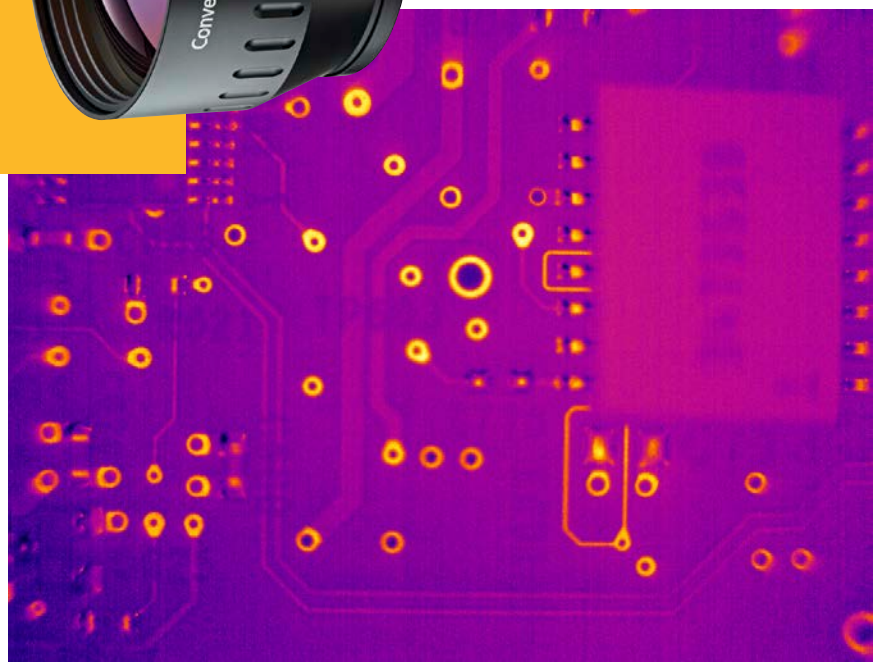
APPLICATION NOTE

Semiconductor inspections utilizing infrared thermography

A solid understanding of macro lenses is crucial for many photographers. The same is true of infrared thermographers. With more lens options come the need for a deeper understanding of optics and how they work and what is required to be successful in inspections of circuit boards and devices.



Multilayer circuit board

Normal, telephoto or wide angle lenses may not provide the spatial and/or measurement resolution needed on a project but adding macro lens options may just provide the fine detail needed for many applications. Applied properly a macro lens can provide the spatial resolution necessary to resolve thermal patterns on targets as small as 25 microns in size, a fraction of the size of a human hair.

