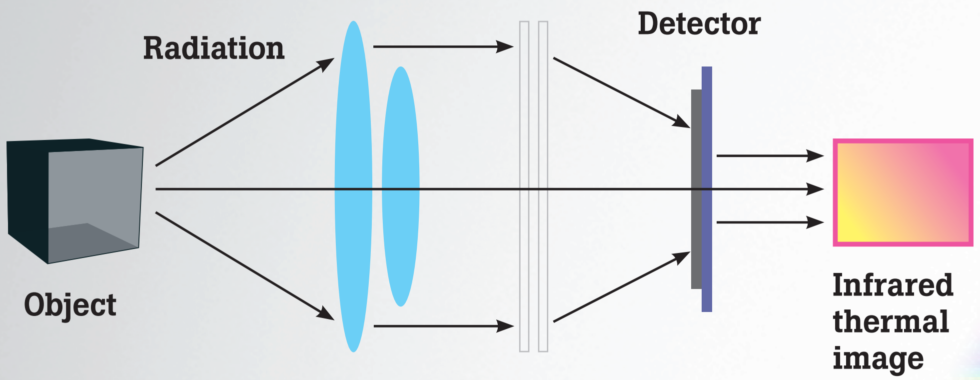
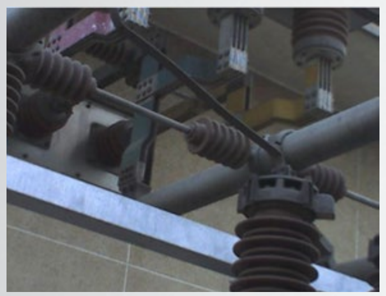
FLUKE®

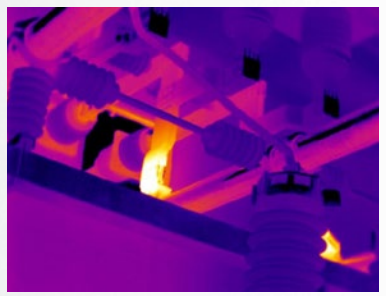
Infrared guide to research and development

REAL WORLD APPLICATIONS AND CASE STUDIES

HOW INFRARED CAMERAS CAPTURE IMAGES




Visible light image


Infrared thermal image

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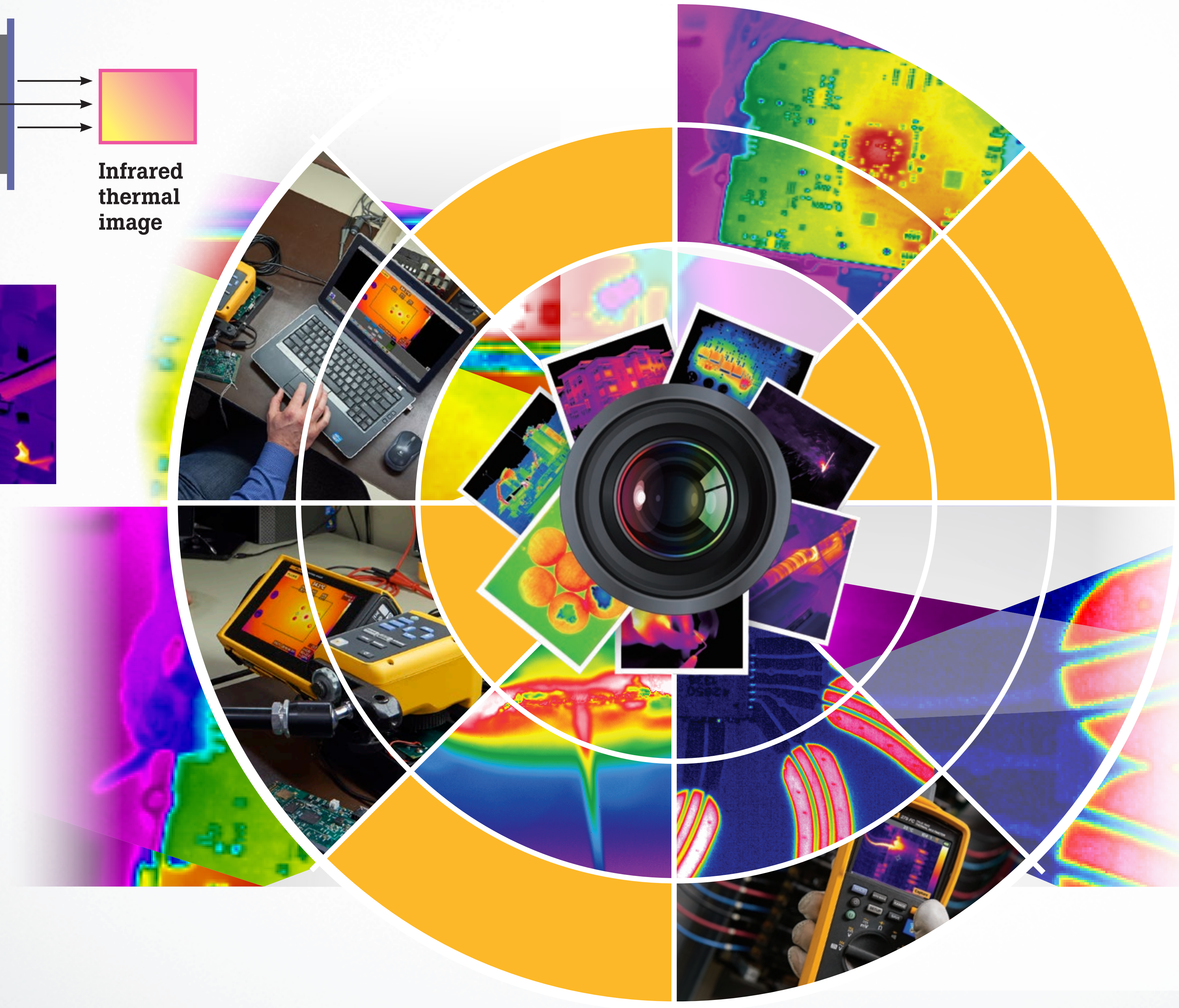


HOW INFRARED BENEFITS R&D APPLICATIONS

The temperature data gathered by thermal imagers, combined with the analysis capabilities of software, is making significant contributions to scientific research. Even in areas which may appear unrelated to temperature, the data provided by thermal imaging technology is leading to improved and better understanding of the results. See illustration *How infrared cameras capture images*, left.

