



Thermography in Aerospace Engineering

Agenda

- ☐ Introduction
- ☐ Microelectronics
- ☐ Material Testing
- ☐ Non-Destructive Testing
- ☐ Propulsion and Aerodynamics
- ☐ Aerial Thermography
- ☐ Space Thermography
- ☐ Technical Summary
- ☐ Q&A

Greetings from Dresden / Germany



Dresden „Zwinger“ Palace

InfraTec at a Glance Infrared in Focus



FACTS

- ☐ Founded and based in Dresden since 1991
- ☐ Privately owned
- ☐ Staff: 250
- ☐ Sales: 45 Mio EUR

MISSION

- ☐ Being a specialist in infrared technologies and offering best services to customers

BUSINESS UNITS

- ☐ Sensor Division
- ☐ Infrared Measurement Division

Sensor Division

Single and Multi Channel Pyroelectric Detectors

- ❑ Development, engineering and production of pyroelectric infrared detectors
- ❑ Production in 1,900 m² clean-room area in Dresden
- ❑ Modular concept with 50 standard detectors offers optimized solutions for nearly each application demands
- ❑ Analog and digital detectors
- ❑ Development and production of customized single and multi channel IR detectors for:
 - ❑ Pyrometry
 - ❑ Gas and flame analysis
 - ❑ Heat and fire detection
 - ❑ Optical measurements



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Application Areas of Pyroelectric Detectors

Sensor Division – Space Qualified Pyroelectric Detectors



IRES-N2 and IRES-C
European earth sensors

In cooperation with




Highest quality and lifetime requirements



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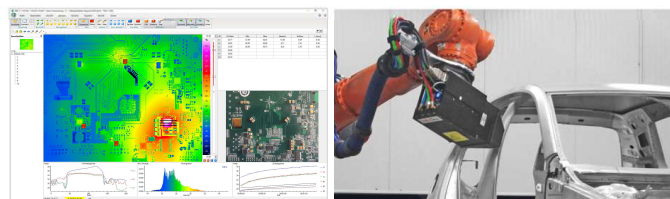
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Infrared Temperature Measurement Division

Development, Design and Production of Thermographic Solutions

- ❑ Thermographic systems for:
 - ❑ Research and development
 - ❑ E-mobility
 - ❑ Process and quality control
 - ❑ Material testing and active thermography
 - ❑ ...
- ❑ Bespoke turnkey solutions for:
 - ❑ Process monitoring
 - ❑ Preventive fire detection
 - ❑ Surveillance
 - ❑ Failure analysis in electronics and semiconductor
 - ❑ ...
- ❑ Thermography training courses
- ❑ Thermographic services
- ❑ Thermographic software



InfraTec's Expertise in Thermography

Experts and Technology where They Are Needed

- ❑ Manpower for you – 250 experts in ...
 - ❑ Development
 - ❑ Engineering
 - ❑ Programming
 - ❑ IT environment
 - ❑ Collaboration
 - ❑ Service
- ❑ Technology to support your project
 - ❑ Calibration lab:
 - Certified reference pyrometers, blackbody radiators, climate chambers and spectrometers
 - ❑ Optics lab with certified targets
 - ❑ Active thermography lab with wide range of excitation units for different materials and failures to be investigated



InfraTec's Sales and Service Network Acts Globally

Experts Around the Globe for Close Customer Contact



Worldwide Aerospace References



Broad Range of Fixed-Mount Thermographic Cameras

The Most Suitable Camera for Each Measurement Situation

- Research & Development
- Process & Quality Assurance
- Monitoring



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Thermography in Aerospace Engineering

11

Thermographic Software IRBIS® & Additional Software Tools

Efficient and Convenient Software Solution by InfraTec



- Workflow supporting software
- Multitude of analysis thermography specific tools
- Ready for integration with other measurement data
- Software Development Kit
- Customized thermography software



Control & Acquire



Monitor & Analyse



Use & Share



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Thermography in Aerospace Engineering

12

InfraTec in Joint National and International R&D Projects

Partner of Research and Science

- InfraTec regularly expands its know-how in the field of applied thermography by participating in cooperation of various research projects, like:



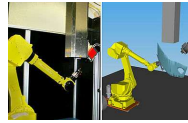
Crack Detection in Steel Production
The AMPLAST Research Project



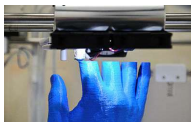
Thermography in Use for Research Applications
The SPIRIT Research Project



Inspection of CFRP Compounds and Components
The GEWOL Research Project



Automated Crack Detection on Forging Parts
The ThermoBot2 Research Project



More Efficiency in Laser Sintering with Plastics
The HiPer-LS Research Project



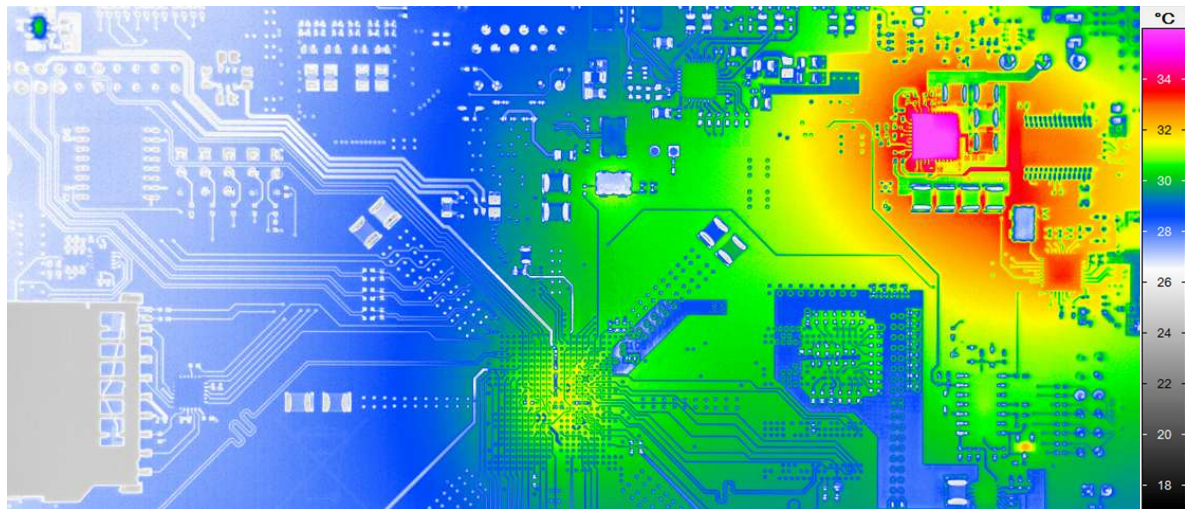
Thermographic Process and Quality Monitoring for Dissimilar Lightweight Designs
The LaserLeichter Research Project

Thermography in Aerospace Engineering

- Microelectronics
 - Components and subsystems
- Material Testing
 - Structures and mechanical components
- Non-Destructive Testing
 - Product safety
- Jet Engines and Aerodynamics
 - Propulsion and flow
- Aerial Thermography
 - A higher perspective
- Space Thermography
 - A look into the future

Electronics / Electrical

Optimized Heat Management and Quality Control



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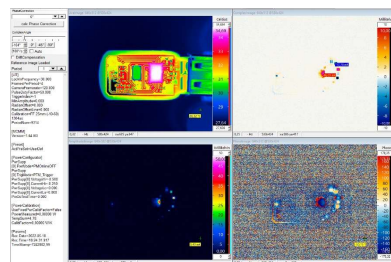
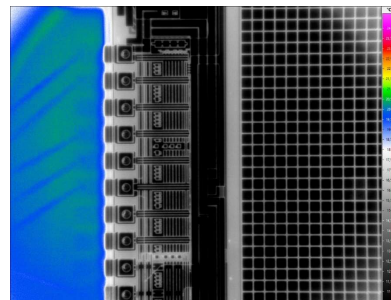
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15

Thermography for Electronics

Purposes, Benefits, Solutions

- ❑ Electronic component testing for:
 - ❑ Life cycle optimization for longevity of operation
 - ❑ Complex and challenging replacement
 - ❑ Waste reduction
 - ❑ Safety of people
- ❑ Typical Tasks for Thermography
 - ❑ Absolute Temperature Measurement
 - ❑ Hot Spot Detection
 - ❑ Defect Detection (Shots)
- ❑ Typical Solutions
 - ❑ High-performance Quantum Detector Cameras
 - ❑ Microscopic lenses: from 1x to 10x magnification
 - ❑ Best possible NETD
 - ❑ E-LIT chamber



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Thermography in Aerospace Engineering

16

Parameters and Solutions

Overview



Spatial resolution
- iFOV -



Thermal resolution
- NETD -



Spatial resolution
- FPA size -
- FOV -



Time resolution
- Hz -



Synchronization

ImageIR® 8300

The Flexible

(640 × 512) IR pixels
(1,280 × 1,024) MicroScan

HDR

15 / 25 μm pitch

355 / 1,105 Hz full-frame

Up to two wheels

ImageIR® 9400

The Large Flexible

(1,280 × 1,024) IR pixels
(2,560 × 2,048) MicroScan
(640 × 512) Binning

10 μm pitch

181 / 622 Hz full-frame

Two wheels

ImageIR® 10300

The High-definition

(1,920 × 1,536) IR pixels

10 μm pitch

100 Hz

ImageIR® 12300

The High-definition

(2,560 × 2,048) IR pixels

5 μm pitch

140 / 1600 Hz full-frame

Spatial Resolution – iFOV

Significance of Lenses



M=1.0x, 4 cm WD



M=1.0x, 20 cm WD



M=1.0x, 30 cm WD



M=2.5x



M=3x

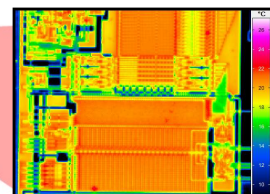
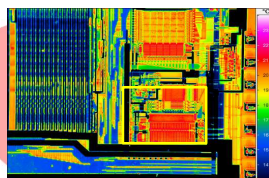
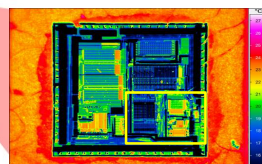
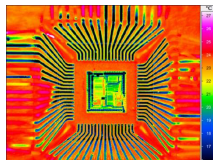


M=8x

New:

□ M=5.0x

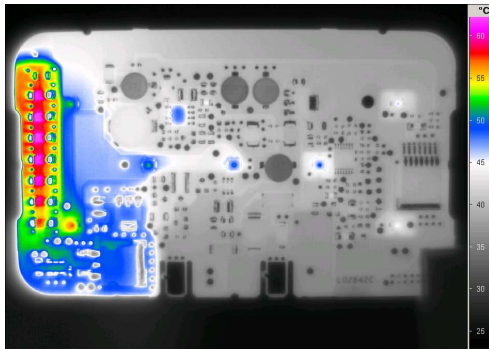
□ M=10x



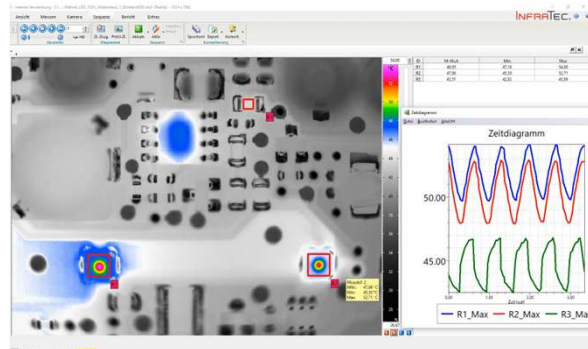
Micro-thermography of a semiconductor chip with different resolutions and FOV

Research and Development

LED Assemblies (Circuit Boards)



LED board with and without macro attachment

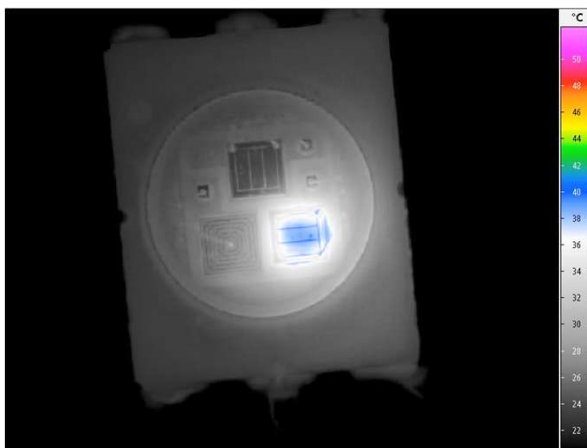


Evaluation of the IR sequence via an IR time diagram

- ☐ Monitoring the temperatures of the individual LEDs
- ☐ Image was taken with VarioCAM® HD with the 30 mm standard lens incl. macro attachment
- ☐ Evaluation of the measurement with the software IRBIS® 3 via time or IR sequence

Research and Development

Measurement on RGB LED



RGB LED switch-on process

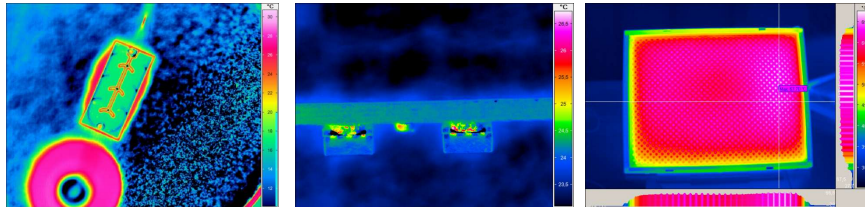
- ☐ Thermal development on an RGB LED is to be detected - small structure
 - ☐ High geometrical resolution required
- ☐ Measurement through polymer plastic layer
 - ☐ Partial transparency in the mid-infrared
 - ☐ LWIR camera is not suitable here
 - ☐ MWIR camera ImageIR® 8300
- ☐ Microscope objective M=1.0×
 - ☐ Pixel resolution: 15 µm
- ☐ Frame rate: 20 Hz
 - ☐ Only secondary role



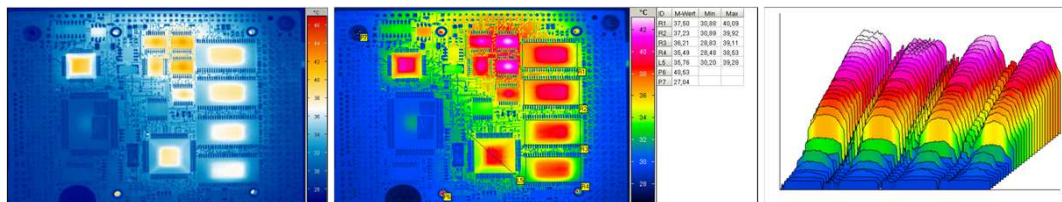
RGB LED

Electronics Needs to Reduce Power Consumption and Heating

Quality Control and Product Development in Electronics



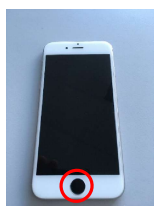
Tests of LED products at different vertical integration levels



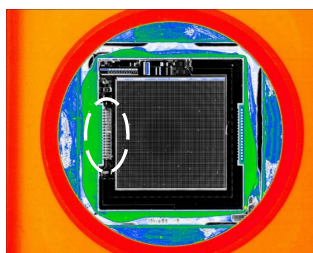
Temperature distribution of a PCB and thermal behavior over time