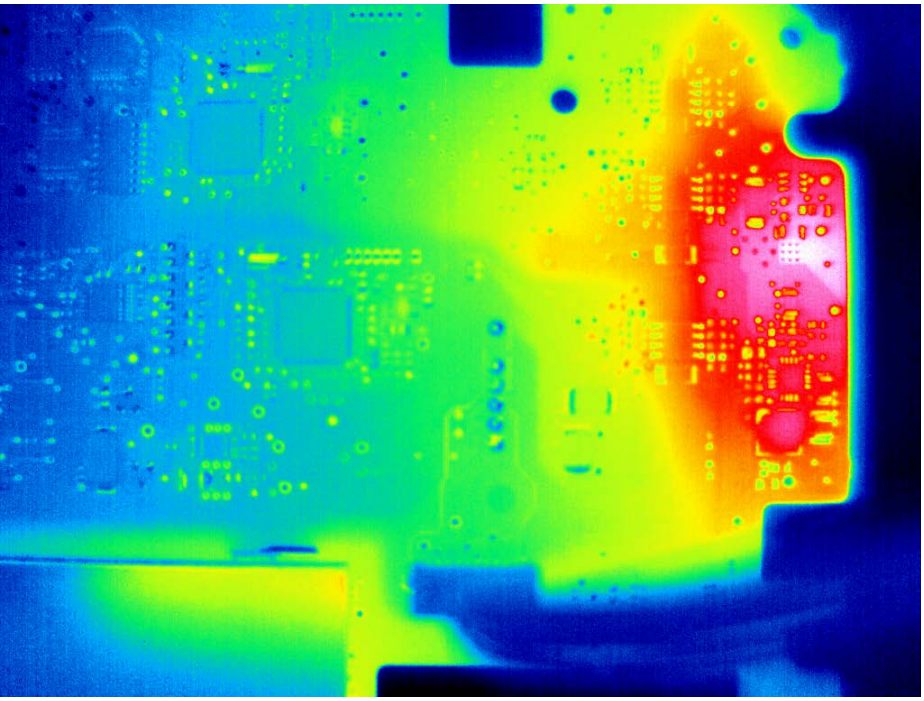
One application where many thermal aspects must be considered, controlled and measured is the design, manufacture and repair of circuit boards, electronic and microelectronic devices. Printed circuit boards (PCB) can be single-sided with one layer of copper, double-sided with two copper layers, or multilayer with outer and inner layers of copper. Multilayer are typically the most complex with high component density, through hole connections and even embedded components such as, capacitors or resistors in the substrate. So whether you are designing or performing quality control testing on individual components or complete assemblies—or simply troubleshooting—the use of an infrared camera with the proper optics is crucial for the detection or measurement of small thermal differences or thermal profiles on these devices.

Design

From the design perspective a key to solid reliability is semiconductor junction temperatures. When in operation a semiconductor, memory device or power transistor may generate significant heat. This heat will move in all directions but will conduct especially efficiently along the electrical connectors due to their high thermal conductivity. This can create increased temperatures at the junctions where the chips are soldered to the circuit board. Components with high junction temperatures often have reduced life. Infrared can be used to evaluate this heating and appropriate design changes can be implemented such as additional heat sinking or other forms of cooling.

Manufacturing

During manufacturing the metallization and deposition processes are always a concern with regards to quality control. Single-sided, double-sided or multilayer boards present many challenges during the manufacturing process. Traces, connector pads and plated through hole quality are crucial to the production of high reliability PCBs. High resistance, shorts or open traces from the etching process can produce increased heating or no heating when current is supplied. Poor metallization can lead to shorts or lifting of connector pads or issues with surface-mounted components. Through holes may be drilled with high speed tungsten carbide bits or laser drilled. They are utilized to provide a conductor path to two or more layers of a two-sided or multilayer



Multilayer circuit board dissipating excess heat

PCB. Smearing from the drilling process or poor surface finishes from laser drilling may result in high resistance connections or open conductor paths. Consistent thermal indications on multiple samples can suggest a manufacturing process issue. Utilizing infrared thermography with the appropriate optics can help provide high quality finished products.

Troubleshooting

Several challenges exist when attempting to troubleshoot either design concerns or in field situations. Access for proper imaging of components may be supported in the field by extender cards. Another consideration if the relatively shallow depth of field when utilizing macro lenses. Relatively flat two-dimensional objects are not usually a problem but three-dimensional objects may cause some focus issues and therefore data quality considerations.