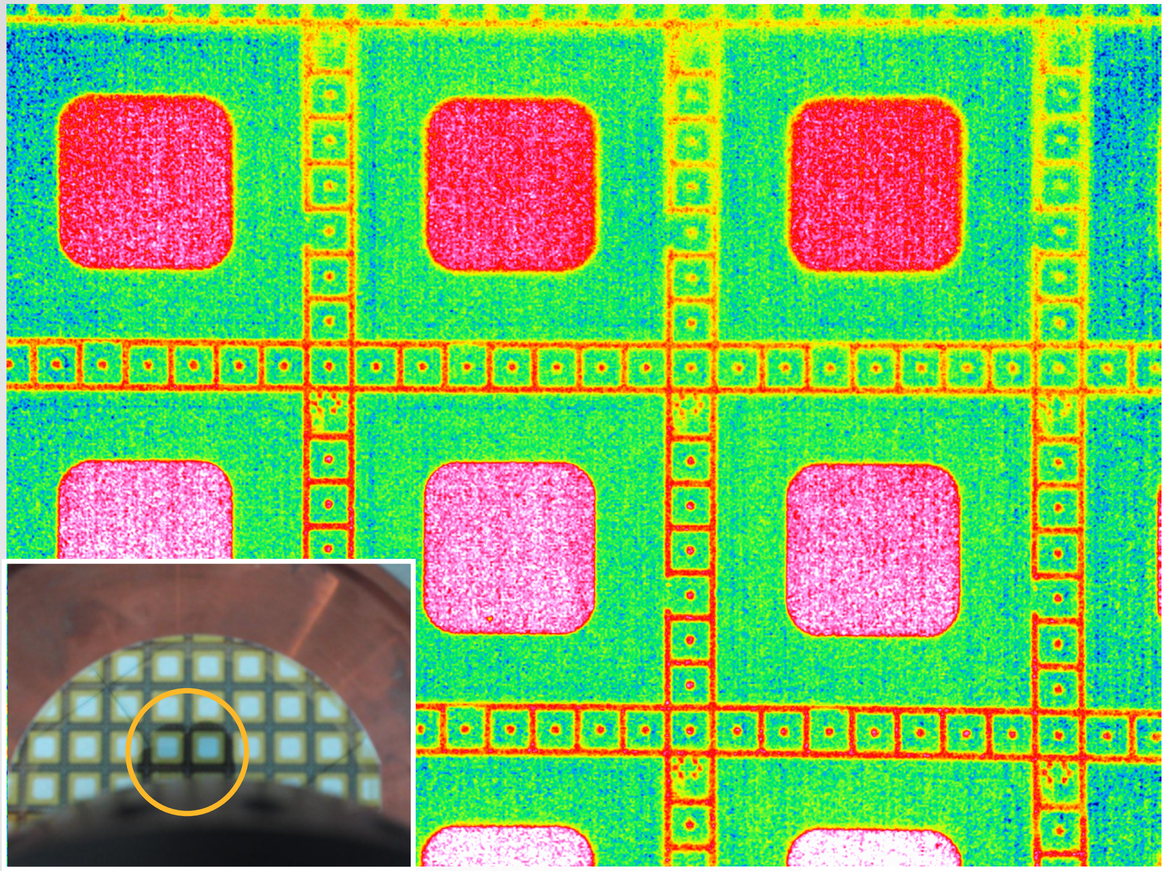
Fluke's infrared camera products provide researchers with powerful tools that allow users to analyze surface temperatures. The difference in colors on infrared thermal images very quickly and visually represent variations in temperatures that could indicate problems. In addition, through the use of dedicated software and plug ins that enable your camera to communicate with your preferred R&D software (MATLAB® or LabVIEW®), real-time temperature data can be read off for individual points on the thermal video or image allowing detailed data analysis to be inserted into reports created for research projects.

The ramifications of missing something you can't see in R&D can be huge:

- Missed experiment details that invalidate research
- Incur high costs due to failed components
- Confidence in the products your company produces
- Catch vendor product quality issues before accepting shipments.

All quickly and easily with the power of Fluke infrared.

CASE STUDY #1: TESTING OF ELECTRONIC COMPONENTS AS SMALL AS 32 MICRONS



Thermal image of the chip lattice taken with the Fluke infrared camera with a macro lens

Extremely small targets measured in microns are usually a challenge in temperature testing, and as contact thermometers are restricted by their size, they have no way of testing targets which are smaller than 1 mm, while high-end infrared cameras and their specialist macro lenses are capable of effectively testing targets as small as 32 microns in size. This describes a case study on the use of Fluke infrared cameras during the process of temperature testing for micron chips, as well as offering a system solution.

Test case

A certain research institute needed to test the temperature distribution in a chip lattice. The usual minimum target size for effective testing with common thermal imagers is 0.2 mm and above. Precision testing can only be achieved by meeting certain performance requirements in terms of pixels and optical systems.

The on-site configuration used here was:

1. Fluke infrared camera
2. Macro telephoto lens–camera was placed at a distance of 10 cm. The macro telephoto lens configuration was just able to meet the dual focusing requirements of a small target and relatively large distance.
3. In order to make focusing easier during the tests, a tripod and a two-dimensional adjustable precision displacement platform were used.

In the test, there were two layers of lattice components, with the temperature of the upper lattice component layer being 34.1 °C and the temperature of the lower lattice layer being 34.2 °C. In terms of heat dissipation, each of the lattice layers had different heat dissipation profiles. The researchers were able to use this difference to test the effect of the different arrangements on the components, and independently test certain problem components. The smallest test target that the cameras can handle is 32 microns,

which fully met the researchers' needs in testing extremely small targets measured in microns.

As the test distance was small, neither laser auto-focusing function nor auto-focusing function were suitable for the macro lens here; when manual focusing is used, very precise adjustments of the optical system are necessary, and it is easy to either under focus or over focus when focusing manually over very short distance; out of focus images can have an impact upon the effectiveness of the test.

A fairly effective method: first, adjust the focus for the smallest target (i.e. shortest distance), then move the target or the thermal imager so that the image becomes clear. As a result more precise displacement can be made, and the precision of the focus on the nearby small target will also be improved.

Applications

Research departments testing microelectronic or electronic component targets measuring smaller than 0.2 mm, and in particular electronic components under 0.1 mm in size, such as chips, integrated circuits and electronic components, etc.

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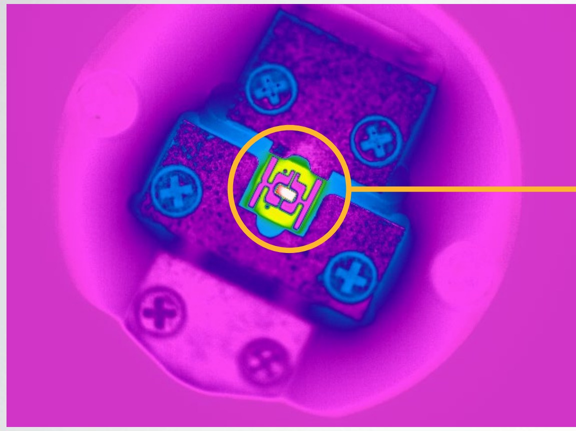
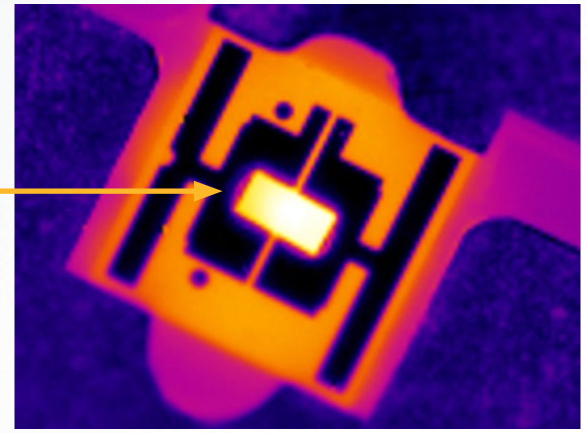
CASE STUDY #2: THERMAL ANALYSIS OF A 1 MM CHIP

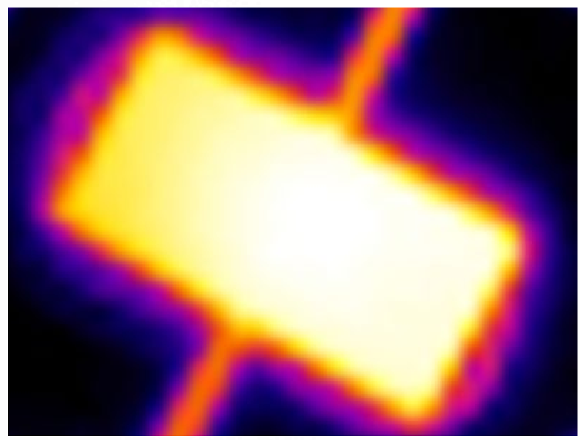


The circle shows the LED chip, the area around it is the electrode. This chip is 2 mm x 1 mm in size.



Zoom function used to display the chip at x4 magnification of the camera display.