Microscopic Imaging with ImageIR® 9400 (1,280 × 1,024) IR Pixels

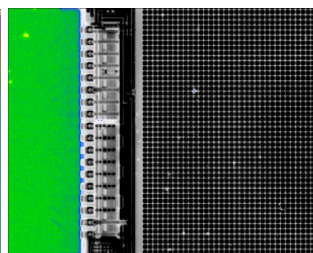
Example: iPhone 6 Touch ID



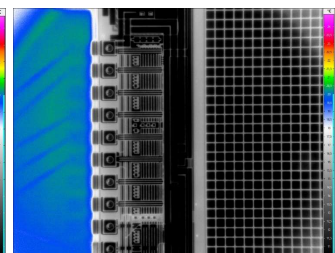
iPhone 6 with Touch ID



Touch ID with M1× lens → IFOV 10 µm/pixel



Detail zoom; M1× lens



M8× lens → IFOV 1.25 µm/pixel

- ☐ Touch ID Sensor is covered with an IR-semitransparent plastic cap
- ☐ IR image has been realized „through“ this cap
- ☐ Sensor dimension approx. (6 × 6.2) mm

In Focus – ImageIR® 9400

Future-proof Flexibility

ImageIR® 9400 The Large	ImageIR® 9400 hs The Fast	ImageIR® 9400 hp The Full Flex
(1,280 × 1,024) IR pixels (2,560 × 2,048) IR pixels with MicroScan	(640 × 512) IR pixels (binned pixels)	(1,280 × 1,024) IR pixels (640 × 512) Binning (2,560 × 2,048) IR pixels with MicroScan
180 Hz full-frame	622 Hz full-frame 1053 Hz with (640 × 256) IR pixels	1053 Hz with (640 × 256) IR pixels
Two wheels	Two wheels	Two wheels



Pixel resolution down to 1.3 µm

10 µm Pitch

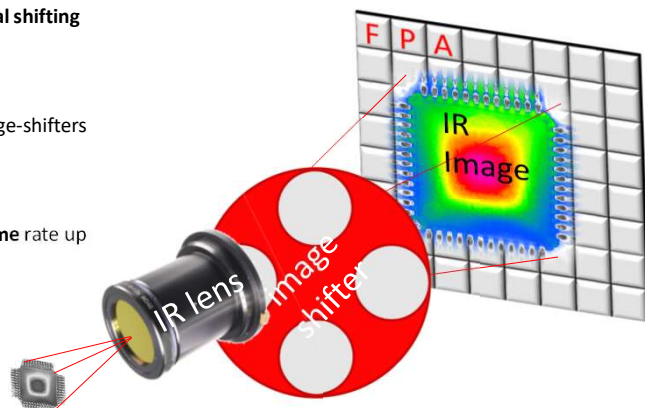
HighSense ScaledNUC calibration

10GigE Vision interface DIRECT data storage at control computer

InfraTec's MicroScan feature

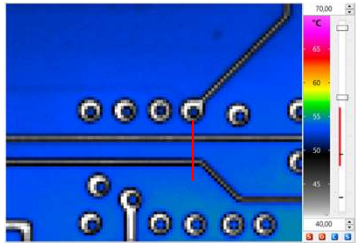
4 times more pixels on standard cooled cameras

- Enhancement of spatial resolution by **opto-mechanical shifting** of the optical path
- **High-speed** rotating **wheel** equipped with optical image-shifters in 4 directions
- Speed of optical wheel up to **5,400 rpm** (**detector frame** rate up to **360 Hz**) -> frame repetition rate up to 87 Hz
- MicroScan frame rate output with **full detector frame rate**

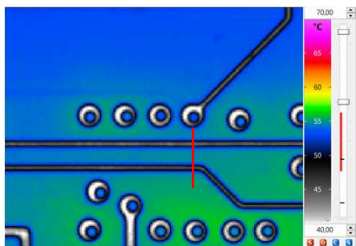


MicroScan

Comparison Images



Standard resolution (640 × 512) IR pixels



Resolution with MicroScan (1,280 × 1,024) IR pixels

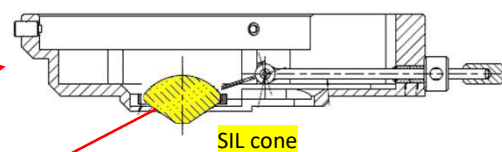
SIL Attachment

Special Features by InfraTec – SIL

- ☐ Solid Immersion Lens (SIL) for ImageIR®
- ☐ SIL cone made from Germanium (n = 4)
- ☐ Adapters for M=3.0× and M=8.0×



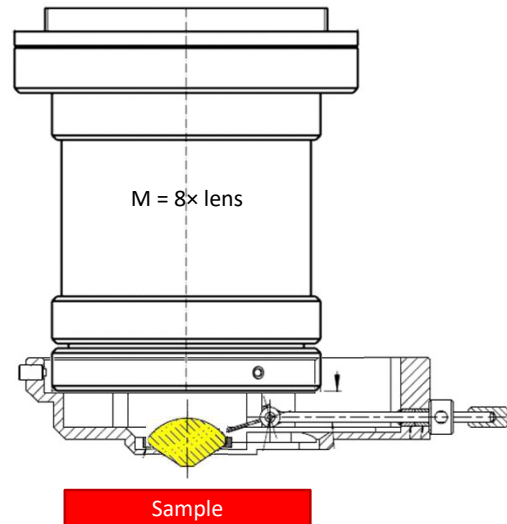
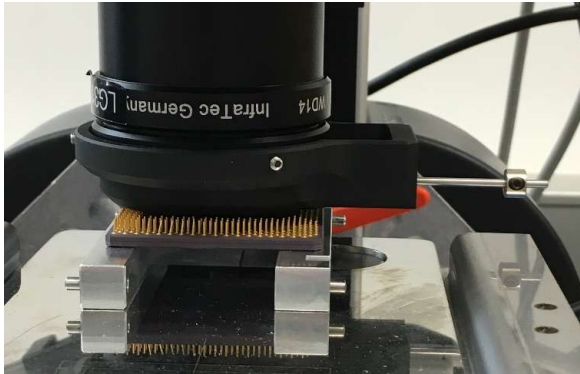
SIL adapter for microscopic lenses



SIL Attachment

Set-up for SIL

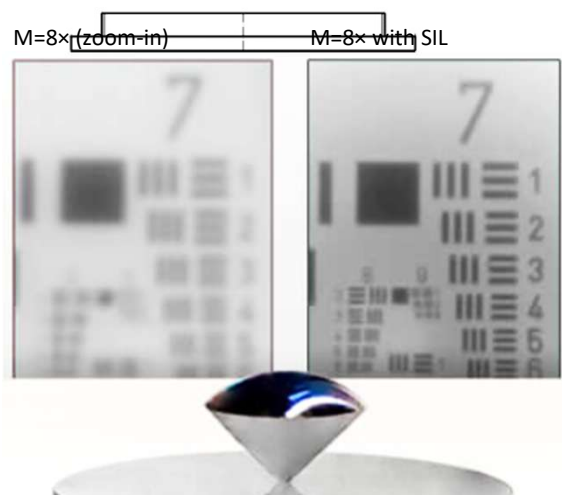
- ❑ SIL application requires precise Z-positioning
- ❑ SIL cone touches surface of the object
- ❑ SIL increases optical performance (line resolution)



SIL Attachment

Result of SIL

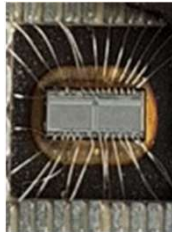
- ❑ With $M = 8\times$ lens (ImageIR® 9400):
 - ❑ W/O SIL: FOV (1.6×1.28) mm²; iFOV = 1.25 μm
 - ❑ With SIL: FOV (0.4×0.33) mm²; iFOV = 0.31 μm
- ❑ Comparison same @FOV:
Significant enhancement of the spatial resolution!
- ❑ Acceptable FOV: 0.3 mm diameter
- ❑ SIL is in contact with sample



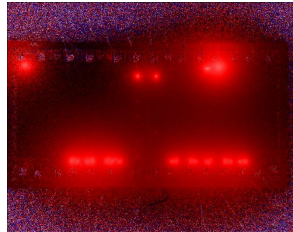
Lock-in Thermography in Electronics

Failure Detection at a Microchip Bonding

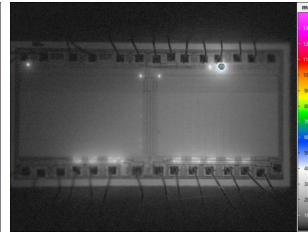
Lock-in thermography with M3× microscope



VIS Image



Phase Image



Amplitude Image



E-LIT Chamber

InfraTec, Thermography and You

Software IRBIS® active online at a Glance

Device Settings

- ☐ Camera
- ☐ Excitation sources

Measurement Settings

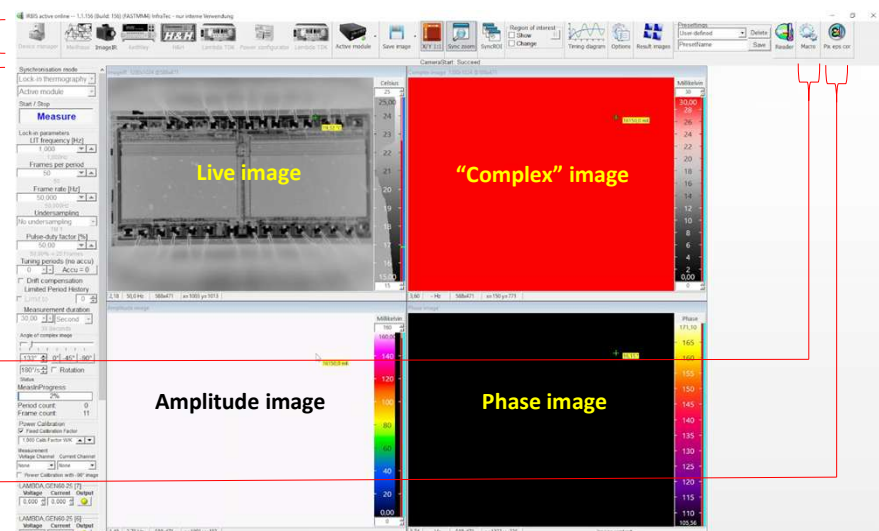
- ☐ Settings can be stored
- ☐ Undersampling optional
- ☐ Update of Amp / Phase Results after each period
- ☐ ...

Batch Mode Definition

- ☐ Automatic measurement
- ☐ External devices accessible

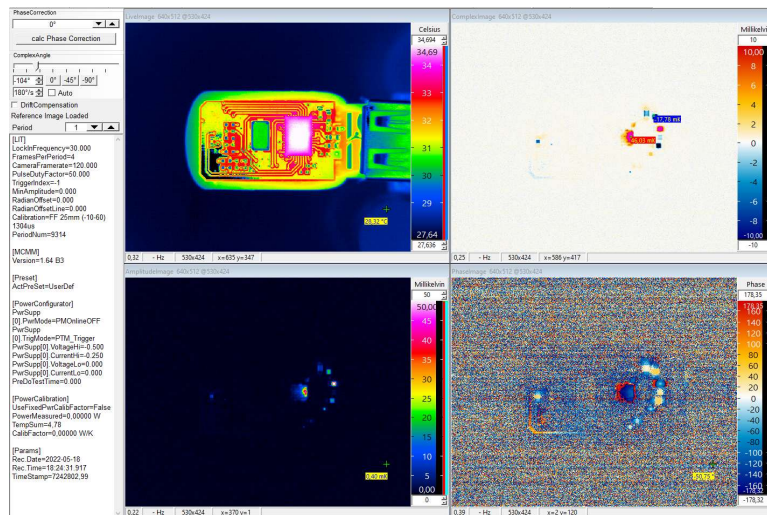
Correction Settings

- ☐ Emissivity map
- ☐ Drift compensation



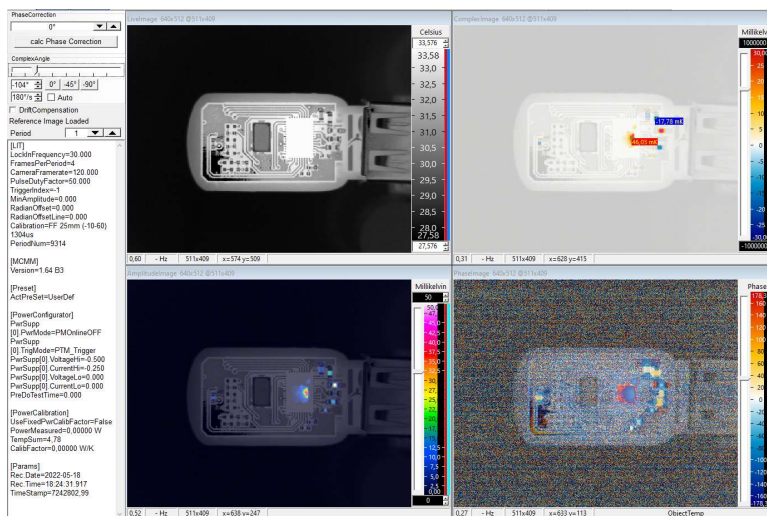
InfraTec, Thermography and You

Software IRBIS® active online – Some Features



InfraTec, Thermography and You

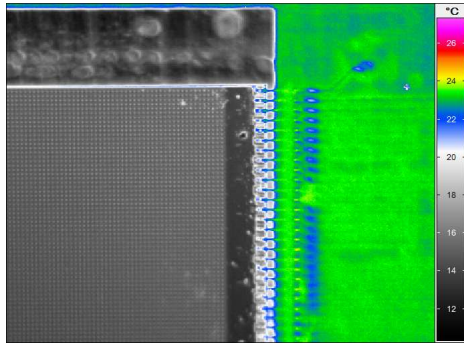
Software IRBIS® active online – Some Features



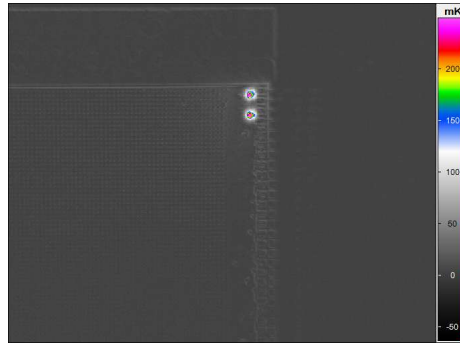
Merging allows location of hot spots

Lock-in Thermography in Electronics

Failure Detection – Microchip



Standard thermography image → No defect visible



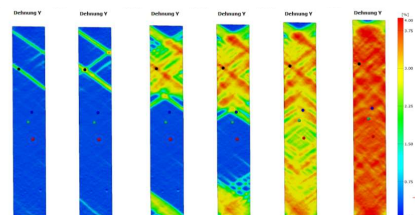
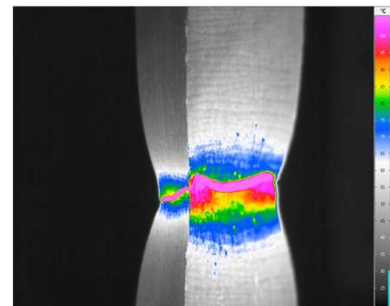
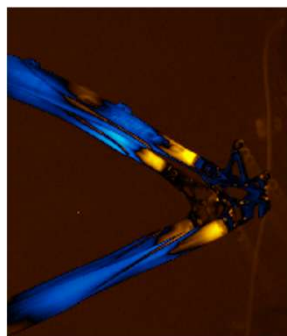
Amplitude result from lock-in thermography
→ 2 defect locations

