miniaturization and function integration increase the equipment power density and as a result - increase the operating temperatures of electronic components and current caring traces. These factors decrease the reliability and life time of electronic equipment. So the very important problem of PCB design is the thermal analysis to provide the optimal technology solution.

The thermal effects in active and passive electronic components were completely investigated and analyzed [1,2]. But the physical and technological limitations in modern PCB copper traces in the context of their thermal stability are still under consideration. A few works where thermographic technique was used for control and monitoring of PCB systems were published [3,4]. The purpose of this work was investigation and analysis of modern PCB current currying capacity of traces (CCCT) in dependence of board materials and trace sizes (thickness, width, length) to provide high levels of electro-thermal stability and operating reliability of electronic systems realized on new boards.

Test boards for thermographic analysis of temperature-current rise in traces

Two types of test boards [5,6] have been fabricated and investigated:

1) Test board for high current application (power supply units, electromechanical, automotive and other power equipment). The boards (Fig. 1) were manufactured using FR-4 substrate (of 1.5mm thickness) with dimensions 100x200 mm^2. The board was manufactured in two versions: with nominal copper layer thicknesses of 18 and 35 µm and traces with the different shapes, widths and lengths.

2) High density boards for modern equipment (Fig. 2). The boards were manufactured using perspective substrates: Al_2O_3 ceramic substrate (of 500 µm thickness) and aluminium/polymide (240 µm / 4,0 µm) substrate with dimensions 60x48 mm^2. Trace parameters: material Ti-Cu-Ni-Au (0,05-2-0.3-0.2 µm), length L = 1,5 – 28 mm, widths W = 150 - 530 µm.

Thermographic analysis of temperature-current rise in test PCB traces

Thermographic analysis of temperature-current rise in PCB traces was conducted using Flir A40 IR camera with macro (17 µm resolution) lens, precise micro positioning system and specially developed software tool (IRDataProc) for object emissivity coefficients map generation and object temperatures correction [7,8].

Thermal images of all conducting traces of test boards were investigated in dependence of electric current. Maximal temperatures of the traces were defined and plotted as a function of electric current.

Results for high current test board.

The measured I-T characteristics and IR images of traces with different shapes, widths and lengths (see Fig. 1) and Cu layer thickness of 18 and 35 µm values are presented in Fig. 3 – Fig. 4 .

It is seen from Fig. 4 that (for the same current values) trace "G" has much more higher temperature values in comparison with the other traces.

Results for high density test boards (Fig.2).

The measured I-T characteristics and IR images are presented for different trace widths (Fig. 5), ceramic and aluminium/polymide substrates (Fig. 6), trace lengths (Fig. 7).

It is seen from Fig. 6 that ceramic substrate provides much more better heat removing for traces in comparison with aluminium/polyimide substrate.

Analyzing the temperature measurement results for traces with different lengths in Fig. 7 it is seen that the maximal length 27.5 mm is limited by the temperature value of 122.4°C.

Conclusion

Temperature- current characteristics of PCB conducting traces were measured and analyzed by means of thermography techniques for two types of boards: high current for power applications and high density for modern electronic equipment.

- Current and temperature limits for traces with different layer thickness, substrate materials, trace widths and lengths were defined based on board reliability.
- The results allowed to provide recommendations on design of reliable boards for modern electronic equipment. These results were used by PCB designers in their projects.

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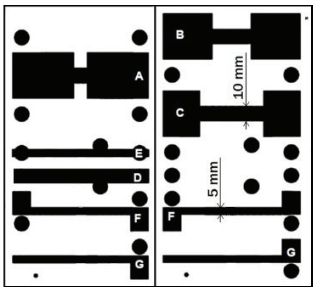
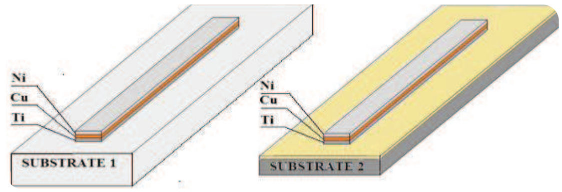


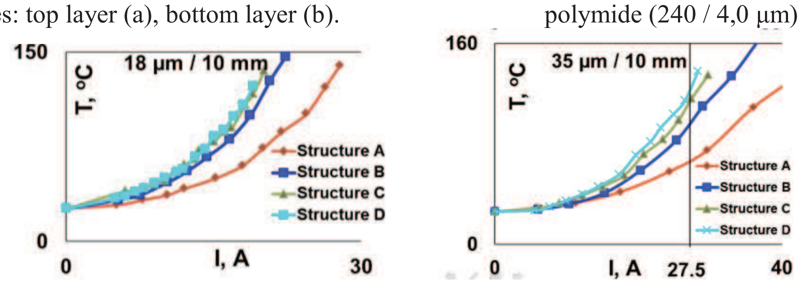
(a) (b)

Fig. 1 Layouts of high current test board [6] with different trace structures: top layer (a), bottom layer (b).