As can clearly be seen from the thermal image, the temperature on the left and right sides of the chip is not the same, and researchers are able to use this as the basis for improving the materials of the component as well as its design in terms of heat dissipation.



x16 magnification of the chip

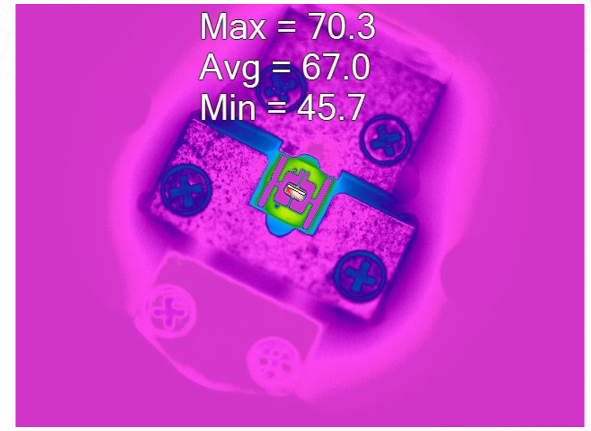
Temperature is a key technical indicator for LED chips, representing the quality of design of the LED components. Heat emission and dissipation directly affect the service life and the color quality of LED products. However, as LED chips are very small, traditional test methods cannot measure their temperature. This article uses a case study to describe the process and system solution in which Fluke infrared cameras were used to test LED chips.

Test case

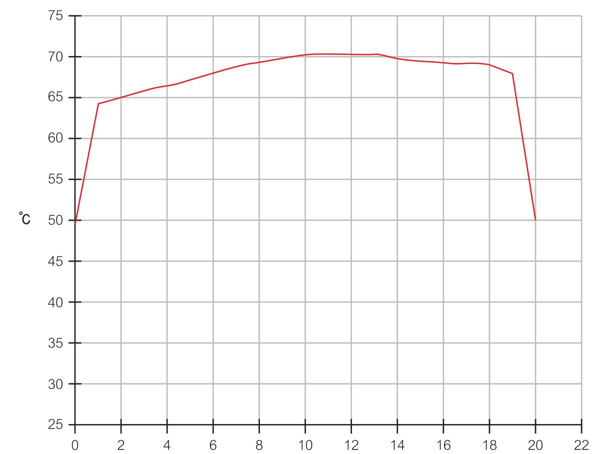
While engaged in the research and development of new products, a certain well-known manufacturer of optoelectronic components had the need to observe and analyze the temperature distribution in an LED chip in order to improve the design in terms of the heat emission and dissipation of the component.

Test solution

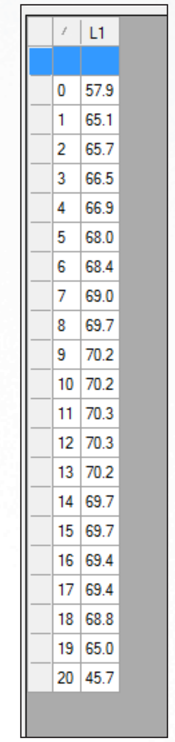
1. A macro lens was selected.
2. A tripod and a two-dimensional adjustable precision displacement platform were fitted, allowing the thermal imager to be positioned vertically downwards for testing to take place.
3. The precision displacement platform was finely adjusted until the image was at its sharpest.
4. The thermal image on the camera was zoomed in to observe the temperature distribution of the chip.
5. The temperature distribution of the chip was analyzed using SmartView® software during this test but temperature data camera exports are also supported in MATLAB and LabVIEW software as well.



Liquid temperature analysis of the chip using software



Trend graph for temperature distribution as pixel position changes



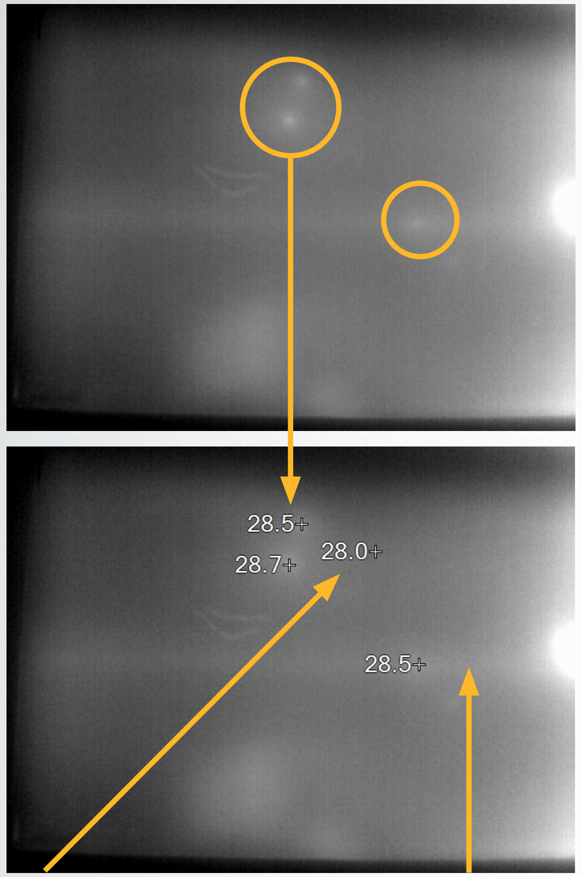
/	L1
0	57.9
1	65.1
2	65.7
3	66.5
4	66.9
5	68.0
6	68.4
7	69.0
8	69.7
9	70.2
10	70.2
11	70.3
12	70.3
13	70.2
14	69.7
15	69.7
16	69.4
17	69.4
18	68.8
19	65.0
20	45.7

Temperature data exported in a TXT file

Applications

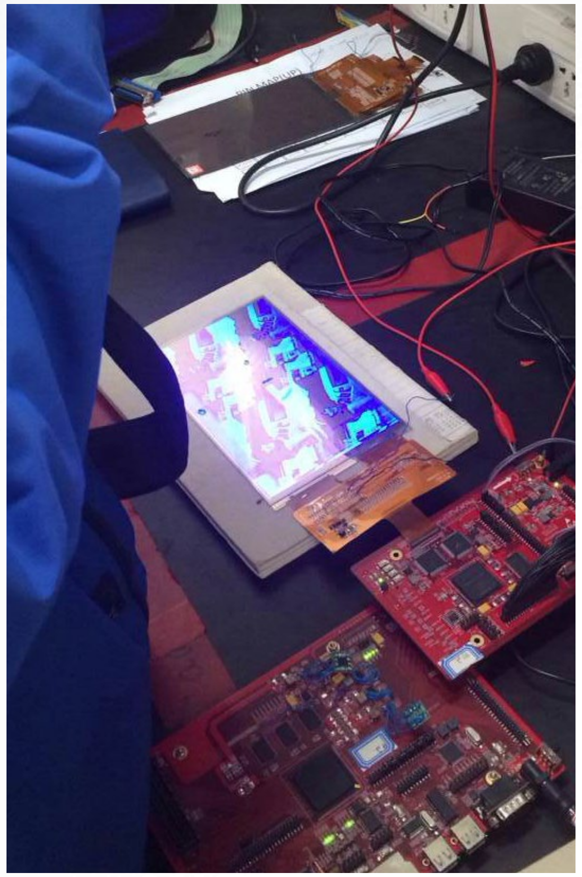
Manufacturers of optoelectronic and electronic chip components, etc.

CASE STUDY #3: TESTING FOR DEAD PIXELS ON LCD PANELS

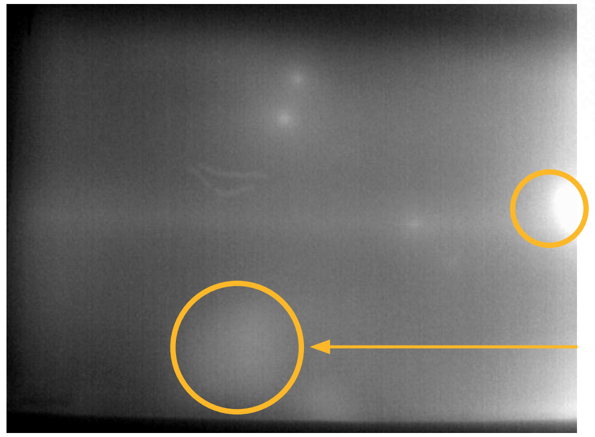


The normal temperature of the LCD panel is 28.0 °C

A heat-emitting line at the center of the LCD panel which requires further testing and analysis at a later date.



Two-dimensional adjustable precision displacement platform



This is the heat given off due to heat conduction from the power supply component on the right of the LCD panel, and is perfectly normal.

This is the reflection of the radiant energy from the tester. This should either be avoided as much as possible, or a material used to block this effect.