- ☐ ImageIR® 8300 hp with M=1.0× lens
- ☐ Passive or differential thermography does not provide any insights
- ☐ Lock-in thermography (electrical excitation) with 25 Hz excitation frequency makes the defects “visible”

Thermography for Material R&D

Purposes, Benefits, Solutions

- ☐ Material testing of:
 - ☐ Ceramics and their heat-resistance
 - ☐ Isolation material
 - ☐ Composites
- ☐ Typical Tasks for thermography
 - ☐ Heat flow detection and measurements
 - ☐ Quality control
 - ☐ Detection of delaminations, defects etc.
- ☐ Typical Solutions
 - ☐ High-accuracy camera systems
 - ☐ Best possible NETD
 - ☐ High spatial resolution
 - ☐ Active thermography



Parameters and Solutions

Overview



Spatial resolution
- iFOV -



Thermal resolution
- NETD -



Spatial resolution
- FPA size -
- FOV -



Synchronization

ImageIR® 8300

The Flexible

(640 × 512) IR pixels
(1,280 × 1,024) MicroScan

20 mK thermal accuracy

15 / 25 μm pitch

12mm to 200mm lens

Up to two wheels

ImageIR® 9400

The Large Flexible

(1,280 × 1,024) IR pixels
(2,560 × 2,048) MicroScan
(640 × 512) Binning

25 mK thermal accuracy

10 μm pitch

25mm to 200mm lens

Up to two wheels

ImageIR® 10300

The High-definition

(1,920 × 1,536) IR pixels
(960 × 768) Binning

35 / 25 mK thermal accuracy

10 / 20 μm pitch

25mm to 100mm lens

ImageIR® 12300

The High-definition

(2,560 × 2,048) IR pixels
Binning

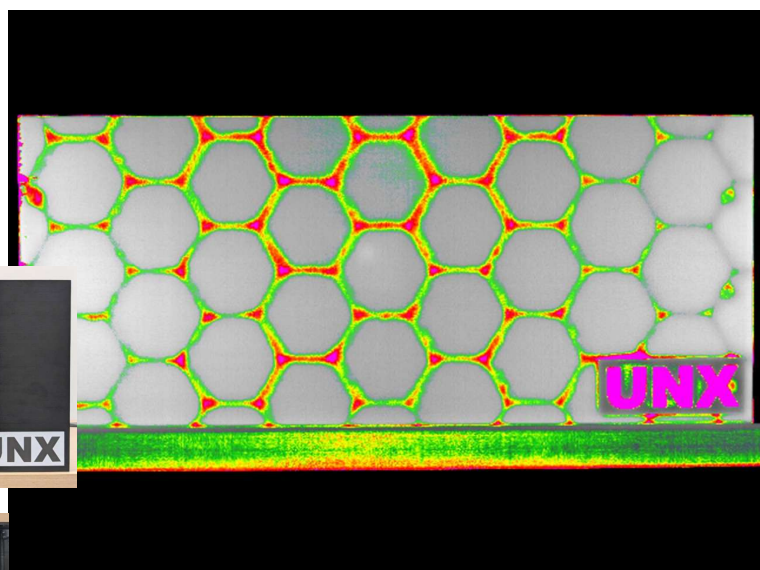
5 μm pitch

25mm to 100mm lens

More than words...

Material Testing

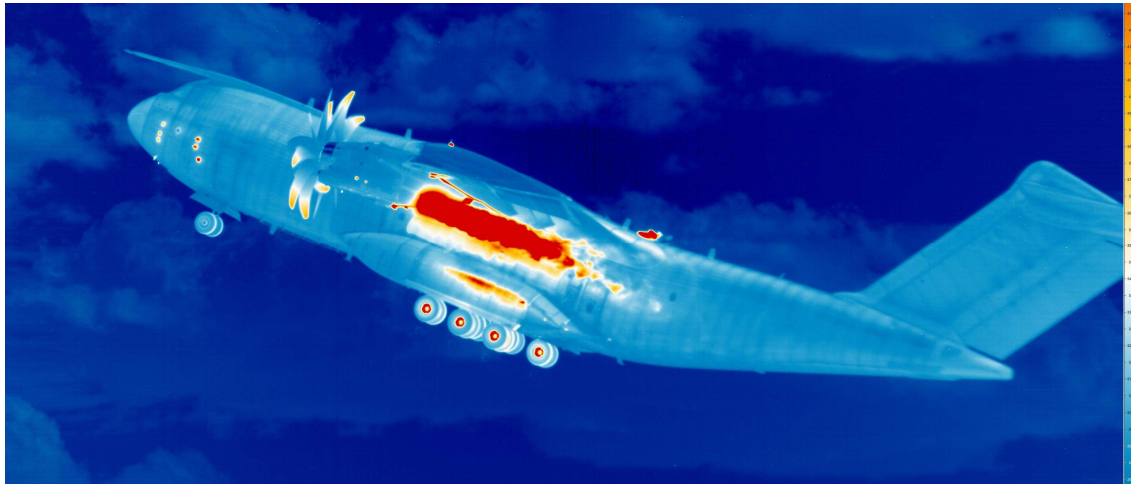
Examples – Satellite Structures



Reveal the invisible

Material Testing

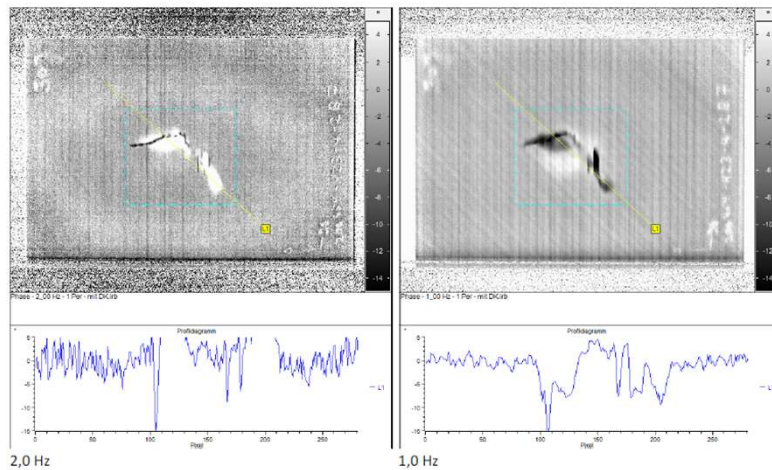
Airframe Structures



Finding defects – tracing structures

Material Testing

Finding Damages via Active Thermography

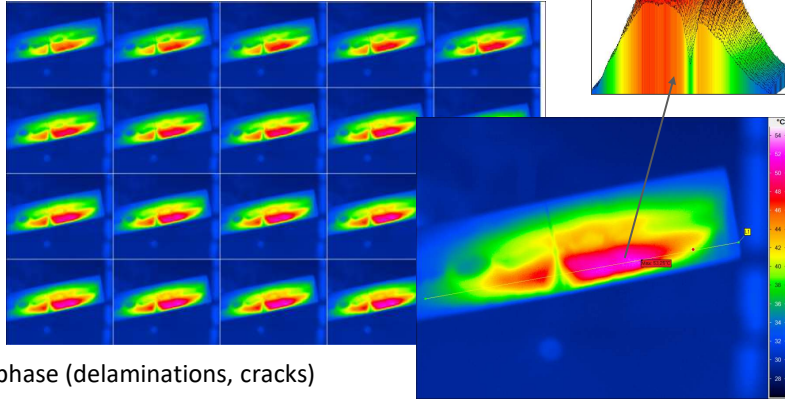


Damaged fuselage and wings

Material Testing

Rotary Blades

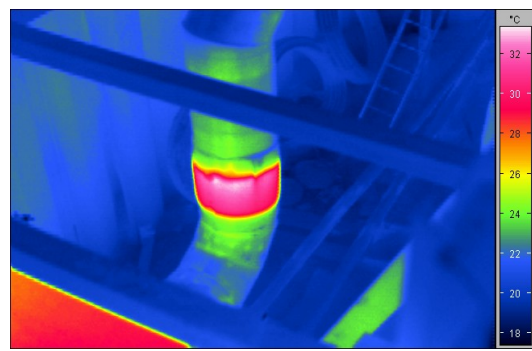
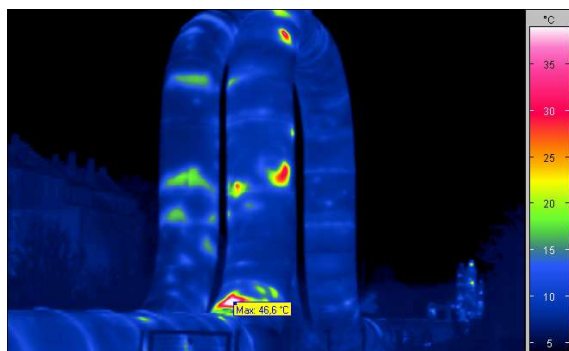
- Development of more efficient blades by controlling the transient from laminar to turbulent air flow



- Control of blades in product phase (delaminations, cracks) to avoid expensive repairs

Material Testing

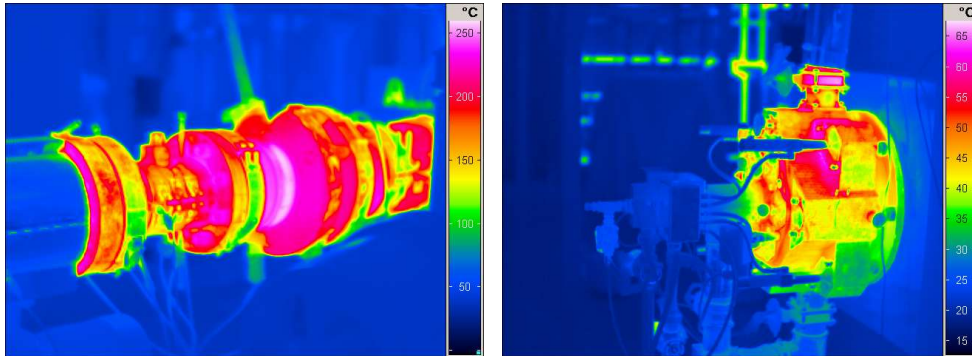
Pipes + Isolations



Finding defects – tracing structures

Material Testing

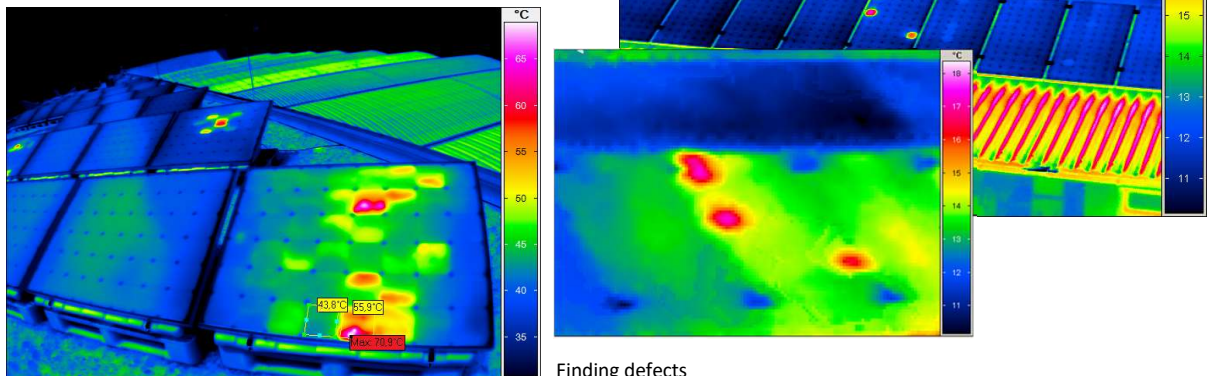
Pumps + Mechanical Assemblies



Stress + efficiency

Material Testing

Solar Panels

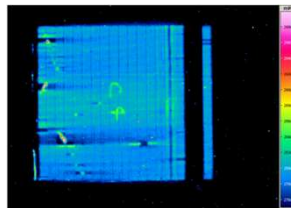
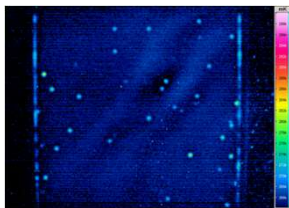
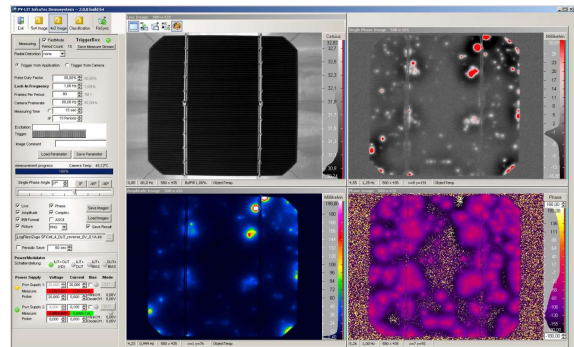


Finding defects

Material Testing

Test Bench for Solar Cells / Modules

- ❑ Active thermography allows to detect multiple failures in various production phases
- ❑ Scalable depending on failures to be detected
- ❑ Indicates already smallest problems
- ❑ Operational with various types of solar cells / modules
- ❑ Automatic result images: phase and amplitude and failure clusters



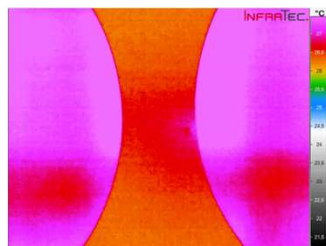
Active Thermography for Stress Analysis I

Thermal Analysis of Mechanical Stress an Example

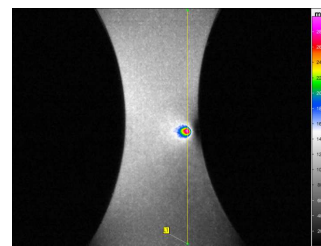
- ❑ Aluminum samples were driven at around 100 Hz with ± 2.25 kN load (0 ... 4.5 kN absolute) periodically



