Non-destructive Testing of Electronic Components Overheating Using Infrared Thermography

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Abstract

Software-hardware IR thermography subsystem for non-destructive testing of electronic components overheating has been developed. IR measuring part included: Flir ThermoVision A40 infrared camera with 17 mkm macro lens, Quantum Focus Instruments Corp InfraScope, precise positioning system. Software part for IR data processing included two standard tools: ThermaCAM Researcher, NEC San-ei Image Processor and several original software tools for extension of the subsystem abilities. The sets of examples are presented to illustrate the efficiency of using IR thermography measuring subsystem for non-destructive testing of electronic components (semiconductor devices, chips, PCBs) to improve thermal stability and reliability of electronic products.

Keywords: Electronic components, chips, PCBs, units, infrared thermography, overheating, hot points, reliability

1. Introduction

Electronic components overheating caused by electrical power is the most important factor reducing their reliability. The increase of 10-15°C in the semiconductor device active region temperature can reduce product lifetime by more than 50%. As a result, the thermal effects are one of the main limiting factors in electronic equipment operation especially for modern components with growing power density and elements temperatures. So the control and monitoring of electronic components thermal behavior is necessary to detect their possible failures and to enhance their reliability. As it is known the most effective way to provide safe thermal regimes of electronic equipment is temperature investigation in the different levels of electronic components: from semiconductor chips to PCBs and units. Thermal imaging with IR cameras [1] provides a nondestructive, nonintrusive, noncontact mapping of temperature in electronic components thus allowing the quick detection and recognition of hot spots and overheating in electronic components.

In this work we describe the infrared thermography system which is used for noncontact mapping of temperature in electronic components. IR images are used then for detection and analysis of electronic components overheating.

2. Infrared thermography system

As it is seen from Fig. 1 the infrared thermography system consists of two parts :

Hardware part is based on Flir ThermoVision A40 infrared camera with 17 mkm macro lens and InfraScope (Quantum Focus Instruments Corp) for IC measuring. The precise 3D positioning system is used providing more opportunities for testing of small-size complex device constructions (semiconductor chips, for example).

Software part for IR data processing includes two standard tools: ThermaCAM Researcher and NEC San-ei Image Processor. Several additional original software tools have been developed to extend the subsystem abilities:

- IRDataProc software tool for generation of emissivity coefficients map of object to improve the accuracy of the object temperature map measurement.
- Tool for IR data conversion between Flir ThermaCAM Reseacher and NEC San-ei Image Processor software tools.

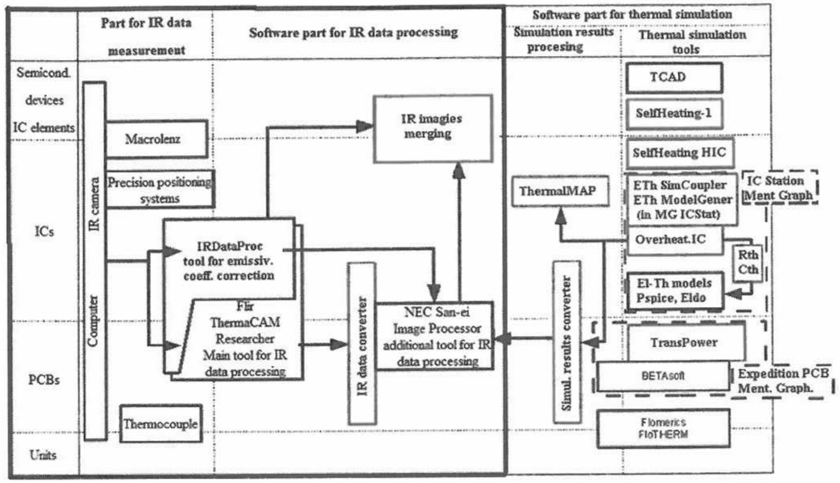


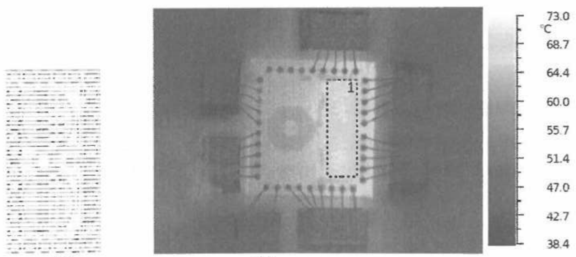
Figure 1. IR system for multilevel non-destructive testing of electronic components overheating (left part) integrated with overheating simulation tools (right part)

3. Non-destructive Testing of Electronic Components Overheating

Using the infrared thermography system the following hierarchy of electronic components was non-destructively tested to detect hot spots and analyze their overheating: integrated circuit (IC) chips, discrete semiconductor devices, printed circuit boards (PCBs), electronic units.

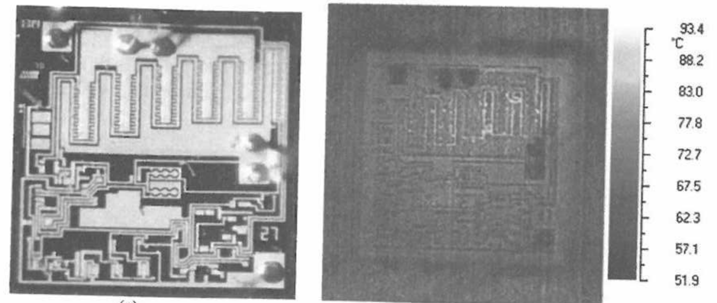
3.1 Integrated circuit chips

The chips for digital ICs with submicron and nanometer elements sizes for low power and high performance; analog middle and high power ICs, high speed and microwave middle and high power ICs were examined.