LCD screens may experience dead pixels due to quality issues; however, these dead pixels are often very small, and checking and analyzing the cause of the damage is very difficult. Currently, an effective method for achieving this is infrared testing; however, as dead pixels are very small, measured in microns, and there are very small temperature variations, this poses difficulties when using infrared testing. This case study describes the process and system solution in which Fluke cameras were used to test for dead pixels on LCD screens.

Test case

A certain well-known LCD manufacturer needed to test for dead pixels on its LCD panels. If the panels do have dead pixels or other defects, due to their high internal resistance, hot spots are presented on thermal images. This panels presented the two following challenges for testing:

1. Small target: each pixel on the LCD panel is micron-sized, with the smallest pixels being only 40 microns in size, varying slightly depending on models.

2. Little temperature variation: this is affected by the energy transfer factor of the overall heat emitted by the LCD panels, with the difference in temperature between dead pixels and normal parts generally being no more than 1 °C.

Solution

1. Selecting a macro lens and configure it depending on the actual on-site conditions.
2. A tripod and a two-dimensional adjustable precision displacement platform were fitted.
3. It is recommended that the color palette be set to grayscale mode, in order to more easily observe the small temperature variations.
4. As the surface of the LCD is made from glass, when testing, it is important to make sure that there are no reflections from personnel or other devices on the LCD screen, causing interference. It is recommended that an opaque material which is impervious to infrared energy be used (such as cloth or paper, etc. for blocking; synthetic paper may not be used).

Applications

LCD manufacturers and manufacturers of related devices, etc.

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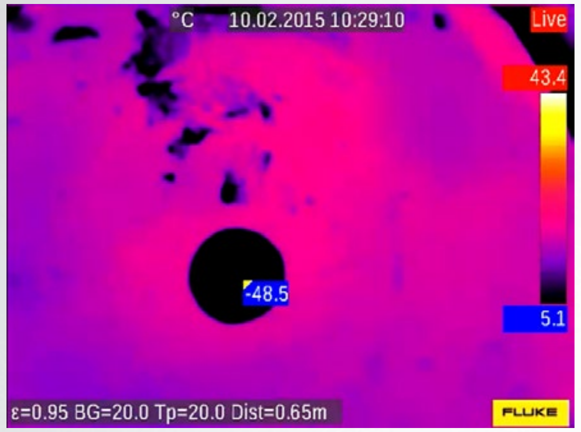
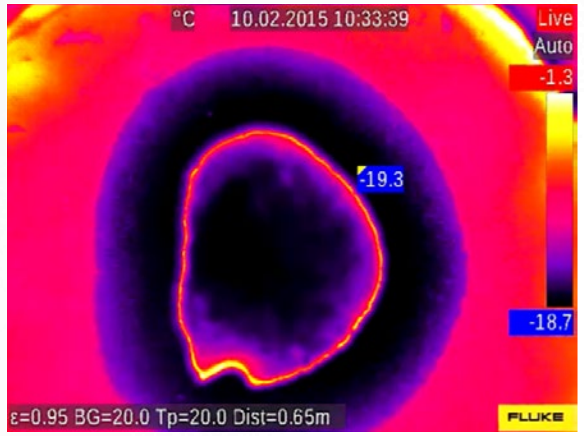
CASE STUDY #4: TESTING HEAT CONDUCTION PERFORMANCE AT LOW TEMPERATURES



The black parts are the special material. After liquid nitrogen is poured onto them, the temperature of these parts suddenly falls to below -40 °C due to its heat conduction coefficient.



Effect spreading, the low-temperature regions have become several times larger than they were in the image on the left. The irregular red circular pattern on the inside is showing from when the heat is transferred, providing supporting data for the heat transfer properties for each part of the material.

In harsh environments, and especially at very low temperatures, monitoring heat dissipation and the heat conduction performance of materials are commonly used techniques in research. However, temperatures below -20 °C and relatively fast temperature changes place special demands on the accurate low temperature capability of thermal imagers. We've outlined some experiments with low temperature heat conduction to describe the use of the rapid temperature analysis methods of Fluke thermal imagers on low temperature targets. This provides effective test solutions for these applications.

Experiment

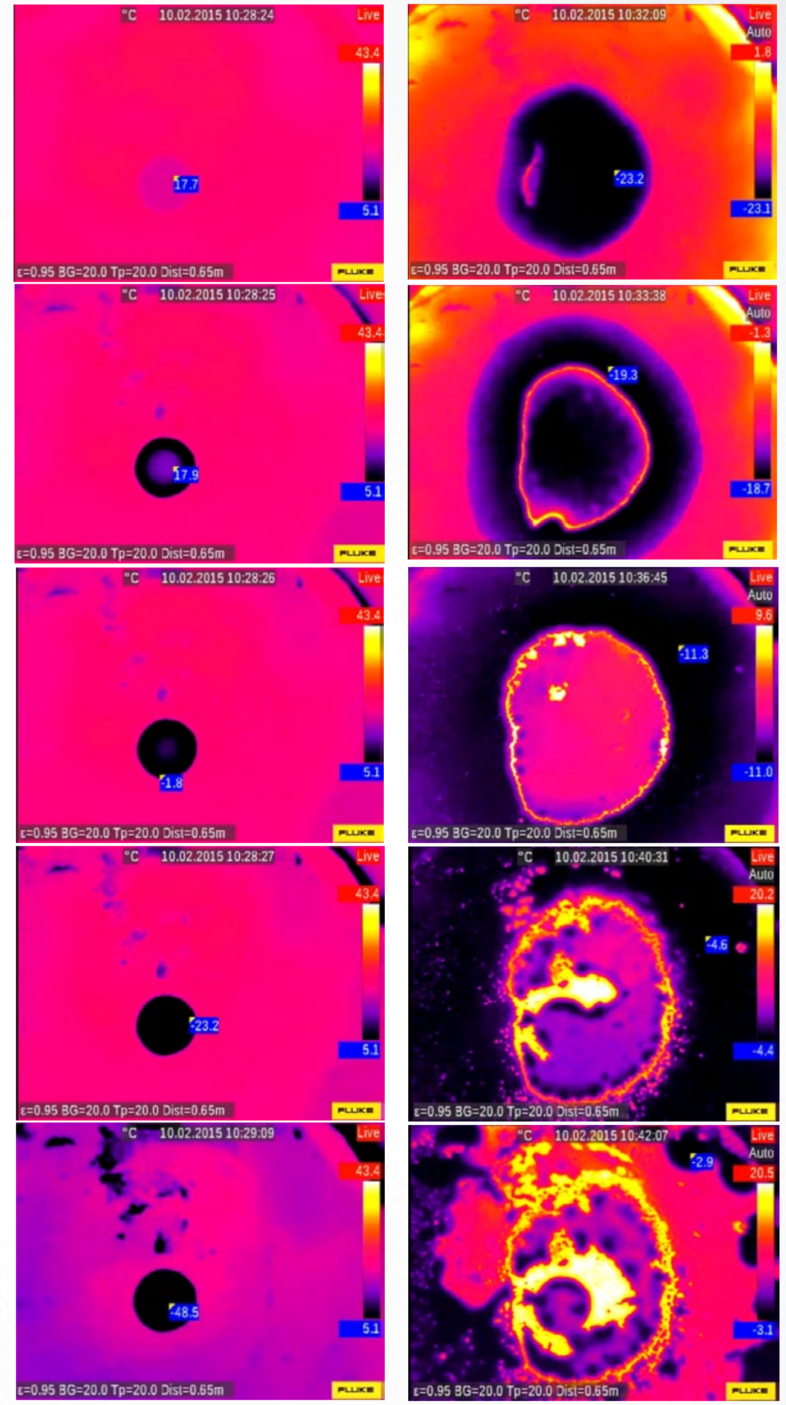
A National Key Laboratory at a higher learning institution tests the heat conduction performance of special materials at low temperatures and needs to clearly see the process of temperature change.