Set up



Thermal sequence

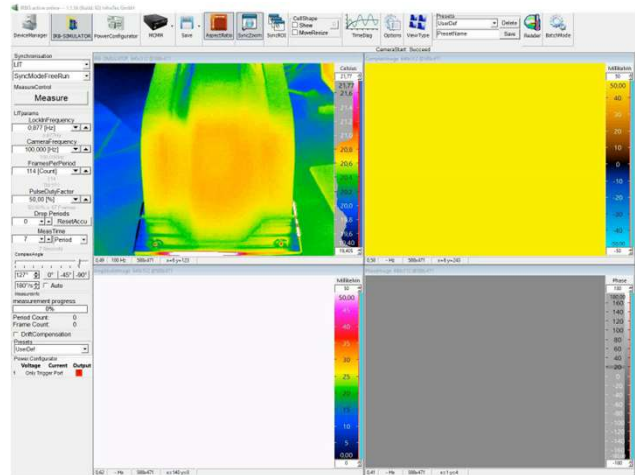


Lock-in amplitude result

Active Thermography for Stress Analysis II

GOM Demonstrator

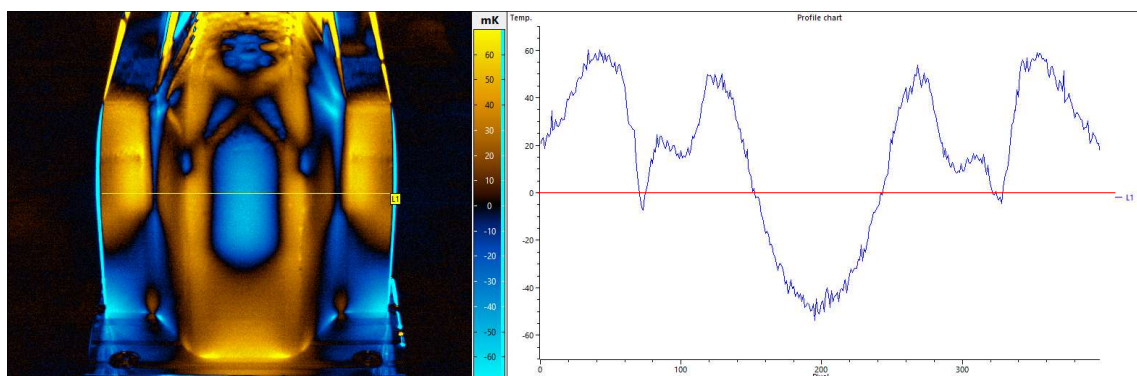
- ☐ Plastic sample
- ☐ Periodically stressed
- ☐ Composite images show regions which are stretched (cooled down) resp. compressed (warmed up)



Active Thermography for Stress Analysis III

Thermal Stress Analysis with Lock-in Thermography

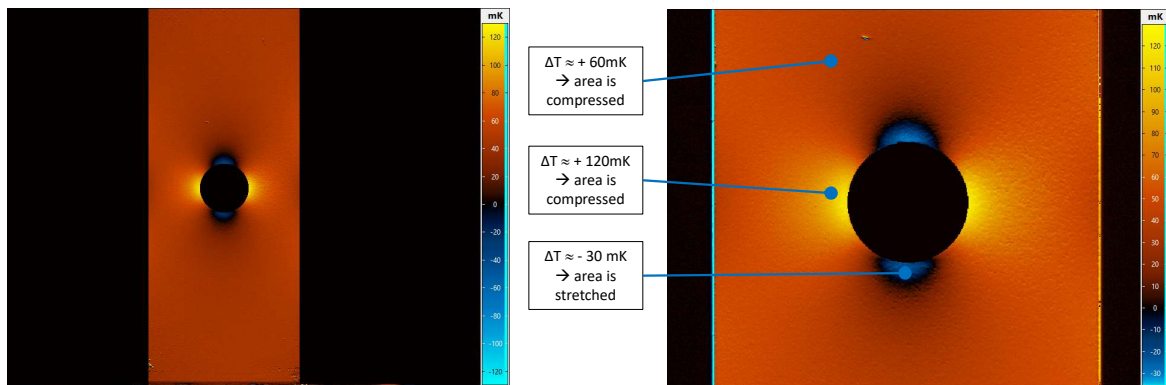
- ☐ Lock-in software "IRBIS® active online" and IR camera ImageIR® 8300 hp are used:
Complex analysis: ΔT amplitude result image @ specific phase angle



Active Thermography for Stress Analysis IV

Example – Elastic Periodical Load Test

- Lock-in software “*IRBIS® active online*” and IR camera *ImageIR® 10300* are used:
Complex analysis: ΔT amplitude result image @ specific phase angle where sample is under pressure.



products

NDT Equipment

Improved SNR by Active Thermography



InfraTec, Thermography and You

Active Thermography – Principle

Passive / standard thermography: Observing / measuring heat- / temperature distribution w/o synchronizing the „reason“ of the heat generation

- ❑ T-resolution in range of 25 mK
- ❑ Long-term analysis for steady-state heat-pattern (final static situation)
- ❑ Small heat sources will be blurred by heat distribution over time

Active thermography: Synchronized energy input to IR image acquisition

- ❑ Temperature-resolution down to μK range
- ❑ Short-time energy input $\rightarrow$ no heat dissipation / distribution $\rightarrow$ localization of even small heat sources
- ❑ Most common active thermography method for electronics:
 - ❑ **Lock-in thermography** (periodically excitation within the non-destructive range of the sample)
 - ❑ **Pulse-phase thermography** (1-pulse excitation and analyzing the cool-down process)

NDT with PPT and LIT

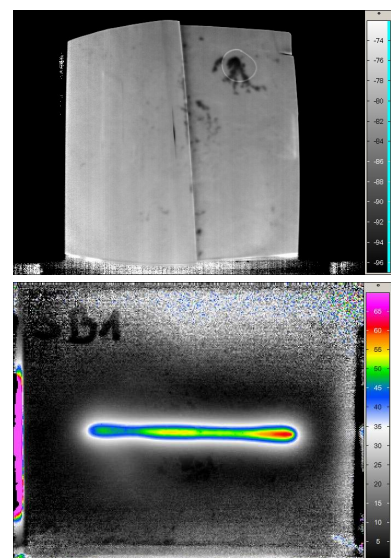
Purposes, Benefits, Solutions

NDT for

- ❑ Localization of material defects, hidden inhomogeneities
- ❑ Material stress test
- ❑ Stress tests on electronics – QA on components, durability
- ❑ Examination/QA of weld seams
- ❑ & much more

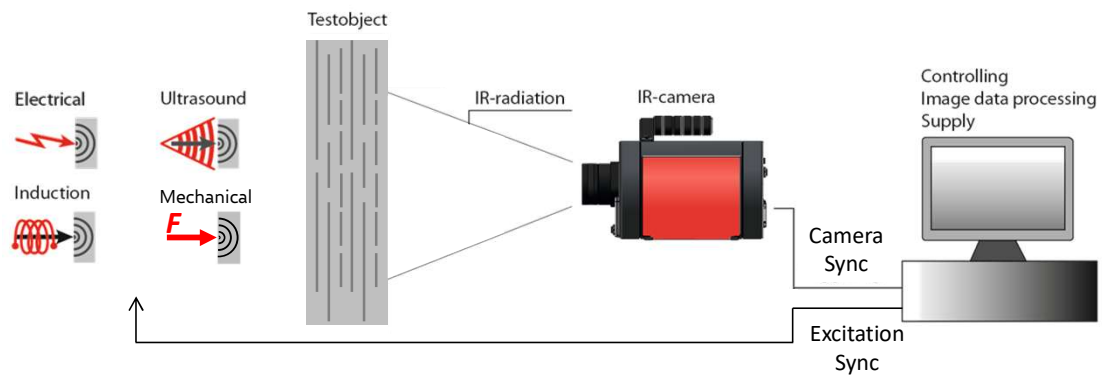
Typical Solutions

- ❑ High-performance Quantum Detector Cameras
- ❑ High-performance $\mu\text{Bolometer}$ Cameras
- ❑ Good Thermal Resolution (NETD)
- ❑ Possibility of Sync and Triggering w. external & internal heat sources
- ❑ For electronics: High spatial resolution (iFOV; FOV) + lenses



InfraTec, Thermography and You

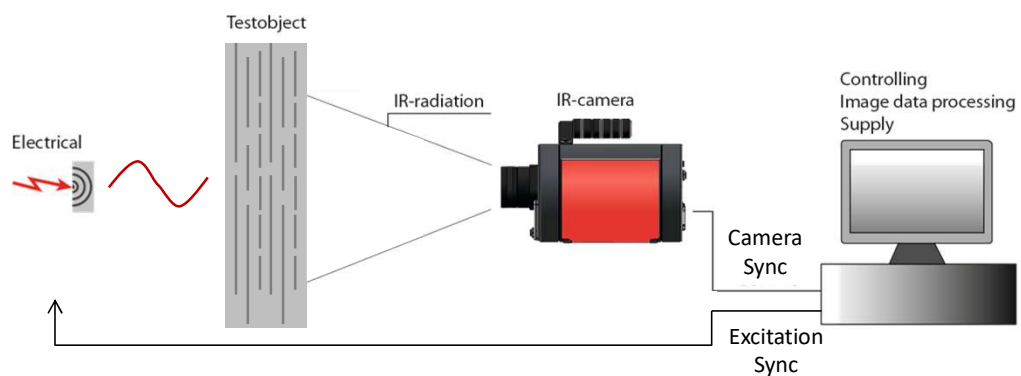
Active Thermography – Principle – Internal Heat Generation



- ☐ Correlated heat generation within the material by energy application to the object
- ☐ Lock-in principle is used mostly: Periodically induced energy with synchronized IR image acquisition

InfraTec, Thermography and You

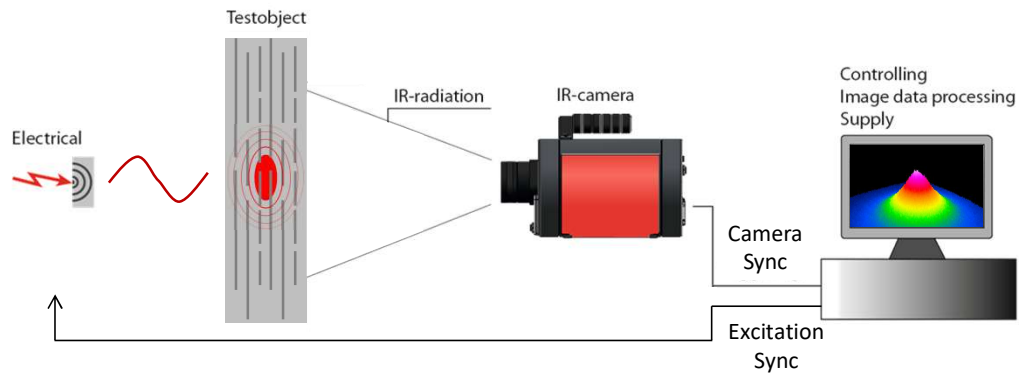
Active Thermography – Principle – Internal Heat Generation



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InfraTec, Thermography and You

Active Thermography – Principle – Internal Heat Generation

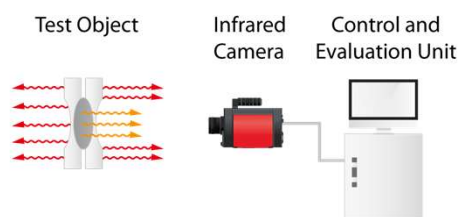


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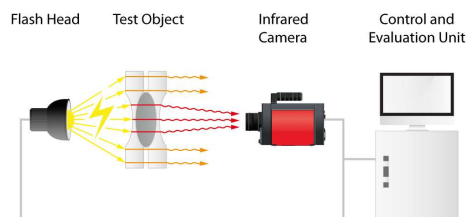
Active vs. Passive Thermography

Measurement Strategy

- ☐ Passive thermography

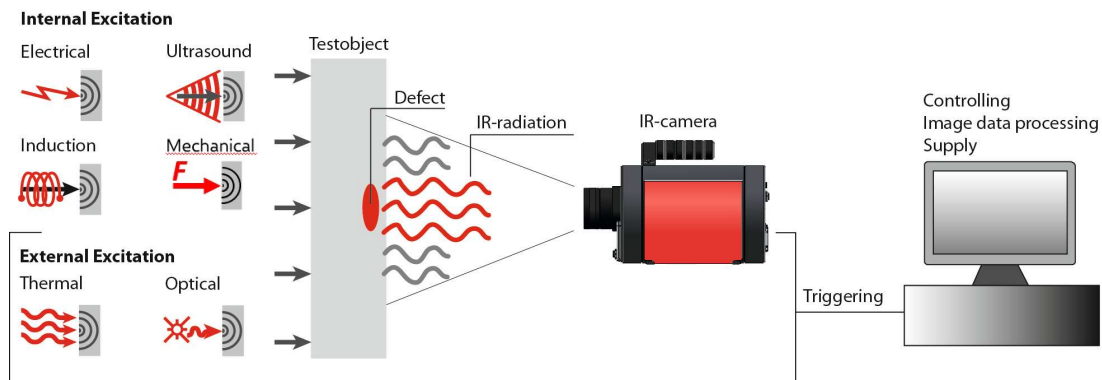


- ☐ Active thermography



Active Thermographic Testing

Excitation Options of Active Thermography

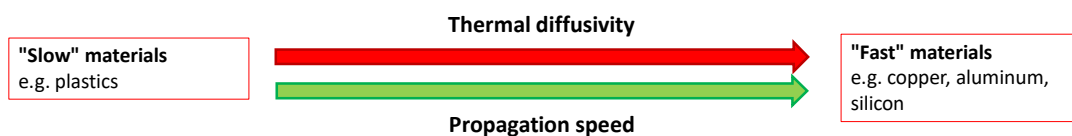


- Most common active thermography methods:
 - **Lock-in thermography** (periodically excitation within the non-destructive range of the sample)
 - **Pulse-phase thermography** (one-shot excitation and analysing the delayed thermal response of the sample)

Heat Flux During the Test Process

Effects of the Material Parameters

- Thermal diffusivity determines the rate of heat propagation in the material



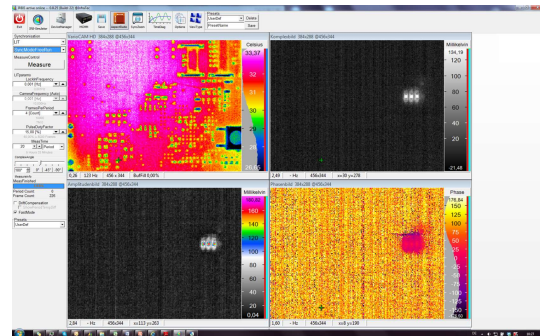
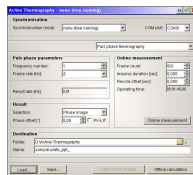
- The higher the velocity of propagation, the shorter the time window within which a transient heat flow is present that can be used for active thermography.
- Materials with higher thermal diffusivity
 - Requires **higher frame rates**
 - Allow **shorter test times**



Active Thermography – Software in IRBIS® 3 Family

Make Data Knowledge

- ❑ Full remote control of thermographic camera
- ❑ Comprehensive control of excitation source
- ❑ Detailed settings of excitation cycle
- ❑ Data acquisition
- ❑ Automatic display of resulting images (amplitude, phase)
- ❑ Advanced analysis of data
- ❑ Online monitoring need? → IRBIS® 3 active online



Integrated Systems as Test Benches

Photovoltaic and Electronics Lock-in Test Bench – Turnkey Solutions by InfraTec



Turnkey Engineering
Solution by InfraTec

- ❑ Solar cell/module & electronics testing using VarioCAM® or ImageIR® with suitable detector sizes and lenses (e.g. also close up and microscopic)
- ❑ Modular concept allows for different excitation types, power, current, temperature control and holding concepts
- ❑ Different sample sizes suitable
- ❑ Full control by attached control unit with comprehensive and customizable software
- ❑ E.g. solar cell testing:
 - ❑ Modes DLIT and ILIT
 - ❑ Shunt detection, loss determination, etc.