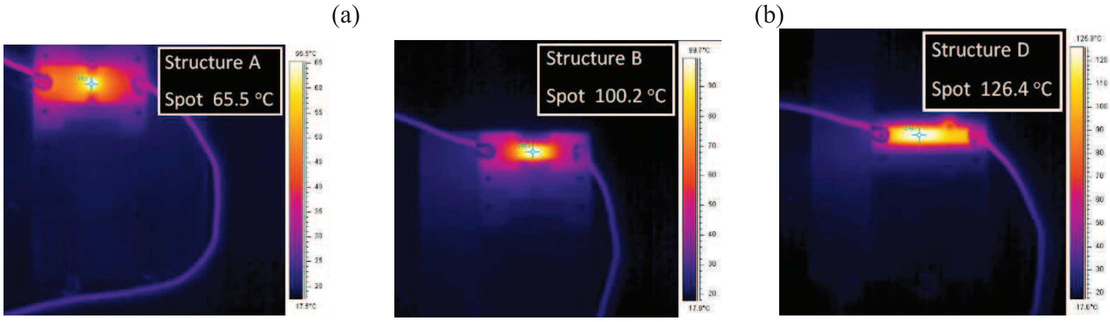


(a) (b)

Fig. 2 Structures of modern high density test board: with ceramic Al_2O_3 (500 µm) substrate (a) , with aluminium / polymide (240 / 4,0 µm) substrate (b).

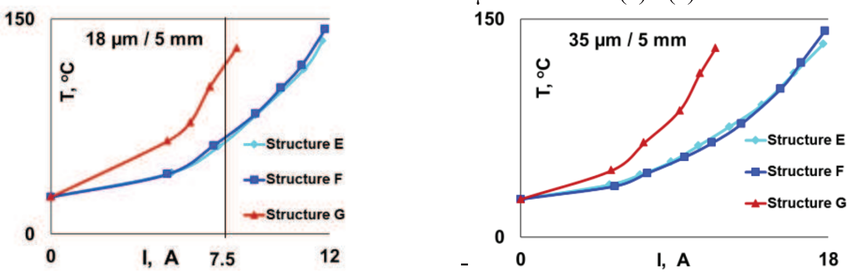


(a) (b)

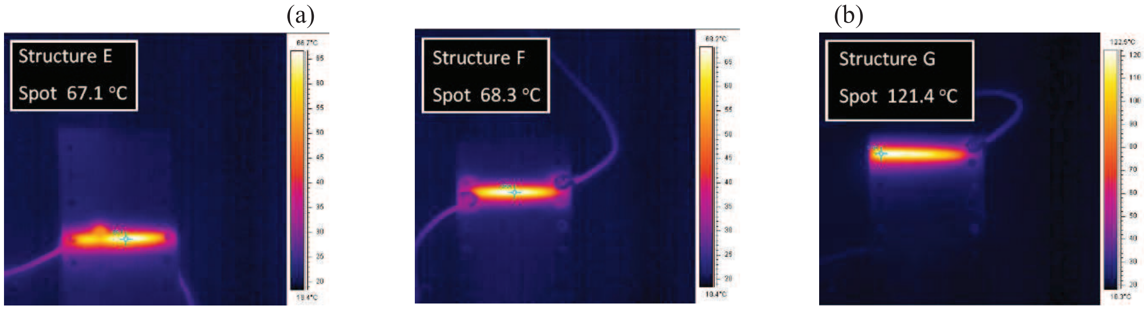


(c) (d) (e)

Fig. 3. I-T characteristics for traces A-D (Fig. 1) with 18 µm (a), 35 µm (b) layer thickness. IR images of the mentioned traces for 7.5A current and 18 µm thickness (c) –(e).