Three challenges to this experiment

1. Low temperature: liquid nitrogen is poured directly onto the special materials. A Fluke infrared camera is used to observe the rapid decrease in temperature after round materials are subjected to the effects of low temperature, as well as the later changes when gradual heating occurs. The lowest temperature will reach almost -50 °C.
2. High speeds: the process of temperature reduction only takes 3 seconds, dropping from ambient temperature straight down to -40 °C. The changes when the temperature decreases need to be seen.
3. Small target: the diameter of the materials is less than 5 mm.

Solution

Use the video recording and automatic low temperature range settings.



The initial temperature is 17 °C

It begins to cool after liquid nitrogen is poured on

It decreases by 19 °C after 1 second

After another second it decreases by a further 21 °C

The final low temperature is -48.5 °C

Some parts in the low temperature area begin to heat up

Isotherms are gradually formed after they heat up

The interior continues to heat up, but there is one area that is heating up particularly quickly

A relatively high temperature area gradually forms around the special material

The outline of the low temperature part of the special material is very obvious

Applications

Research institutes with low-temperature test requirements (for example: high and low temperature experiments, physics, and materials).

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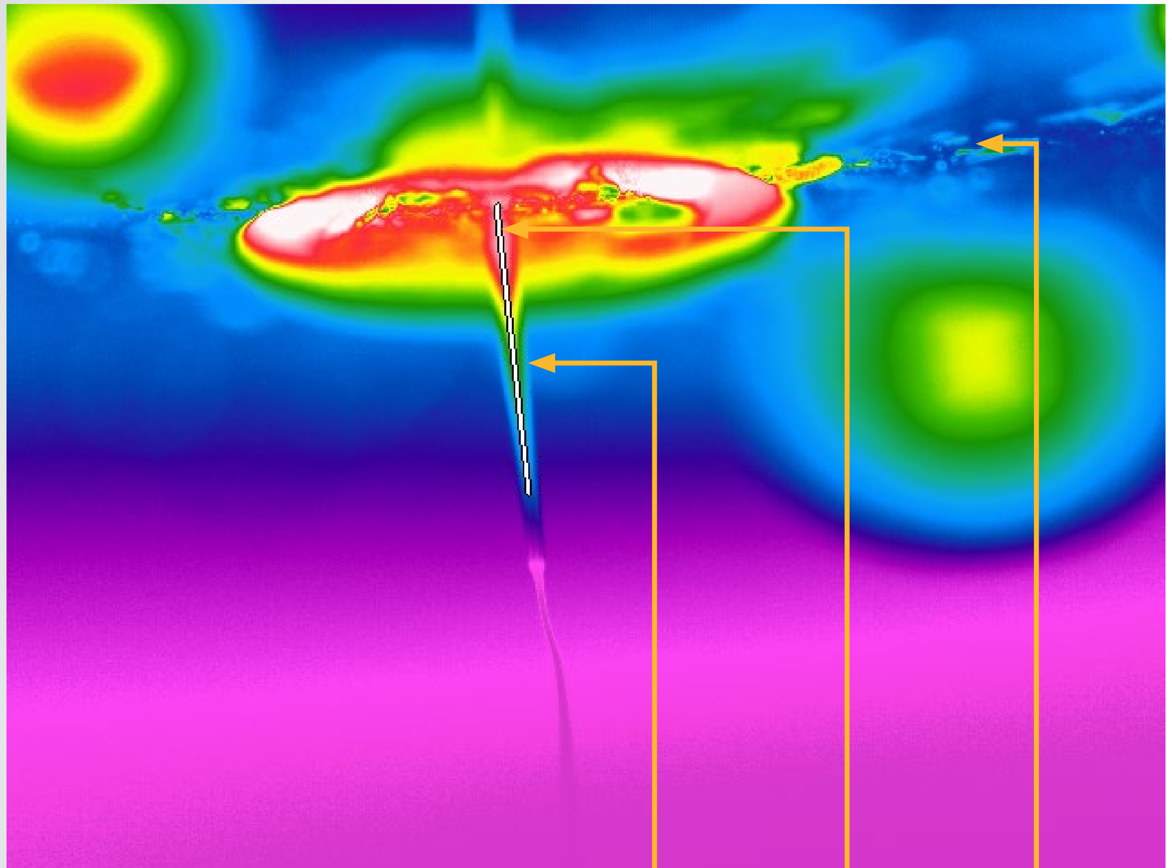
CASE STUDY #5: RESEARCH AND PROCESSING OF NEW FILAMENTARY MATERIALS MELTING AT LOW TEMPERATURES



Temperature analysis of filamentary material after melting at different distances from the discharge port

1 cm from the discharge port

Filamentary material discharge port

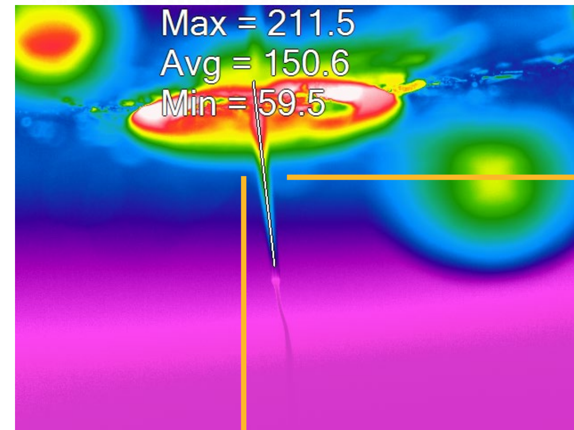
Bottom of container

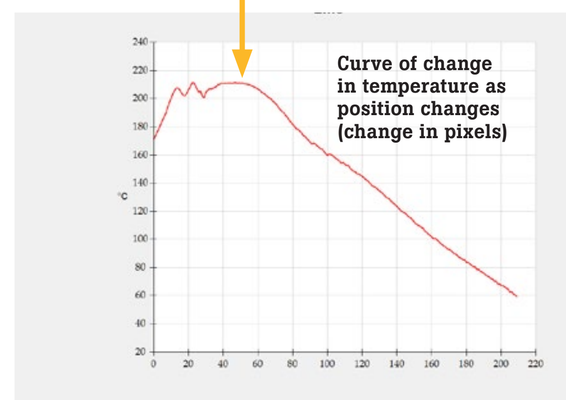
When filamentary materials are melted, the temperature distribution must be measured within a certain length from the melting exit point in order to provide the temperature data that is the basis for analyzing the characteristics and quality of these materials. However, as filamentary materials tend to be thin, and are limited in terms of container sizes, imaging them clearly becomes difficult. This case study looks at a situation where a Fluke infrared camera was used to test the temperature distribution at different positions as a filamentary material was melted, in order to provide effective data to support the research.

Test case

A mechanical and engineering college melted a new filamentary material in a container at a temperature of 260 °C. As it melted the material passed through a discharge hole in the bottom of the container. The temperature of the tested material was analyzed up to a distance of 1 cm from the discharge port to ensure that the technical indicators such as strength and viscosity were met.

The main challenge during this test: The filamentary material was only around 0.2 mm in diameter, the target was small and the shape of the bottom of the container presented limitations, making it impossible to image from close range.





Curve of change in temperature as position changes (change in pixels)

All temperatures in °C.						
		Emissivity	Background (°C)	Average (°C)	Minimum (°C)	Maximum (°C)
		0.95	20	150.6	59.5	211.5
Label	Points (°C)					
L0						
	171.1					
	173.5					
	176.3					
	178.8					
	181.7					
	184.6					
	187.3					
	189.8					
	193.9					
	197.2					
	200.3					
	203.6					
	205.8					
	207.7					
	207.5					

Full set of this online temperature data exported in .txt or Excel format

Solution

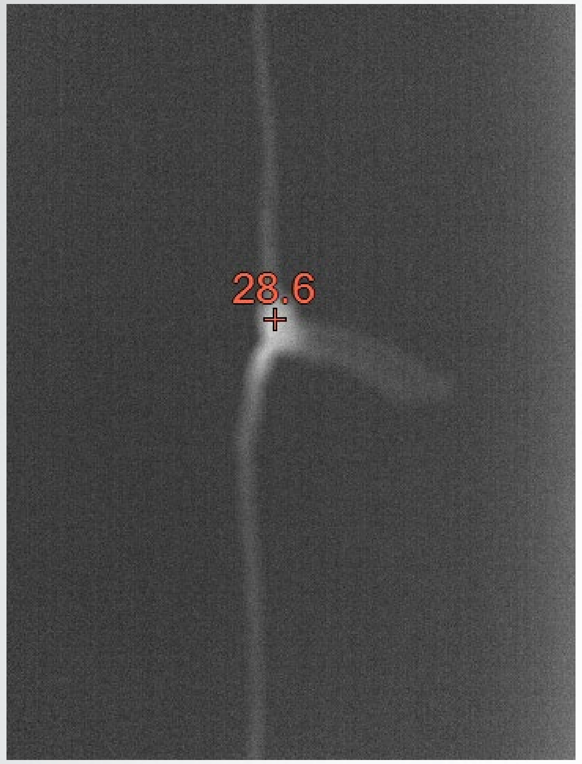
The thermal imager with a macro telephoto lens was placed below the container at an oblique angle of 45° and mounted on a two dimensional adjustable precision displacement platform.