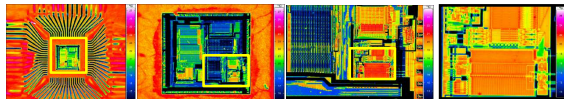
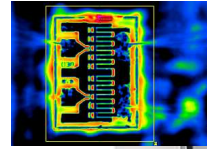
Microelectronic Failure Analysis and Hotspot Detection

InfraTec E-LIT Lock-in Thermography Test Bench

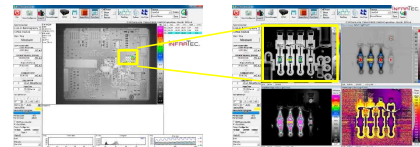


Turnkey Engineering
Solution by InfraTec

- ❑ Modular concept providing:
 - ❑ Full manual control for exploratory work and fully programmable for automated in-line testing
 - ❑ State of the art cameras and optical system for maximum resolution
 - ❑ Flexible lock-in settings for analysis with thermal sensitivity in the μK range
 - ❑ Full temperature control and integrated emissivity correction for quality assurance



Product video:



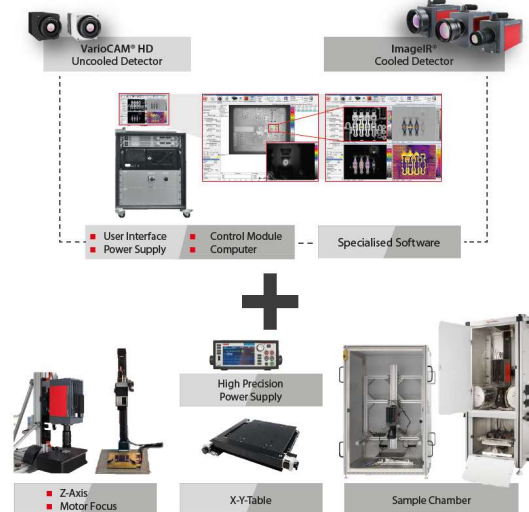
Integrated Systems as Test Benches (E-LIT)

From a Thermographic System To A Full Integrated Test Bench



Turnkey Engineering
Solution by InfraTec

- ❑ Some applications exceeds the limits of a standard thermographic system (camera and software)
- ❑ Additional components and hardware needs to be included into the system manual which requires a lot of preparation time and know-how
- ❑ An automated solution includes additional components and is set-up to work properly for the specific application

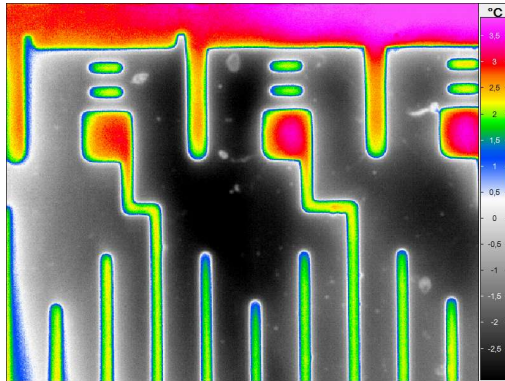


CB1 Hier ist ganz schön viel zu sehen auf der Folie. Wollt ihr das lieber auf 2 Folien aufteilen?

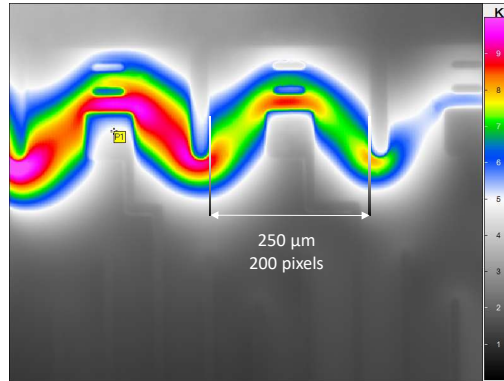
Carolin Bittner; 2026-06-30T07:20:35.444

Active Thermography – Lock-in in Electronics I

What Could Be the Result – Microstructure on Electronics



Passive thermography image – background is heated up and metal structure seems cool because of low heat capacity and low emissivity.

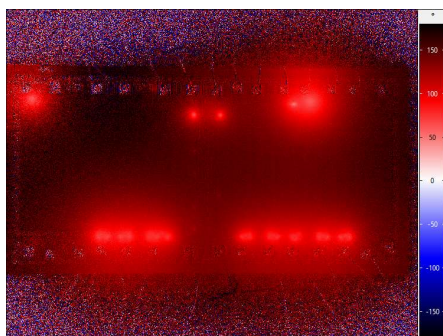


Lock-in amplitude result image – heated background is suppressed by frequency-based amplification. Heat generated by current can be seen in the metal structure.

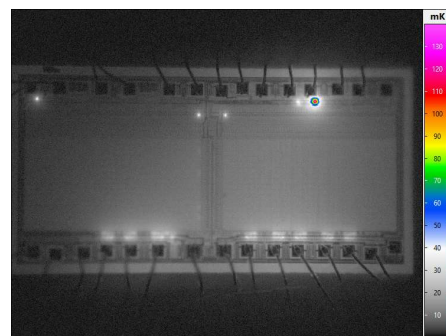
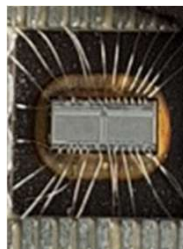
Active Thermography – Lock-in in Electronics II

Hotspot Detection at a Microchip Bonding

Lock-in on Electronics



Phase result

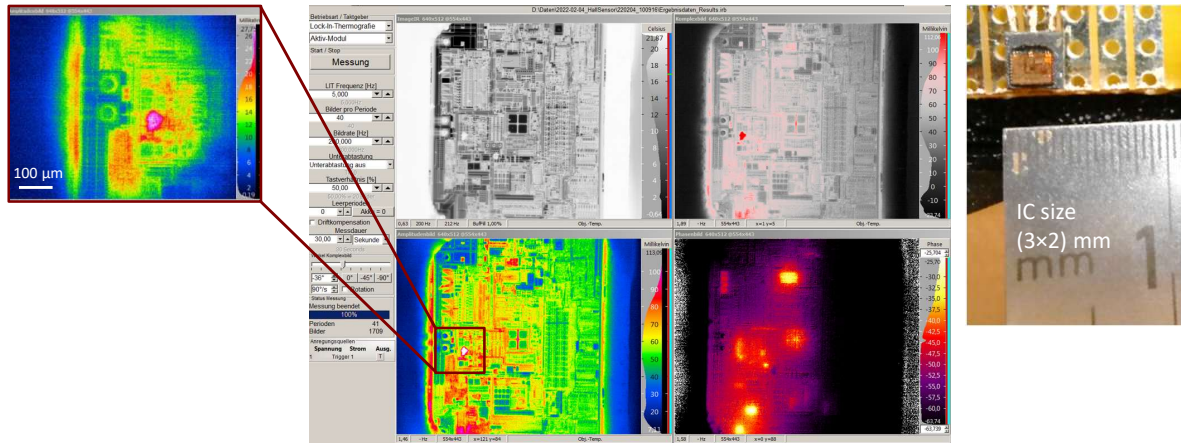


Amplitude result

Active Thermography – Lock-in in Electronics III

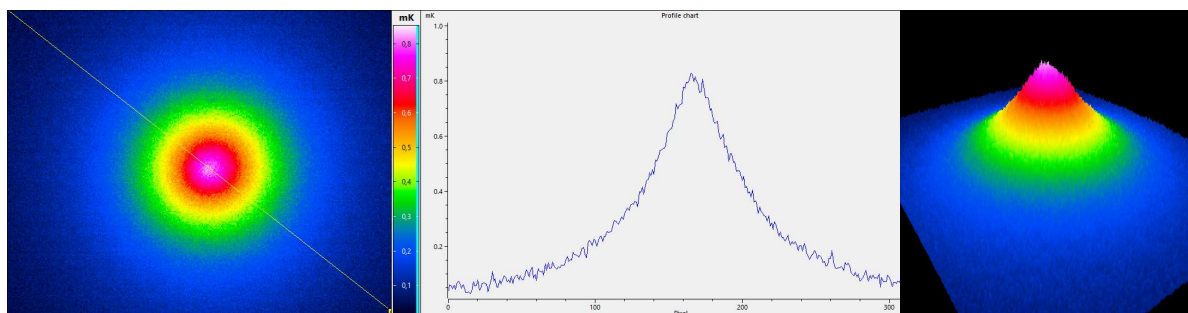
Excitation of a Hall Sensor Circuit

Lock-in on electronics – Measurement of very small temperature differences in mK range (μK resolution)



Active Thermography – Lock-in in Electronics IV

Hot Spot Detection on an IC with Rather Low Energy



Applied energy: 70 μW

Peak value of this “Hot-Spot” is just **0.8 mK = 0.0008 K**

The **thermal measurement resolution** is about **8 μK !**

(FOV: 4.8×3.8 mm²; iFOV: 15 μm)

Active Thermography – Material Testing I

Homogeneity Test on Foam-filled Exterior Vehicle Part (Halogen Lamp Excitation)

- ☐ Test specimen with marked suspect area

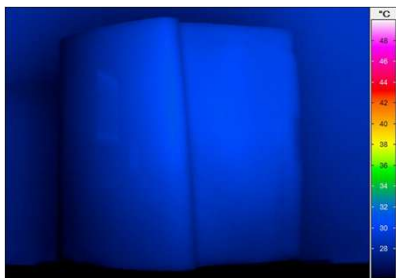


- ☐ Test setup
- ☐ LWIR microbolometer camera VarioCAM® HD
- ☐ Reflective configuration
- ☐ 2 kW halogen lamp reflector spotlight

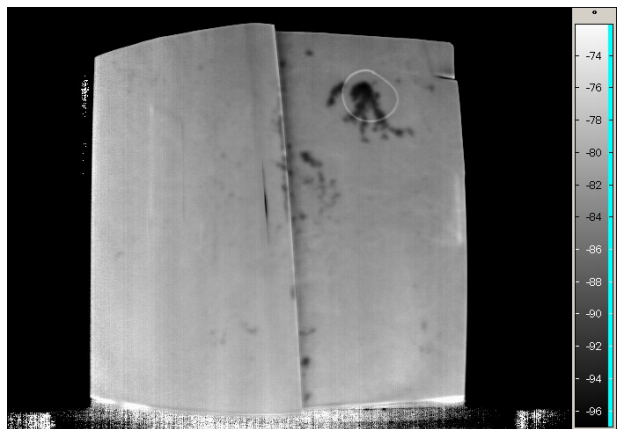
Active Thermography – Material Testing II

Homogeneity Test on Foam-filled Exterior Vehicle Part (Halogen Lamp Excitation)

- ☐ Data acquisition and evaluation with IRBIS® 3 (active thermography module)
- ☐ 25 Hz image frequency



- ☐ 50 s measuring time (50 % on / off)
- ☐ Lock-in thermography with 0.02 Hz frequency, 1 period
- ☐ Phase image



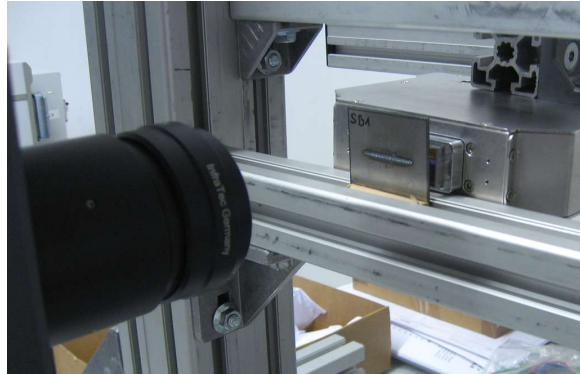
Active Thermography – Material Testing IV

Inspection on Laser-welded Metal Sheets with Flash Excitation 1

- Test specimen (photo)



- Test setup
- MWIR camera ImageIR®
- Transmissive configuration
- Water-cooled high-power flash lamp



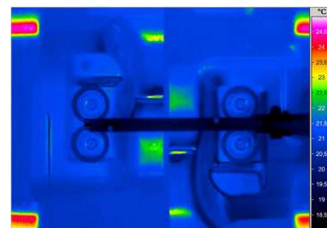
Bespoke Turnkey Solutions Based on Active Thermography

From Test Stand up to Automated Solution



Turnkey Engineering
Solution by InfraTec

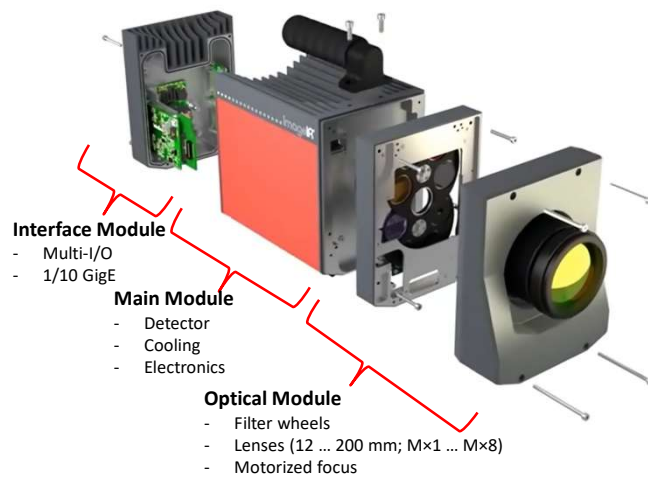
- Manually operated test stand
- Robot manipulated solutions
- Fully production chain integrated solutions



► products

High-End Cameras ImageIR® - Spectral Thermography

Modular Design



Parameters and Solutions

Overview



Spatial resolution
- iFOV -



Thermal resolution
- NETD -



Spatial resolution
- FPA size -
- FOV -



Time resolution
- Hz -

ImageIR® 8300

The Flexible

(640 × 512) IR pixels

HDR

15 / 25 μm pitch

355 / 1,105 Hz full-frame

Up to two wheels

ImageIR® 9400

The Large Flexible

(1,280 × 1,024) IR pixels
(640 × 512) Binning

10 μm pitch

181 / 622 Hz full-frame

Up to two wheels

ImageIR® 10300

High-Definition

(1,920 × 1,536) IR pixels
(960 × 768) Binning

10 μm pitch

140 Hz full-frame

ImageIR® 12300

High-definition

(2,560 × 2,048) IR pixels

5 μm pitch

140 Hz full-frame

ImageIR® 8855

The Long-wave

(640 × 512) IR pixels

HDR

15 μm pitch

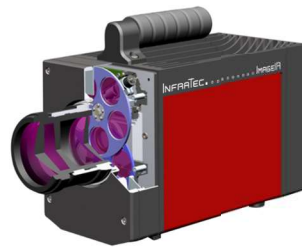
233 Hz full-frame

High-End Cameras ImageIR® – Multiple Wheels for Maximum Flexibility

Wheel Solutions for Spectral, High Dynamic Range and MicroScan Measurements

Depending on camera model most different filter wheel combinations are possible:

- ❑ **Filter Wheel**
 - ❑ Up to 5 (4) filters 1" diameter
 - ❑ Max. 1 (2) mm filter thickness
 - ❑ Can be combined with aperture wheel
- ❑ **Aperture Wheel**
 - ❑ Up to 5 (4) filters 1" diameter
 - ❑ Max. 1 (2) mm filter thickness
 - ❑ Can be combined with filter wheel
- ❑ **Fast Filter Wheel**
 - ❑ Up to 7 filters 1" diameter
 - ❑ Max. 1 mm filter thickness
 - ❑ 5,400 rpm - suitable for detector frame rate up to 360 Hz
 - ❑ Can be combined with aperture wheel