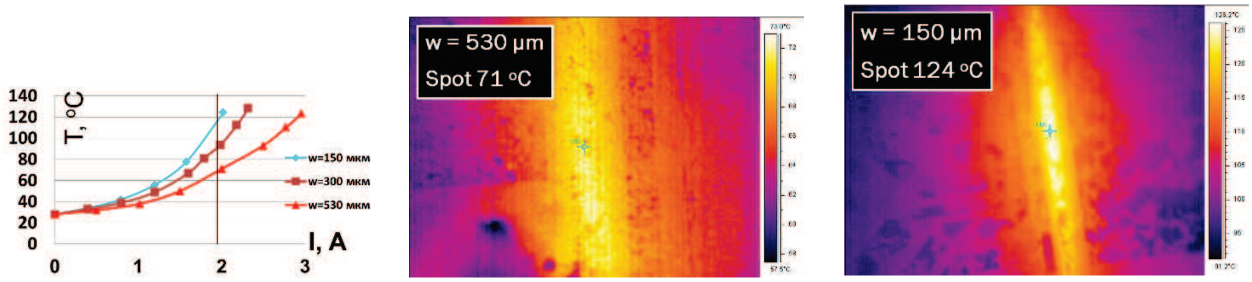


(a) (b)



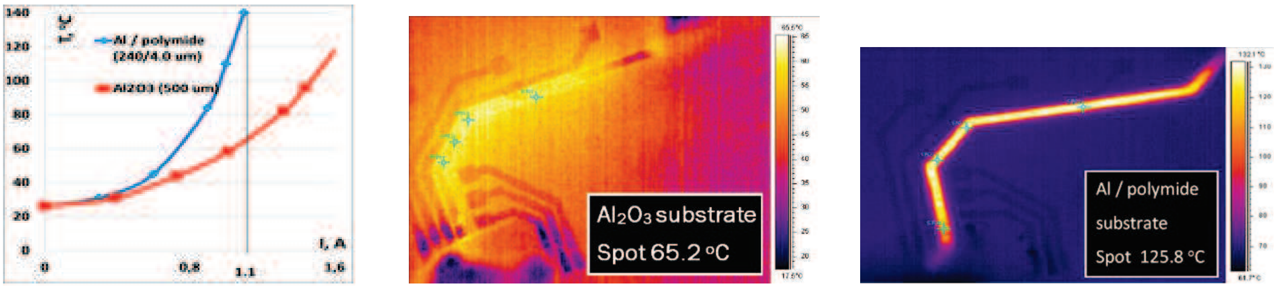
(c) (d) (e)

Fig. 4. I-T characteristics for traces E- G (Fig. 1) with 18 µm (a), 35 µm (b) layer thickness ; IR images of traces with the mentioned structures for 7.5A current and 18 µm thickness (c) –(e).



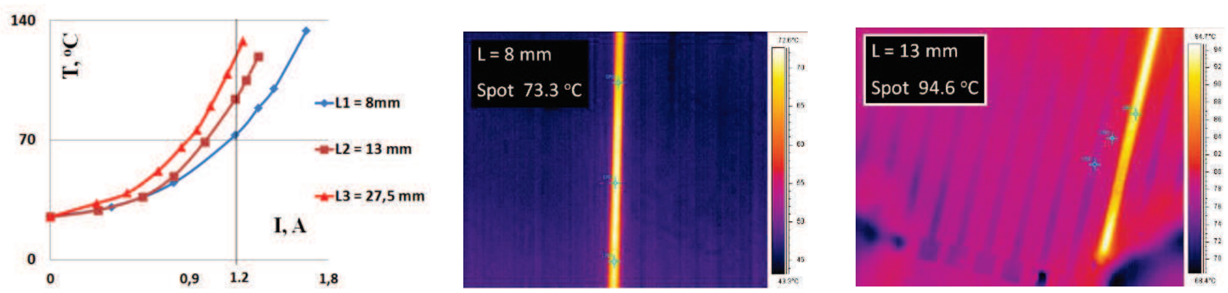
(a) (b) (c)

Fig. 5. I-T characteristics (a) for high density traces (see Fig 2) with different widths and IR images (for 2A current) for trace placed on a polyimide board for the different trace widths of traces (b) – (c).

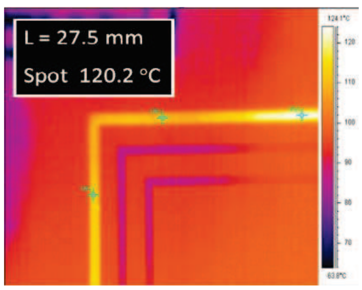


(a) (b) (c)

Fig.6. I-T characteristics (a) for high density traces (Fig 2) for different substrates; IR trace images (for current of 1.1A) for trace placed on a ceramic (b) and Al/polyimide (c) substrates .



(a) (b) (c)



(d)

Fig. 7. I-T characteristics (a) for high density traces (Fig 2) with different lengths; IR images (for current of 1.2 A) for trace placed on Al/polyimide substrate for different trace lengths (c)-(d).