In order to avoid any shaking when saving the thermal images, the thermal imager's automatic capture function was enabled, as well as the recording function.

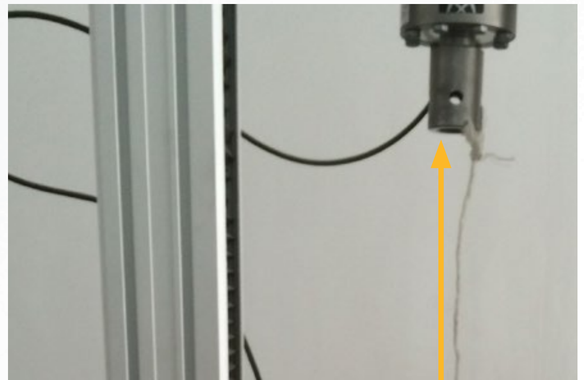
Applications

Scientific research of materials, research and development and production of new materials, production equipment manufacturers of similar materials.

CASE STUDY #6: ANALYSIS OF CHANGE IN TEMPERATURE OF ELASTIC MATERIALS AFTER BEING STRETCHED



The temperature quickly went from 23.3 °C to 28.6 °C when the knot was subjected to the maximum tractive force.



Testing was carried out using a Fluke Infrared Camera with optional macro lens at a distance of 10 cm from the knot target.

Traction device

After materials are stretched, heat is given off either as a result of internal stress within the material or from increased external friction. This increase in heat may lead to a reduction in the performance of the material.

Such tensile tests take place quickly, produce very little heat and involve fairly small targets.

A Fluke infrared camera was used in a case study where tensile tests were carried out on knots. This case study involved verification testing of changes in temperature during the stretching process; to provide an effective testing solution in these types of tests.

Test case

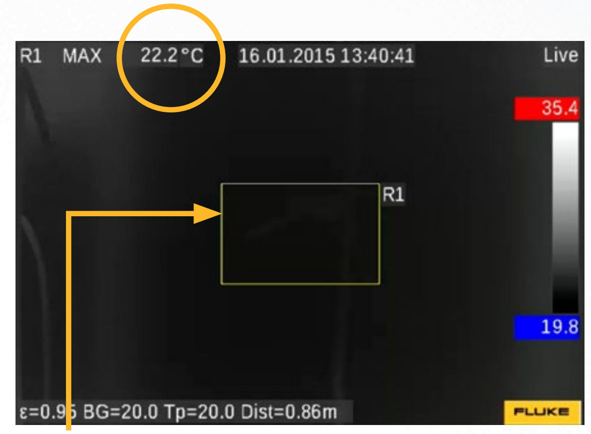
During research into agricultural machinery at an agricultural university, the need for testing and analyzing the heat emitted by elastic materials during the stretching process, such as rope and other similar materials, presented itself. Excessive heat can directly affect the performance of the material, e.g. by causing it to age prematurely, lose its elasticity and break easily. At the same time, these factors in turn also affect the quality of agricultural machinery.

Three testing challenges

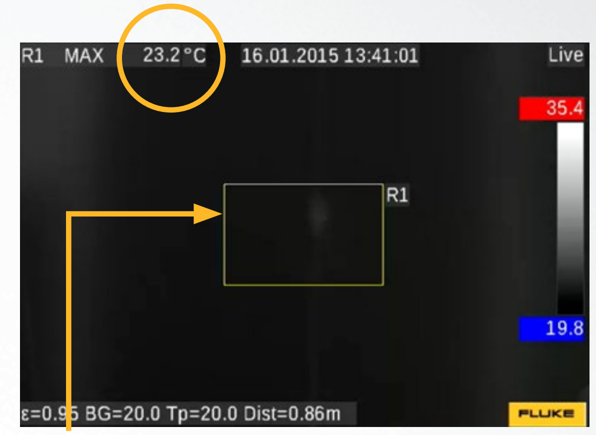
1. Small target: The rope was 3 mm in diameter, the maximum size of the knots were 5 mm. The specific point of heat emission on the rope and the heat distribution needed to be found.
2. Speed: The entire tensile test usually lasts between 7 and 8 seconds, while some limit testing for 2 to 3 seconds. Changes in both the maximum temperature and in the position of the maximum temperature during the whole process needing to be observed.
3. Little temperature variation: When limit testing was not involved the change in the maximum temperature of the knot was only about 1 °C.

Solution

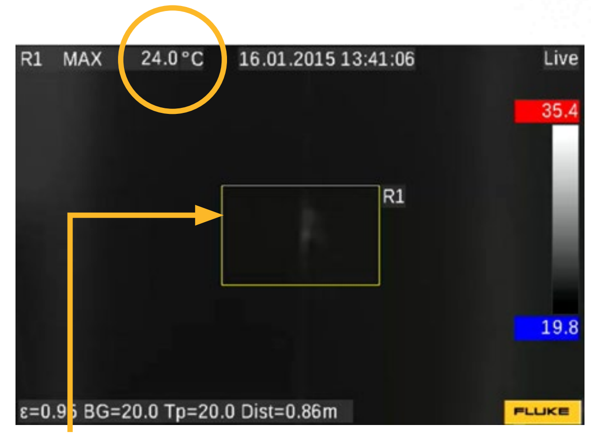
1. A safe distance was needed so the test team chose to use a macro lens capable of operating over fairly large distances (80–100 mm).
2. A tripod and a two-dimensional adjustable precision displacement platform were fitted.
3. The color palette was set to grayscale mode, in order to more easily observe the small temperature variations.



At the start of the test, the knot remains unstressed, and the maximum temperature is 22.2 °C.



During the middle of the test, the knot is subjected to a relatively small force (less than 1,000 N), with the force then being increased slowly so that a maximum temperature of 23.2 °C is recorded, rising 1.0 °C within 16 seconds.



At the end of the test, the knot has been subjected to a considerable force (about 3,000 N), with the knot increasing in temperature by 1.8 °C within 5 seconds to a maximum temperature of 24.0 °C.

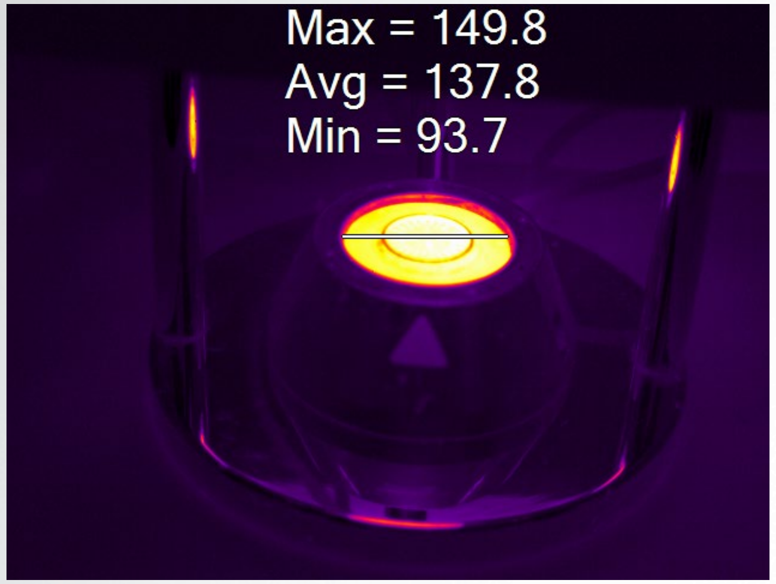
4. The rectangle function was used on the thermal imager for recording and noting the maximum temperature on the knot.
5. The recording function was enabled, with the maximum temperature of the rectangle being tracked.