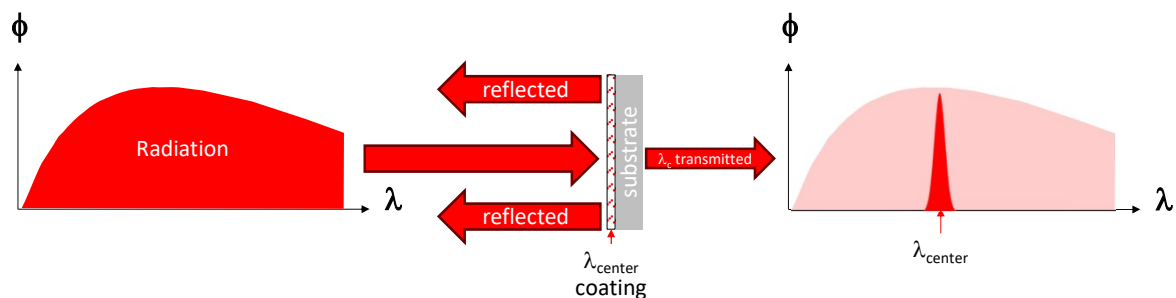


→ Unique 35 filter combinations conveniently software controlled

Spectral Thermography

How is it realized? **Spectral Filters**

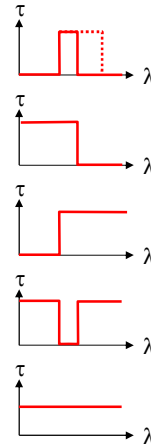
- ❑ Realization of Infrared sub-bands with **spectral filters**
- ❑ Principle:
Thickness of the metal coating is designed to create constructive interference for ONE center wavelength λ_{center} which then will be transmitted through the coating:



Spectral Thermography

How is it realized? **Spectral Filters**

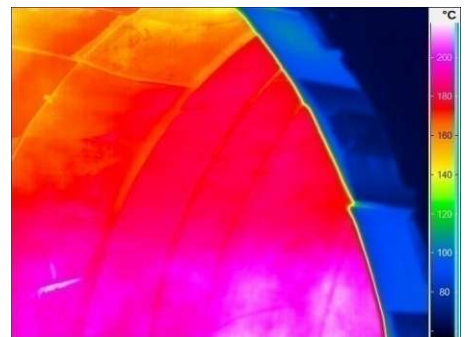
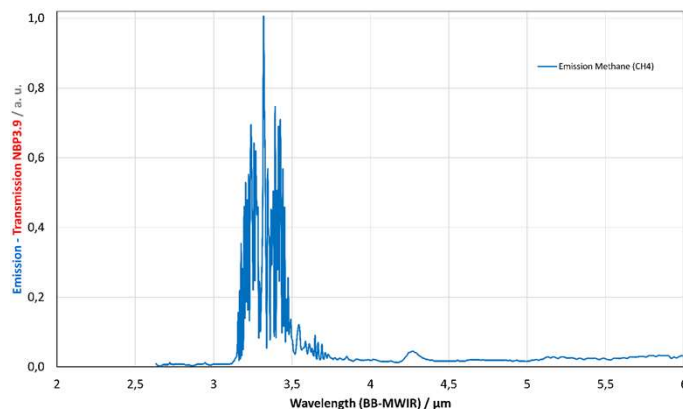
- ☐ Different filter characteristics are available
- ☐ Bandpass filters (narrow and wide)
- ☐ Shortpass filters
- ☐ Longpass filters
- ☐ Notch filters
- ☐ Neutral density filters (not really spectral band filter...)



Spectral Thermography

Why?

- ☐ Discrimination of emitted IR radiation of a material (semi-transparent for IR)
→ Goal: Measurement "through" the material
- ☐ Example: Flames

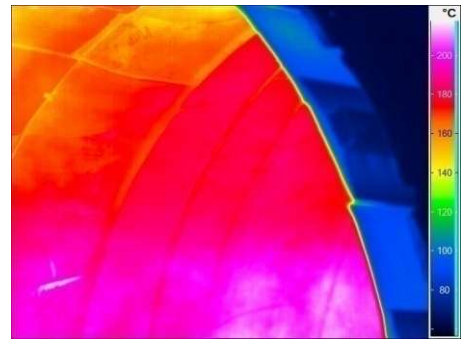
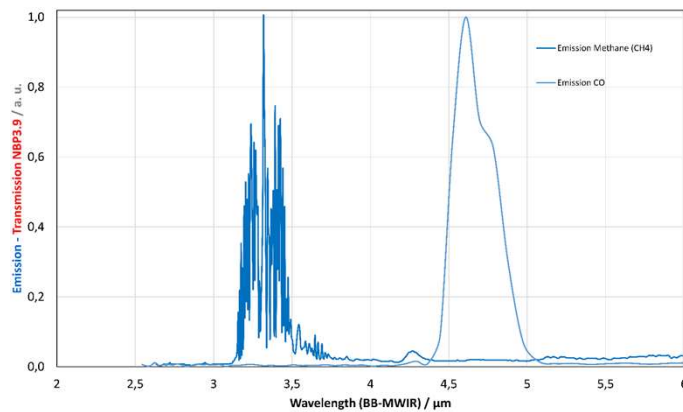


IR image with MWIR camera (2.5 ... 5.5) μm w/o spectral filter: Nozzle of a jet-engine

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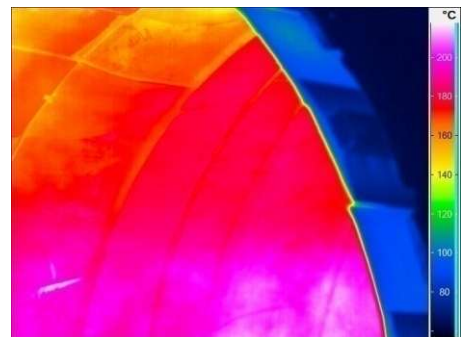
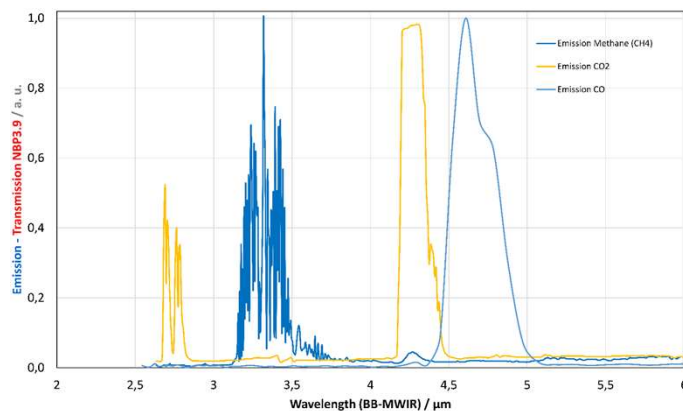


IR image with MWIR camera (2.5 ... 5.5) μm w/o spectral filter: Nozzle of a jet-engine

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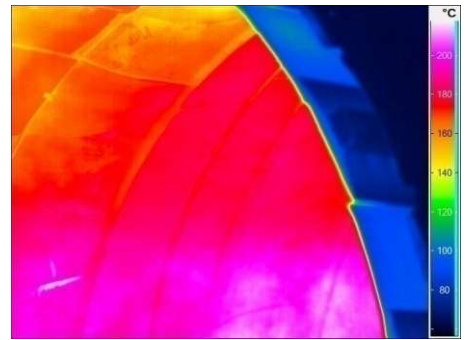
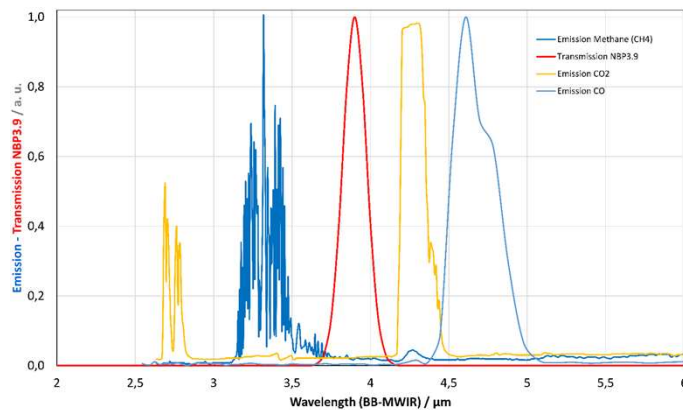


IR image with MWIR camera (2.5 ... 5.5) μm w/o spectral filter: Nozzle of a jet-engine

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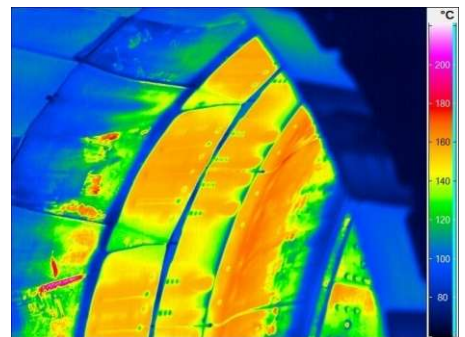
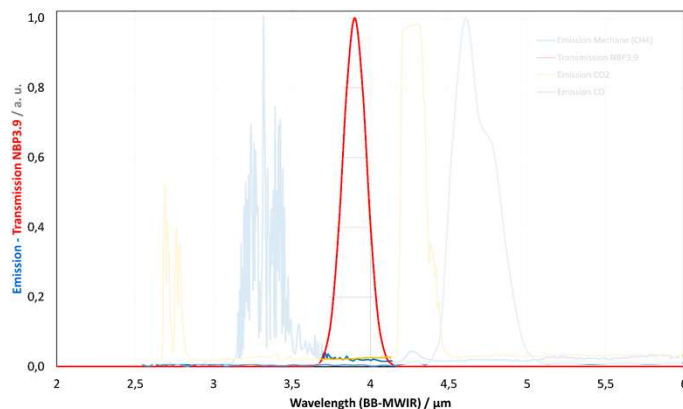


IR image with MWIR camera (2.5 ... 5.5) μm w/o spectral filter: Nozzle of a jet-engine

Spectral Thermography

Why?

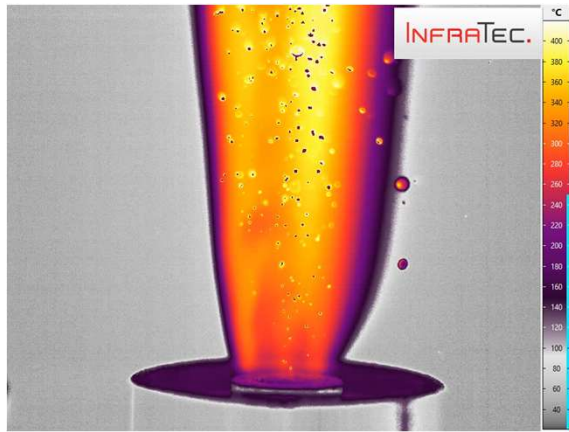
- ❑ Discrimination of emitted IR radiation of a material (semi-transparent for IR)
→ Goal: Measurement “through” the material
- ❑ Example: Flames



IR image with MWIR camera /w spectral filter NBP 3.9 μm ; 150 nm: Nozzle of a jet-engine

Spectral Thermography

Why?



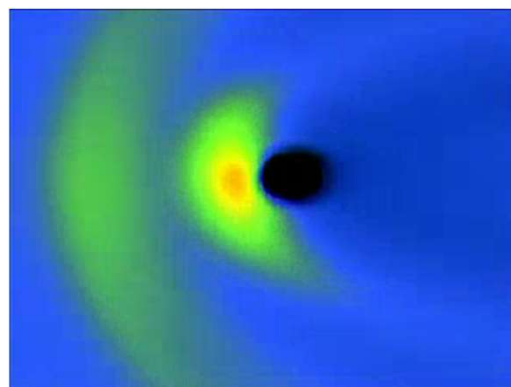
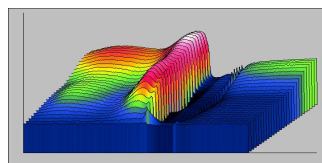
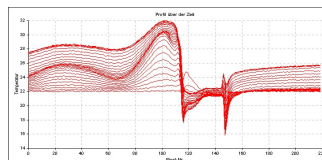
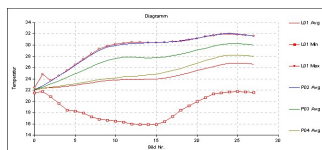
ImageIR®: Flame particles w/o spectral filter



ImageIR®: Flame particles with through-flame filter

Aerodynamics

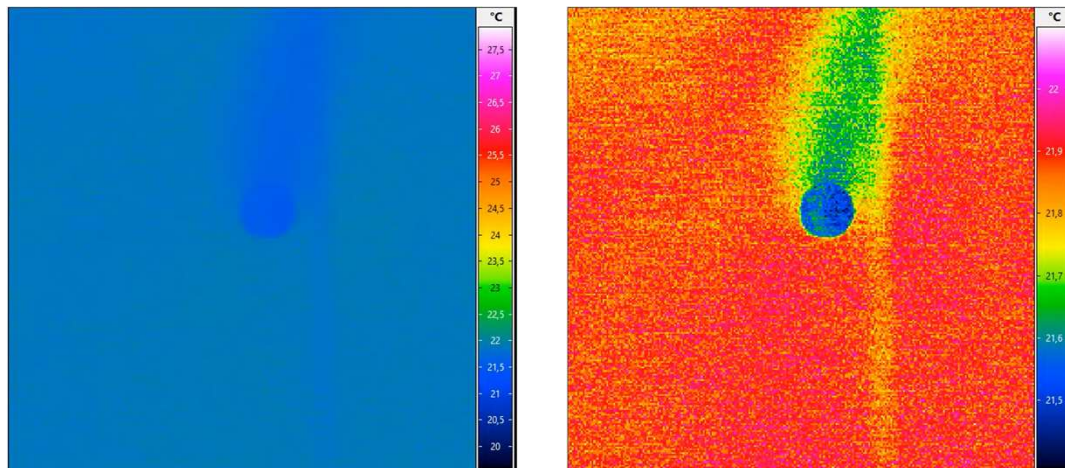
Visualization of Friction in Design of Components



Wind tunnel measurements

Aerospace Industry

Optimization of Components

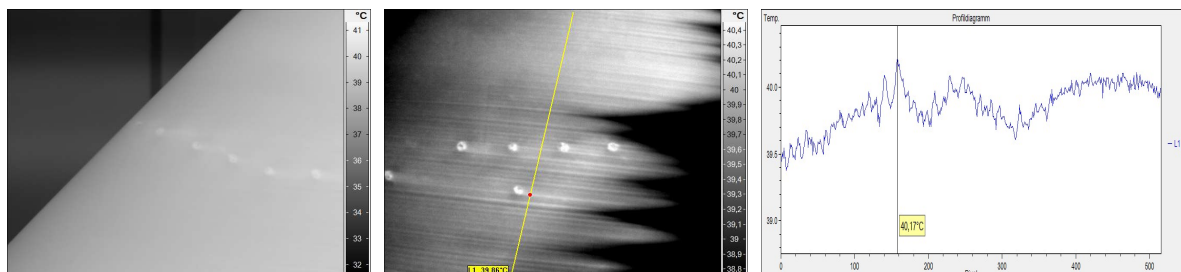


Wind tunnel measurements

Aerospace Industry

Optimization of Components

- ☐ Temperature distribution of vertical tail in a wind tunnel
- ☐ Goal – reduction of turbulent air flows to reduce fuel consumption
- ☐ Demand for highest thermal resolution and most precise triggering



Aerial Thermography

CB1



© InfraTec.eu

Thermography in Aerospace Engineering

85

Aerial Thermography – Some Benefits and Applications

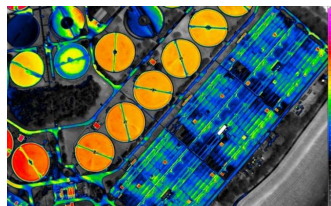
Broad Range of Airborne Options

General advantages

- ☐ Large area monitoring & mapping
- ☐ Raw tiff data and GPS exportable
- ☐ Multisensors: VIS, LIDAR possible – pods, platforms, gimbals
- ☐ Structural resolution (powerlines) is possible
- ☐ Restricted areas can be imaged
- ☐ Area Security

Applications

- ☐ Urban heat mapping
- ☐ Utility inspection and maintenance
- ☐ Distributed heating network monitoring
- ☐ Fire mapping
- ☐ Disaster monitoring
- ☐ Remote sensing
- ☐ Crop science and agricultural monitoring
- ☐ Surveillance



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Thermography in Aerospace Engineering

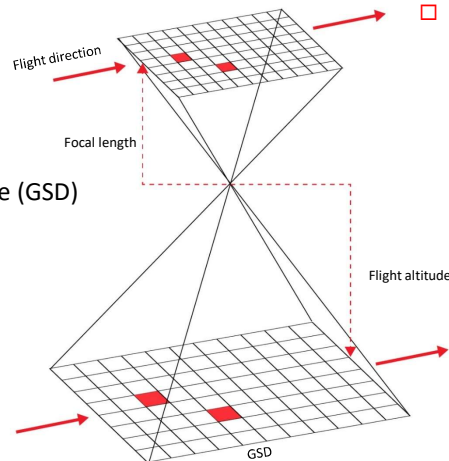
86

CB1 Soll hier noch eine Subline hin?
Carolin Bittner; 2026-06-18T07:22:29.932

Why Aerial Thermography?