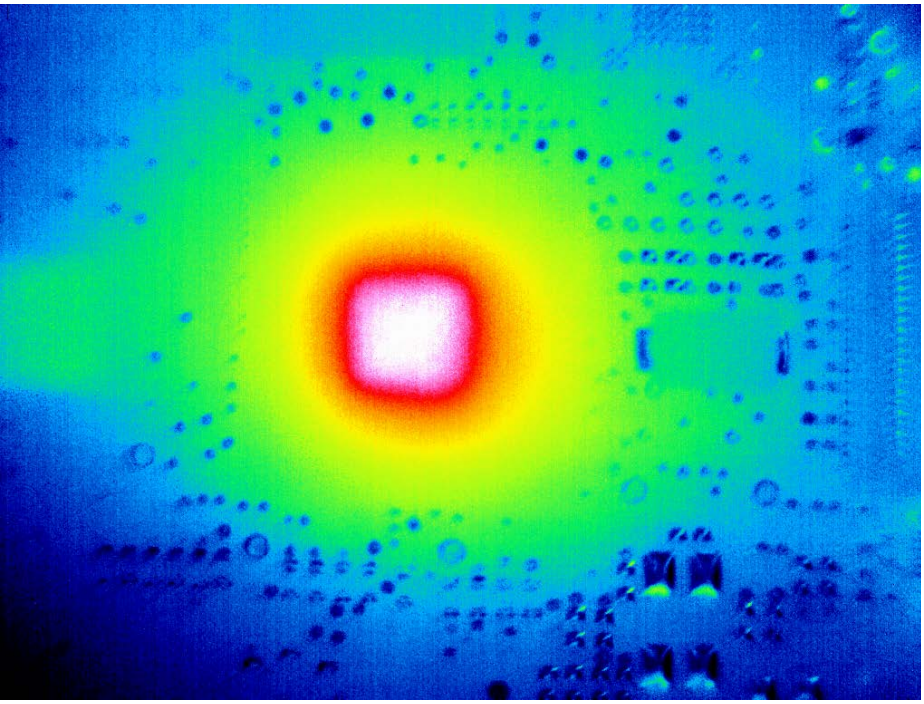
Other issues to consider

Emissivity variations must also be considered when temperature measurements are being attempted. FR-4 glass epoxy is fairly emissive in the infrared spectrum but the components and their connections may be fairly reflective to infrared radiation making it very difficult to get high quality temperature data from this type of material. PCBs that will be exposed to harsh environments may have a conformal coating that will improve emissivity of the entire assembly.

Many components may also be semi-transparent to infrared radiation. In this situation temperature data may not only be coming from the surface of the component but also from inside (below the surface) making for challenging data acquisition and diagnosis. And cooling fans may be doing their job by convectively cooling components but they may also be eliminating thermal patterns that could support diagnostic investigation. So a good understanding of heat transfer and the physics behind infrared thermography are a must for this challenging application.

Many materials used in the manufacture of PCBs are subject to electrochemical migration (whiskers) resulting in shorts or component failure. High case and heat sink temperatures, quiescent currents and thermal response time can be evaluated for design performance of circuits. Additionally we must remember cold (or near ambient) components, traces or connections may indicate a failed or open circuit when troubleshooting.

Analysis tools on the infrared camera and in the supporting software can provide additional capabilities when analyzing data collected from thermograms or radiometric video. Measurement tools such as; spot, area or profile can provide maximum, minimum or average temperature data based on their respective shapes. Also a histogram or isotherm can be used to display temperature distribution mathematically or visually. Data



Circuit board chip dissipating excess heat

accuracy may be increased by the proper utilization of emissivity, background temperature and transmissivity correction provided by infrared cameras and in supporting software.

Whether you are designing a new device, conducting manufacturing quality control testing or troubleshooting components or fully assembled printed circuit boards infrared testing can provide thermal data to help diagnose anomalies and pass/fail boards or components faster and more effectively.

Fluke. *Keeping your world up and running.®*

Fluke Corporation
PO Box 9090, Everett, WA 98206 U.S.A.

Fluke Europe B.V.
PO Box 1186, 5602 BD
Eindhoven, The Netherlands

For more information call:
In the U.S.A. (800) 443-5853 or
Fax (425) 446-5116
In Europe/M-East/Africa +31 (0) 40 2675 200 or
Fax +31 (0) 40 2675 222
In Canada (800)-36-FLUKE or
Fax (905) 890-6866
From other countries +1 (425) 446-5500 or
Fax +1 (425) 446-5116
Web access: http://www.fluke.com

Printed in U.S.A. 10/2015 6006584a_en