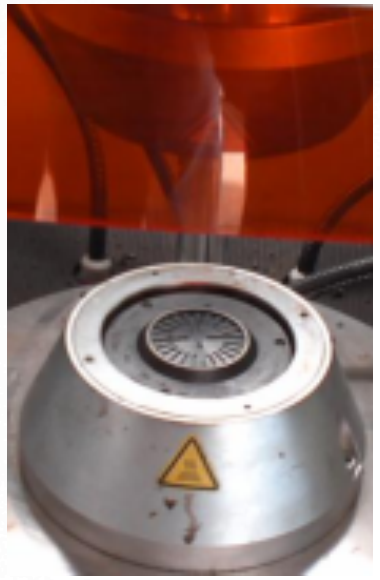
In addition to knot testing in this the application, the method can also be widely applied to performance testing rubber, plastic, organic materials and composite materials which are used with mechanical equipment.

Applications

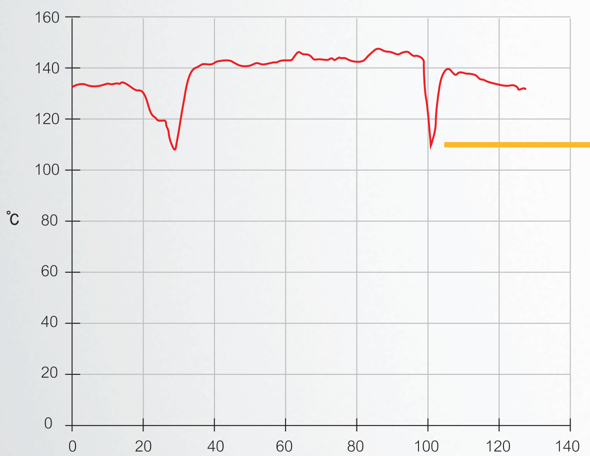
Research into the performance of elastic materials (material science), and performance testing of elastic materials used in agricultural machinery and equipment (mechanical engineering).

RESEARCH TO IMPROVE RUBBER VULCANIZATION PROCESSES





Vulcanization test device heating temperature distribution



Temperature distribution curve for heated surface

All temperatures in °C.						
		Emissivity	Background (°C)	Average (°C)	Minimum (°C)	Maximum (°C)
		0.95	20	137.8	93.7	149.8
Label	Points (°C)					
L1						
	93.8					
	110.3					
	125.5					
	130.6					
	131					
	131.3					
	131.9					
	132.4					
	132.6					
	132.7					
	132.5					
	132.8					
	132.7					
	133.4					

Full set of this online temperature data exported in .txt or Excel format

During the rubber vulcanization process, precise temperature control is needed to achieve the desired performance requirements. A very small difference of temperature in this process will sometimes change the speed of vulcanization and make it faster. This case study describes the temperature measurement solutions with infrared thermography used during research on rubber vulcanization processes, helping researchers to perform effective scientific analysis and increase their understanding of the chemical process taking place.

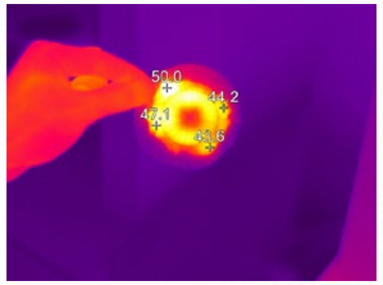
Test case

The National Key Laboratory at a chemical engineering university is responsible for research on improving processes for rubber-based elastic materials.

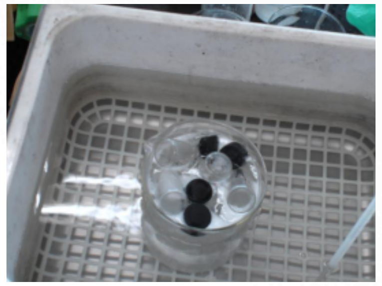
Rubber materials are the most important component of the vulcanization process, while temperature control during vulcanization is also important.

Technical difficulties in measuring temperature during the vulcanization of rubber materials

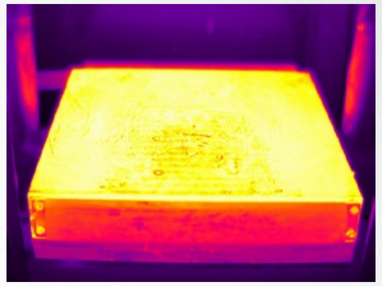
1. Some materials only provide a small target: Some rubber materials are used in precision electronic or mechanical products and size differences vary widely according to the requirements of the product. Small materials are only about 1–2 mm in size, and a macro lens is required to clearly see the temperature distribution on the material surface.
2. The differences in material surface temperature are relatively small: although the temperature during the vulcanization process will always exceed 100 degrees, the surface temperature of materials is still relatively uniform. The differences in temperature in some experiments is only 1–2 degrees, but in high-performance rubber materials, a temperature difference of 1–2 degrees will result in decreased material performance.
3. Real-time temperature monitoring is required during the vulcanization process: some experiments require the real-time monitoring of changes in surface temperature during vulcanization. A vulcanization temperature profile is drawn to confirm the process temperature for the vulcanization of new materials.

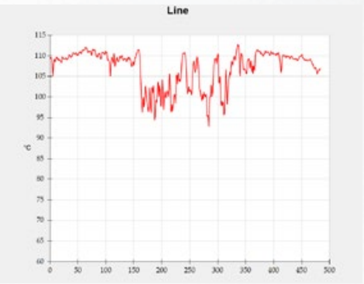


The temperature distribution of a new silicone material prototype after it is removed from the mold. The temperature on the left side of the part is 4–6 °C higher than that on the right side. This may indicate that the material's heat conduction requires further analysis.



A new prototype material in a beaker (the black object) is placed in a heated thermostatic water bath. The increase in temperature is monitored at the same time.



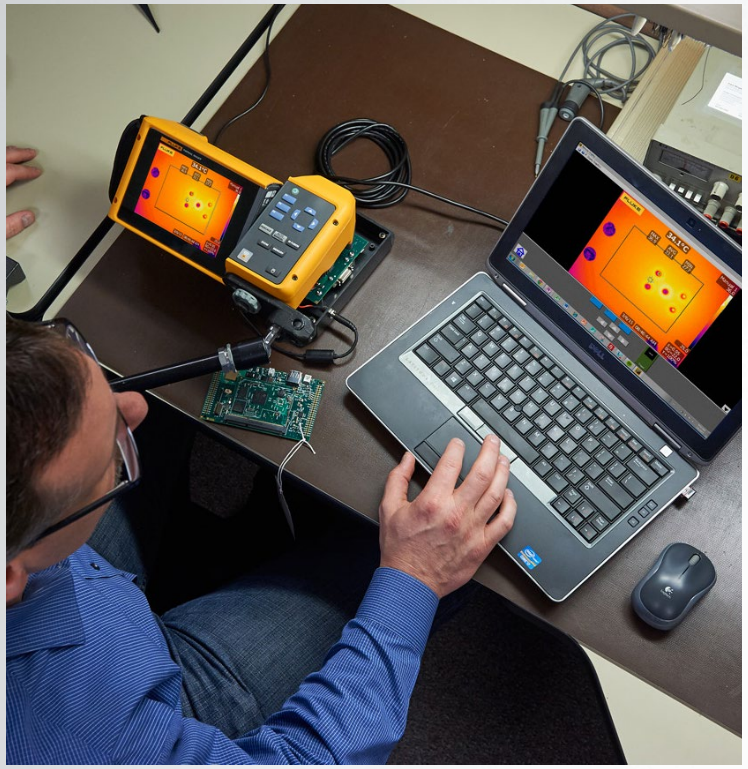


A new prototype material in a beaker (the black object) is placed in a heated thermostatic water bath. The increase in temperature is monitored at the same time.