The Fundamental Parameter

- ☐ Sensor size
- ☐ Focal length
- ☐ Flight altitude (ft, m)
- ☐ Flight speed (kn, m/s)
- ☐ Field of view
- ☐ Ground Sampling Distance (GSD)



- ☐ When choosing a camera system the following parameter should be checked

- ☐ Frame rate & exposure time
- ☐ Flight speed & altitude
- ☐ Sensor size (px)
- ☐ Pixel size (μm)
- ☐ Focal length (mm)

Image source: <https://www.felixikon.info/lexikon/gsd>

Aerial Thermography – Some Definitions

Platforms to Be Used

- ☐ Remote Sensing from flying platforms
 - ☐ UAVs
 - ☐ Helicopters
 - ☐ Fixed-wing aircraft



Infrared Detector – Heart of Thermographic Cameras

Typical Specifications of Infrared Detectors

	Cooled Quantum Detectors	Uncooled Thermal Detectors (Microbolometers)
Materials	MCT, InSb, SLS, QWIP @ ~77 °K; InGaAs	a-Si, VOx
Spectral range	SWIR, MWIR, LWIR	LWIR
Thermal sensitivity	≤ 20 (10) mK	< 30 mK
FPA size	Up to (2,560 × 2,048) IR pixels / 5 µm PP	Up to (1,024 × 768) IR pixels / 17 µm PP
Stability / homogeneity	Very high	„Acceptable“ – (range of quality available)
Time resolution	IT: (< 1 ... > 20,000) µs – up to 105,000 fps	(Thermal) Delay: ~10 ms – around 30 / 50 fps
Acquisition mode	Snap shot	Line-by-line / Rolling shutter
Long-term operation	Mechanical (Stirling) cooler operation	Maintenance free
Investment	High	Low

Infrared Detector – Heart of Thermographic Cameras

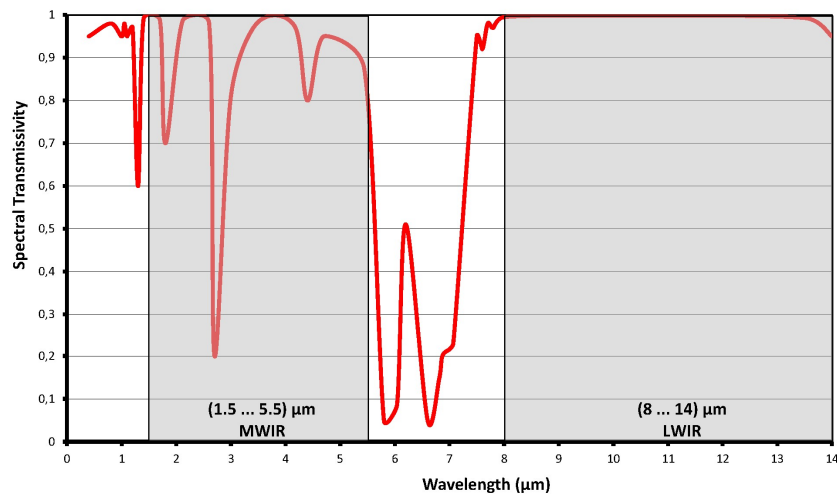
Typical Specifications of Infrared Detectors



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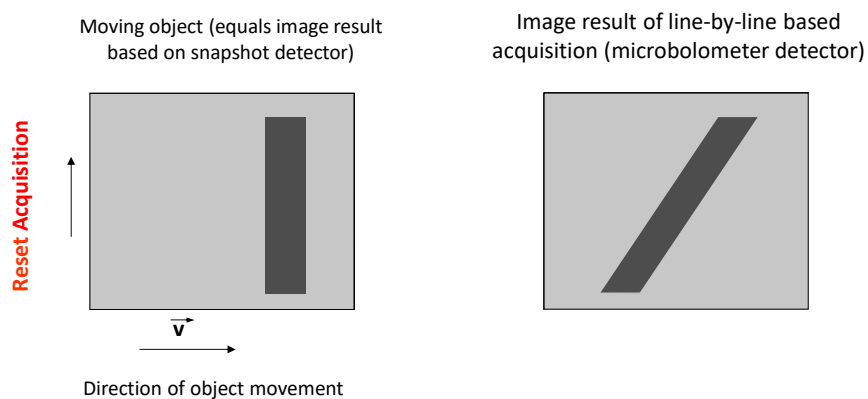
Atmospheric Windows

SWIR, MWIR and LWIR Spectral Range and Atmospheric Influence



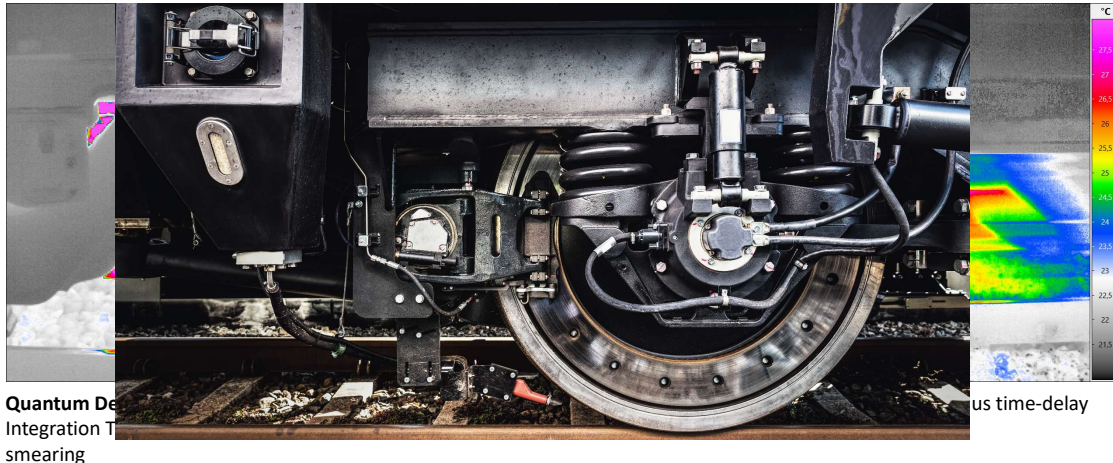
Snapshot vs. Line-by-line Acquisition Principle of Detectors

Working Principle



InfraTec, Thermography and You

Comparison Detector Types – Passing Train Wheel



Quantum Detector
Integration Time
smearing

plus time-delay

Aerial Thermography – Some Definitions

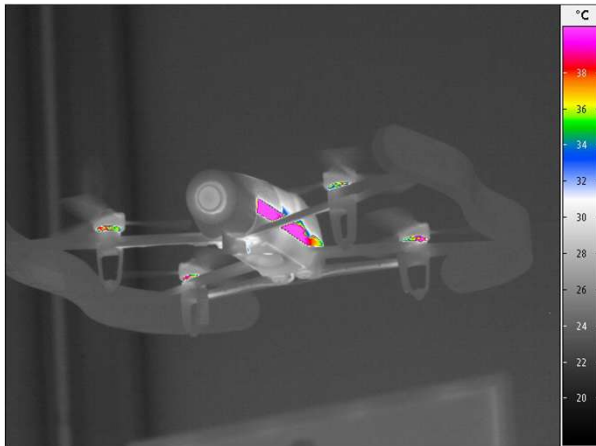
Cameras in Motion

- ❑ Fixed mounted systems
 - ❑ Downward staring platform
 - ❑ For image swaths and stitching / creating mosaics
- ❑ Pan-tilt systems
 - ❑ Gimbal-mounted platform
 - ❑ With additional stabilization feature



Surveillance

Recognition / Detection of Drones

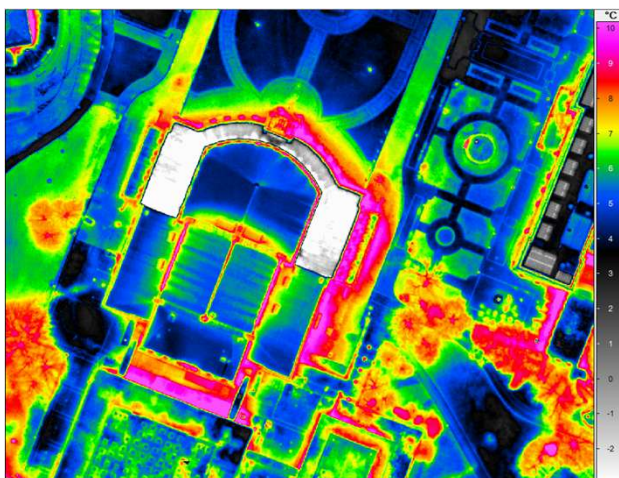


Hovering drone

- Detection of drones in the surroundings
- Difficult with visual cameras in poor backgrounds or darkness
- Clear heat signature simplifies detection using thermography
- Fast flight speed requires cooled camera
→ Imager[®] 8300 with short integration times
→ 530 μ s and high frame rate → 100 Hz

Monitoring at Utility Operations

Thermal Mapping of the District Heating Network of Dresden City



Airborne solution
using Imager[®]

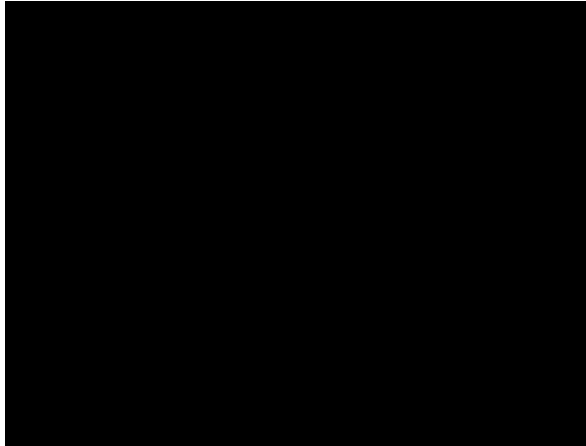
SCAN³DAT
Gesellschaft für Innovative
Fernwärmungstechnologien mbH

Monitoring at Utility Operations

Airborne Overheat Line Monitoring



Turnkey Engineering
Solution by InfraTec



Gimbal based solutions with various camera configurations
(e.g. ImageIR® and special design of VarioCAM® HD)

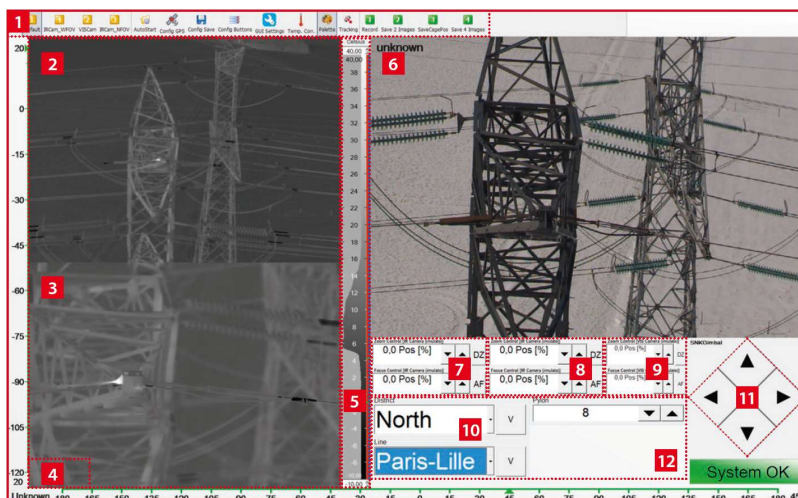


Monitoring at Utility Operations

Airborne Overheat Line Monitoring Software



Turnkey Engineering
Solution by InfraTec



Software GimbalScan®

- 1 Control and adjustment keys
- 2 Image of the cooled WFOV infrared camera
- 3 Image of the uncooled NFOV infrared camera
- 4 Gimbal status and position display
- 5 Temperature scale and setting of the temperature display
- 6 Picture of the color video camera
- 7 Control of the NFOV infrared camera
- 8 Control of the WFOV infrared camera
- 9 Controlling the color video camera
- 10 File name
- 11 Gimbal control buttons
- 12 System status

Monitoring at Utility Operations

Remote and Centralized Preventive Maintenance



Turnkey Engineering
Solution by InfraTec

IRSM System for substation monitoring:

- ☐ Monitoring of complete substations
- ☐ Defined sectors and positions for parts with indication
- ☐ Operates 24/7



Environmental Studies

Airborne Wildlife Monitoring



First detection of free-living
wolves in Germany

Environmental Studies

Airborne Monitoring of Wastewater Ingress into Rivers



© InfraTec.eu

Thermography in Aerospace Engineering

101

Autonomous Landing

Enabling Aircraft to Utilize IR Cameras for an Unattended Landing



Courtesy: TU Braunschweig

© InfraTec.eu

Thermography in Aerospace Engineering

102

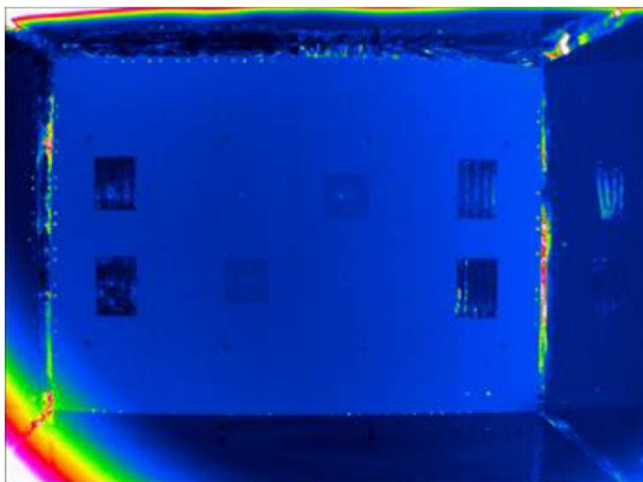
Space Thermography

Purposes, Benefits, Solutions

- ❑ Research and Development
 - ❑ Structures under extreme cold / heat conditions
 - ❑ Material in vacuum
 - ❑ Microgravity-manufacturing
 - ❑ Fundamental solar system research
- ❑ Typical Tasks for Thermography
 - ❑ Classical thermography under extreme conditions
 - ❑ Heatflow thermography
- ❑ Typical Solutions
 - ❑ VarioCAM® HD
 - ❑ ImageIR®