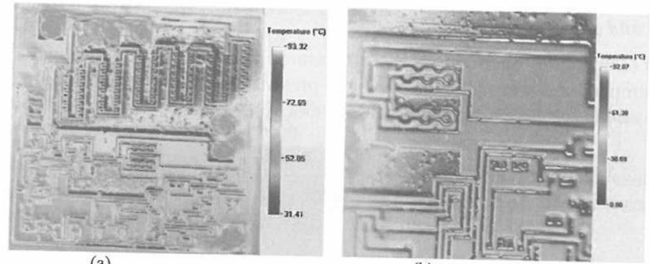
(a) (b)

Figure 2. Layout (a) and IR image (b) of integrated microwave power BJT amplifier (Flir A40 IR camera with 17 mkm macrolenz)



(a) (b)

Figure 3. Photo (a) and IR image (b) of integrated voltage regulator K142EN9, Vin=40V, Vout=27V, Iout=0.27A (Flir A40 IR camera with 17 mkm macro lens)



(a) (b)

Figure 4. More detailed IR images of the integrated voltage regulator K142EN9 (see Figure 3) (a) and it fragment (b) (QFI InfraScope).

3.2 Discrete electronic semiconductor components

1) diodes based on p-n and Schottky junctions; 2) low-, middle- and high-power transistors with bipolar, MOS and IGB structures were examined. The devices without case and packaged in case with removed metallic caps were used for surface chip temperature measuring.

For discrete devices and ICs the results of measured data processing were: temperature distributions in device layout, maximal and average temperatures, hot spots and p-n-junction thermal resistances with account for heat sinks and mounting/packaging and cooling conditions .

It is important to note that IR testing of chip temperatures is really the only method of non-destructive testing of whole chip temperature map. The results of IC chips overheating testing were used then to optimize IC layout, case materials, cooling conditions. For discrete semiconductor devices the testing results were used to optimize case construction, cooling conditions, choosing heat sink. Furthermore IR measuring results were used for power MOSFET electro-thermal model parameters determination.

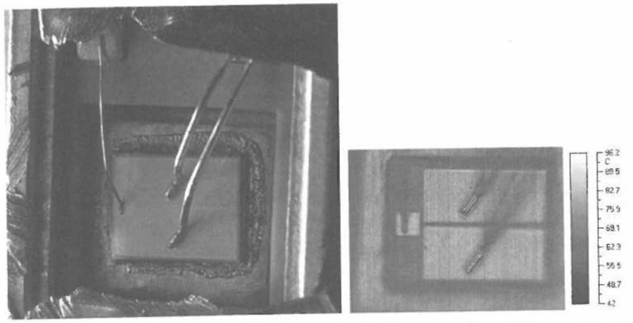
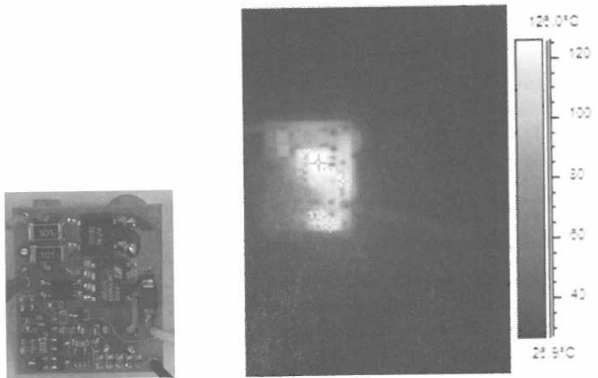


Figure 5. Photo (a) and IR image (b) of power DMOS FET with removed metallic cap placed on heatsink. 10kHz rectangular pulses with 25% duty factor. (Flir A40 IR camera with 17 mkm macrolenz)

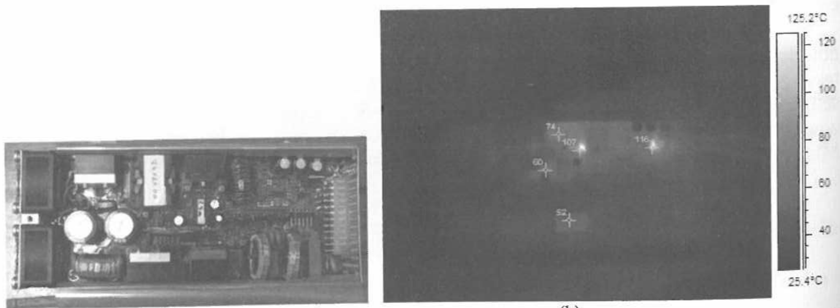
3.3 PCBs and electronic units

2D temperature distributions were measured and after that the critical elements with maximal temperatures were recognized. Fig. 6 presents results for power supply PCB and Fig. 7 presents results for AC/DC converter IP 350 electronic unit.



(a) (b)

Figure 6. Photo (a) and IR image (b) of power supply PCB (Vout=12V, Iout=1A) (Flir A40 IR camera)



(a) (b)

Figure 7 . Photo (a) and IR image (b) of AC/DC converter IP 350 , P=350W (Flir A40 IR camera)

Critical overheating (temperature up to 126°C) elements have been defined for power supply PCB (Figure 6). Bad location of electrolytic capacitors nearly hot elements (temperature up to 116°C) has been detected. The unit construction was corrected to eliminate capacitors overheating.

4. Conclusions

The described IR measuring subsystem has been included into the general hardware-software system for thermal design, control and management of electronic components [2,3]. Except for hot spots and overheating detection the IR measuring results were used for verification and tuning of mathematical models for thermal simulation of chips, PCBs, units. Furthermore, it is important to note that IR testing of chip temperature is really the only method of non-destructive testing of whole chip temperature map.

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