Applications

Research institutes that are responsible for research and development in materials and production organizations

SEE MORE DETAILS WITH INFRARED



The ramifications of missing something you can't see in R&D can be huge.

- Missed experiment details that invalidate research
- Incur high costs due to failed components
- Confidence in the products your company produces
- Catch vendor product quality issues before accepting shipments.

Enter a new partner with the infrared solutions that will help you detect even the smallest issue.

Options to mount a thermal imager for macro inspection work

When conducting research with a macro lens its very helpful to use a boom stand or rack and pinion mount.

There are a number of companies that provide these products but one option is:

Edmunds Optics
edmundoptics.com

The information above is informational and does not imply an endorsement or specific recommendation of their products.

For R&D applications and experiments we recommend the Fluke Expert Series models

TiX580 Infrared Camera

TiX560 Infrared Camera

TiX660 Infrared Camera

TiX1000 Infrared Camera

Now you can see the impossible

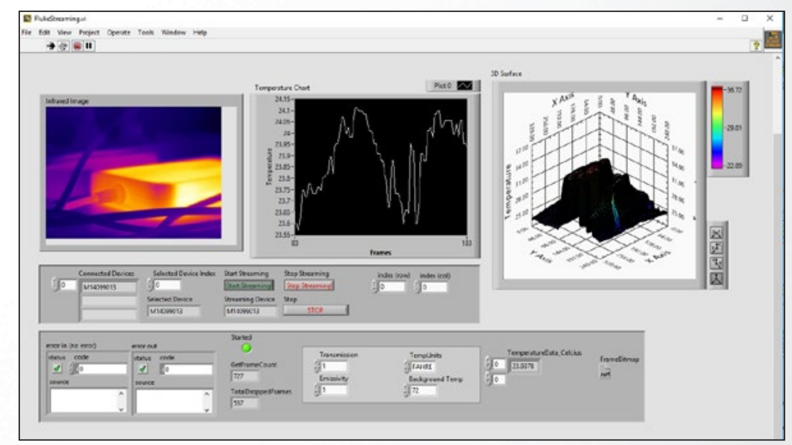
2x, 4x telephoto optional smart lenses give you the option of observing tests from a safer distance while the macro lenses show additional details, essentially turning your camera into an infrared microscope. These optional lenses are equipped with a patent-pending lens attachment system that does not expose the camera detector when changing lenses, protecting it against scratches from dust and air particles.

All smart lenses are not compatible with all camera models. Check with your Fluke representative for more information.

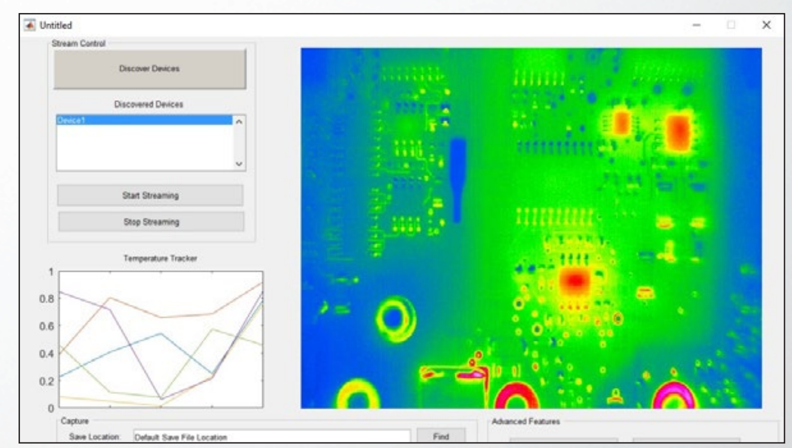
Optimize research and development analysis

Capture and record temperature variation and distributions over time importing your data live into a MATLAB®/LabVIEW® program to carry out your own custom data analysis.

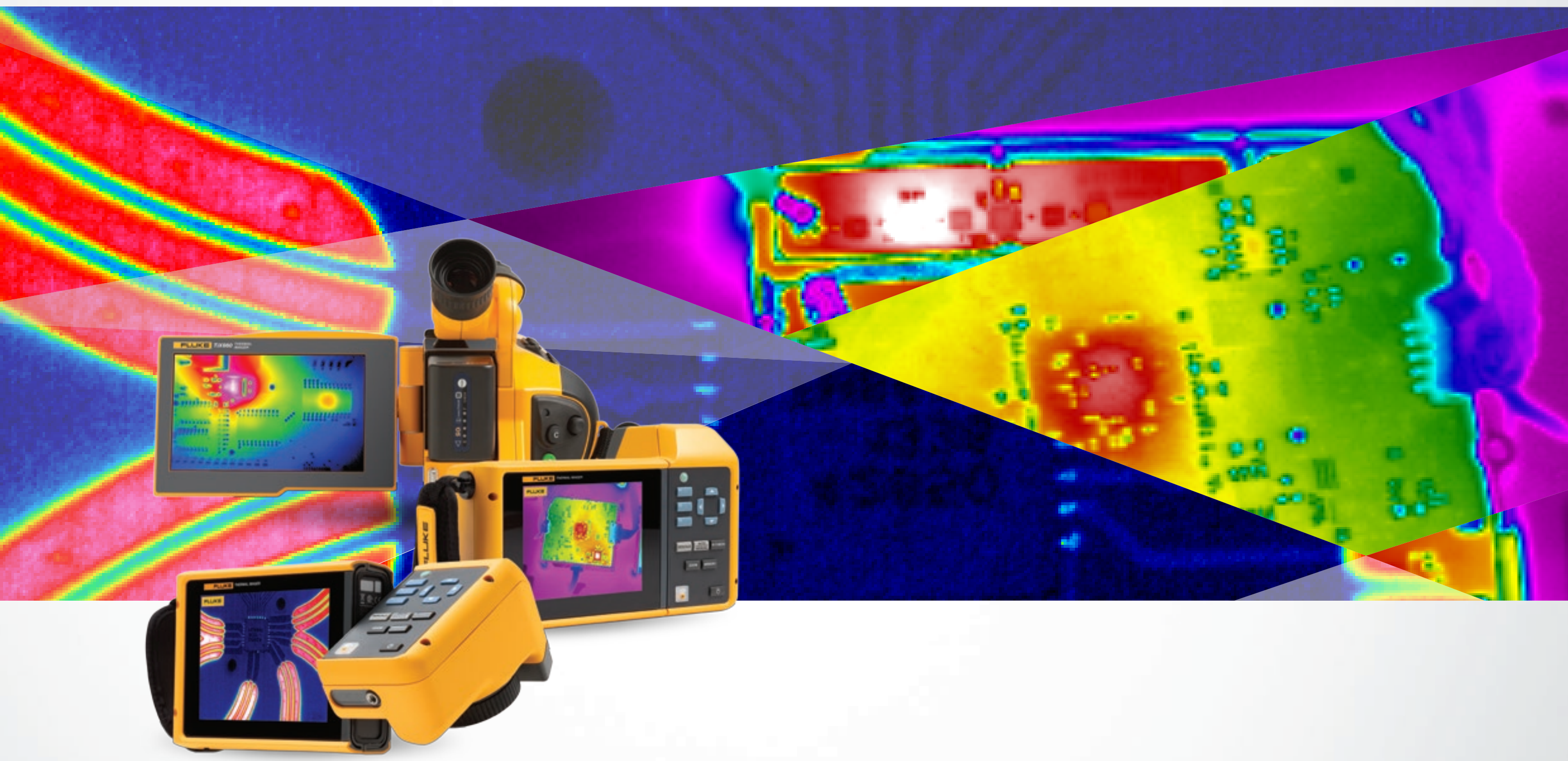
Contact your local Fluke representative for more information about infrared solutions for Research and Development.



LabVIEW



MATLAB



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