Fundamental Research

Low-temperature Thermography

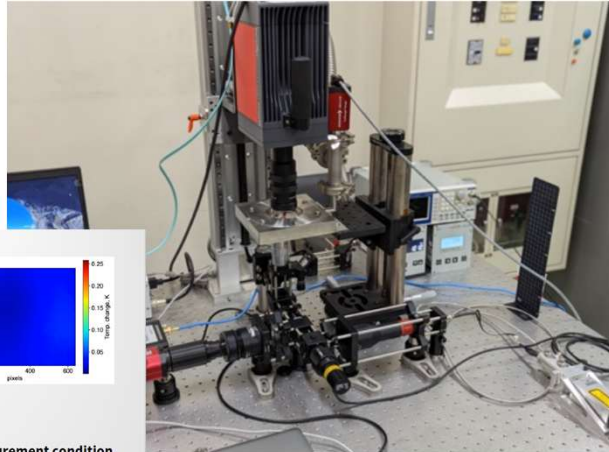
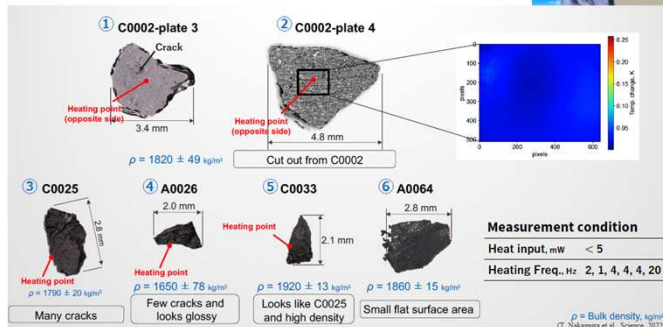


Thermal details at -100°C – space probe component evaluation

Courtesy: TU München

Solar System Research

μ -g Sample Active Thermography



Measuring thermal diffusivity on space-collected asteroid samples

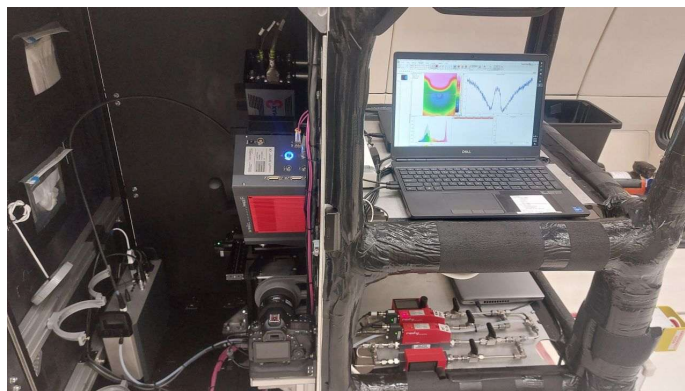
Courtesy: JAXA

Fundamental Research

Process Monitoring Under Zero Gravity

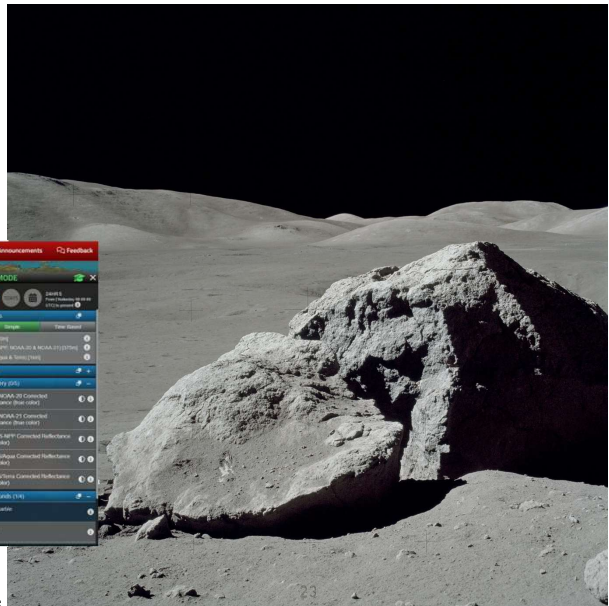
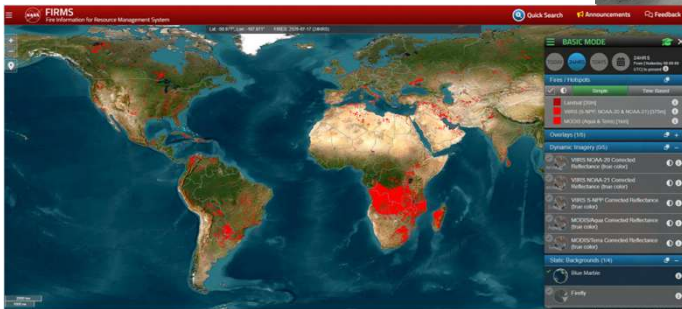


Courtesy: Université Paris Nanterre



ImageIR integrated into Zero-G plasma research project

Fundamental Research Real Space Thermography?



Courtesy: Wikipedia / NASA / common license

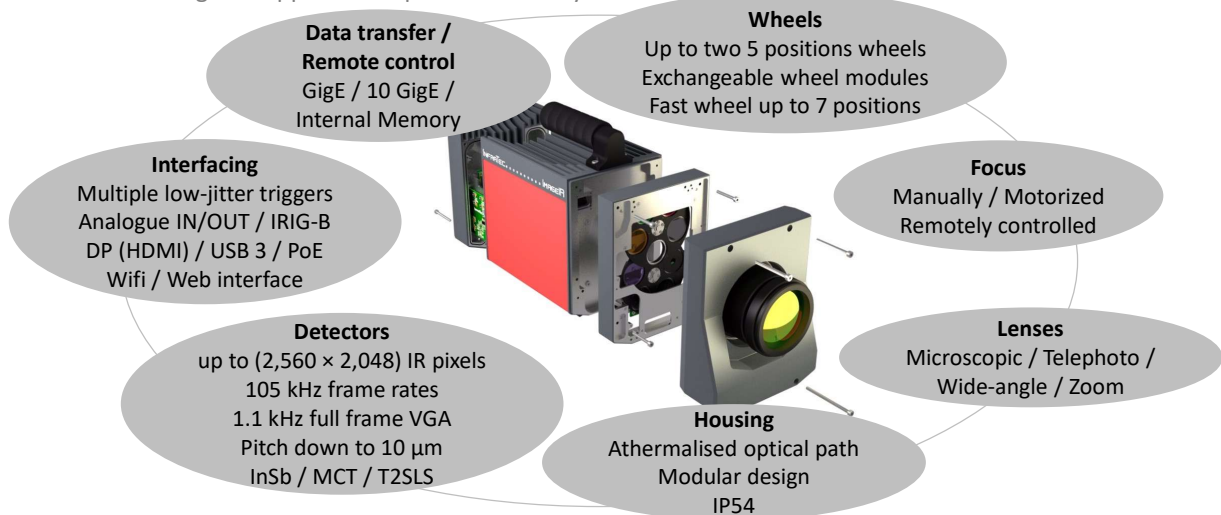
Thermographic High-End Cameras

Precision, Speed, Flexibility



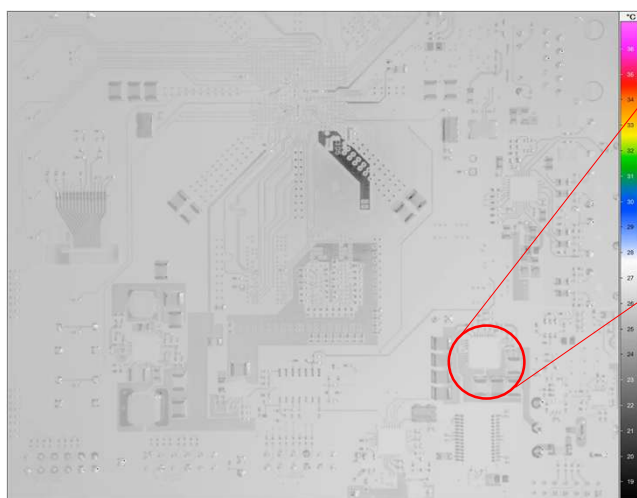
High-End Cameras ImageIR® – Flexibility Meeting Your Needs

Hardware for Highest Application-Specific Flexibility



In Focus – ImageIR® 10300

Excellent Detail Resolution



Large FOV and small IFOV!

Example:

FOV: 50,000 µm × 40,000 µm

IFOV: 26 µm

► content

The NEW Camera ImageIR® 6300 Z

Based on Newest SWaP Generation

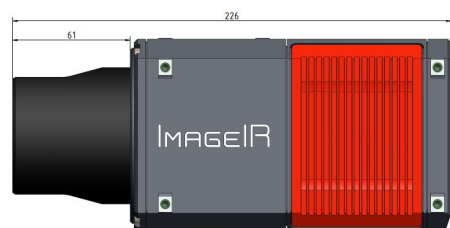
- **Size, Weight and Power**
 - Size (226 × 100 × 100) mm³
 - Weight approx. < 2 kg
 - and Power: Less than 50 W
- **xBn Detector Technology**
 - MWIR Quantum Detector (640 × 512) @ 10μm
 - Snapshot
 - Variable integration times (1 ... 40,000) μs
 - 180 fps (620 fps in binning mode)
- **“Hot”** – Detector: 150 K detector temperature instead of 77 K



The NEW Camera ImageIR® 6300 Z

Based on Newest SWaP Generation

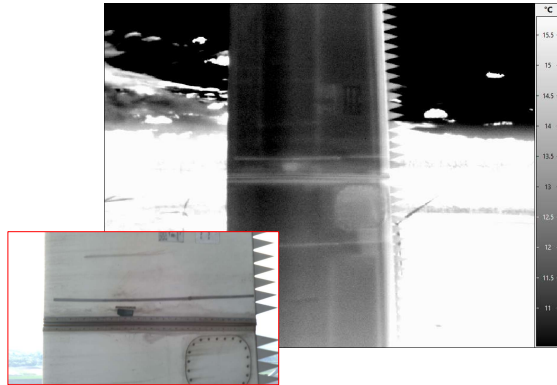
- **Fixed mount 7× ZOOM lens**
 - $f = (15 \dots 115) \text{ mm} \rightarrow (24.5 \times 20)^\circ \dots (3.2 \times 2.5)^\circ$ or
 - $f = (25 \dots 170) \text{ mm} \rightarrow (16.3 \times 13)^\circ \dots (2.15 \times 1.7)^\circ$



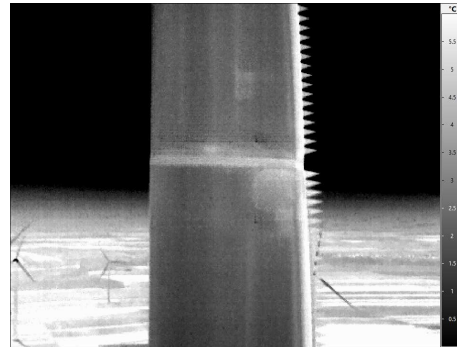
The NEW Camera ImageIR® 6300 Z

Wind turbine inspection – comparison with microbolometer camera

□ Backlit side



ImageIR 6300Z
 $f'=18$ mm, $t_{\text{int}}=7,8$ ms

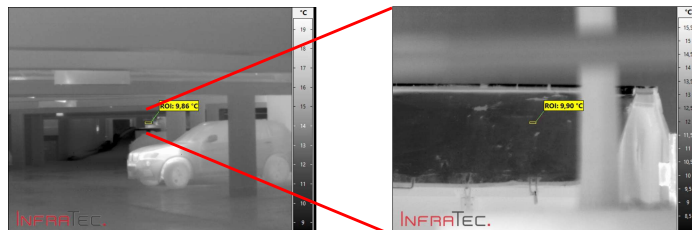


Microbolometer camera
 $f'=19$ mm, $\tau=10$ ms

ImageIR® Goes Zoom

ImageIR® Z – VGA and SXGA with Radiometric Zoom

- Spectral range: **(3.7 ... 4.8) μm**
- Calibration: (-10 ... 300) °C
- Frame rate: 100 Hz
- Focal length: (28 ... 850) mm, **F = 1,350 mm** option
- 30x infrared motorised zoom lens
 - WFOV: (1,280 × 1,024): 39.8°
 - NFOV: (1,280 × 1,024): 1.3°
- Zooming:
 - NFOV → WFOV: ≤ 8 s
 - 100 mm → 850 mm ≤ 2 s
- Detection range:
 - 23 km for persons
 - 27 km for vehicles



Thermographic OEM Cameras

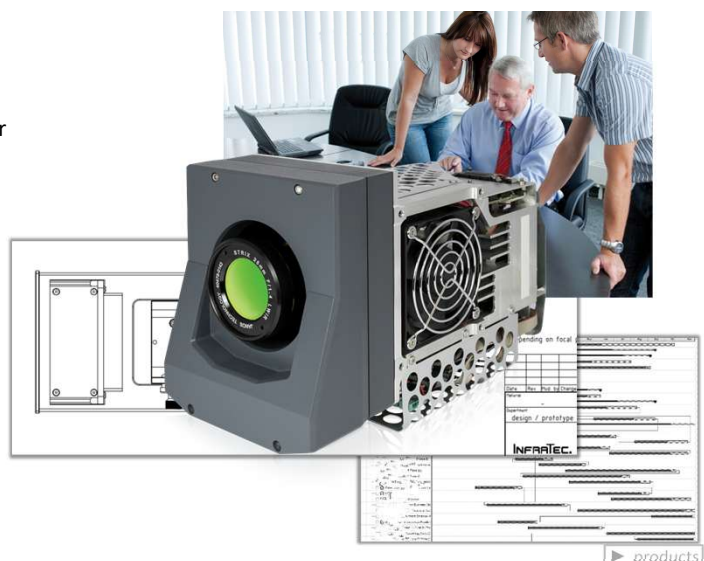
Ready to Integrate



InfraTec's Supports OEM Ventures

Experience in Technology and Processes

- Technical support
 - Adaptation of cameras based on flexible design concepts to match specific customer needs
 - Industry-proof interfacing concepts easy connectability
 - SDK running on camera-level for customer specific applications
 - Necessary application support
- Process
 - Dedicated OEM process management
 - Certification & documentation
 - Comprehensive OEM-partner operation's service



Fundamental Research

Real Space Thermography!



Centaurus A – J. Webb Telescope – 5.6 μm / 7.7 μm / 10.0 μm

Courtesy: Wikipedia / NASA / common license

Infrared Thermography for Your Application Just Ask Our Team

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 www.youtube.com/user/InfraTecGmbH/videos

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