Active – Thermography

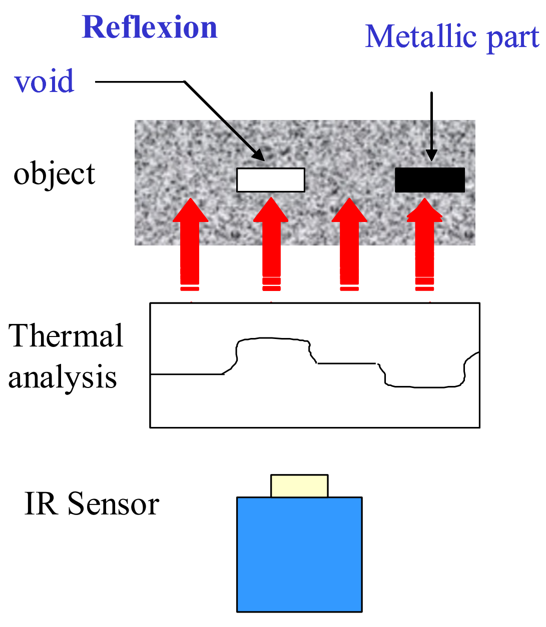
Principles

Pulse Thermography

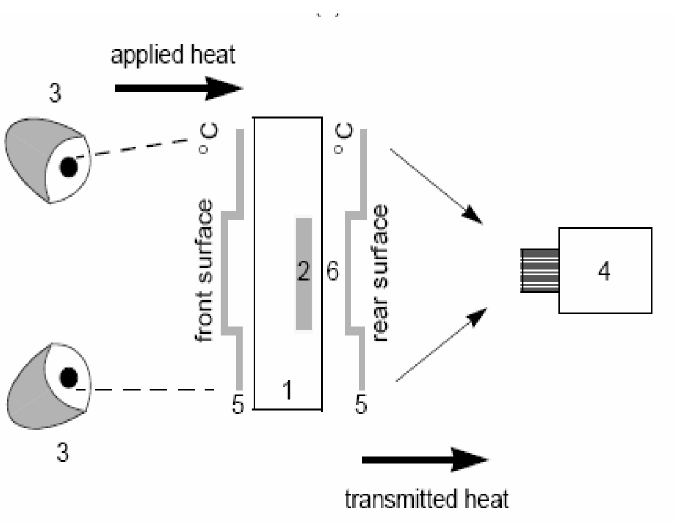
Lock-In Thermography

Pulse-Phase Thermography

Derivative technics



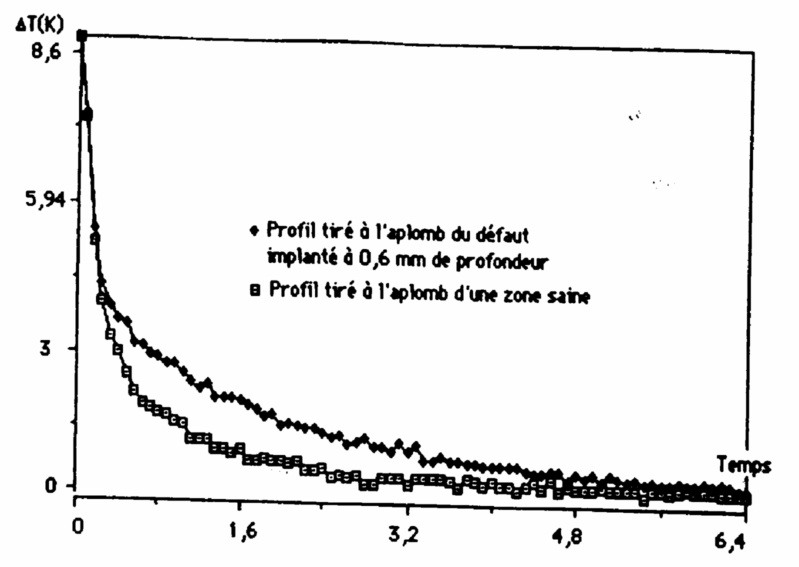
Reflexion
Metallic part
void
object
Thermal
analysis
IR Sensor

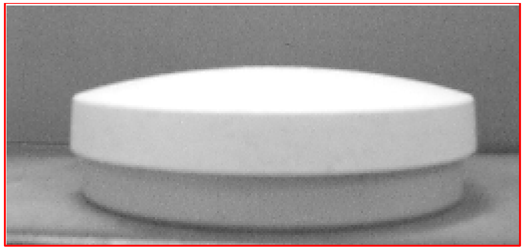


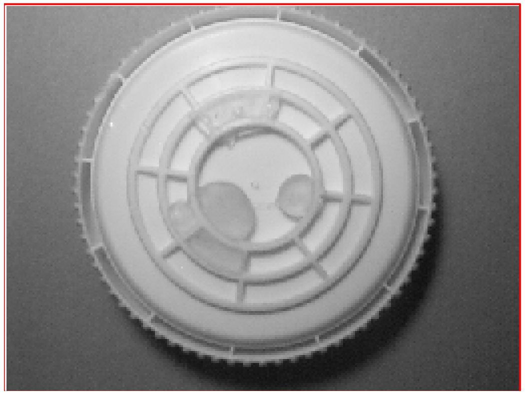
applied heat
3
°C
°C
front surface
rear surface
2
6
4
1
5
5
3
transmitted heat

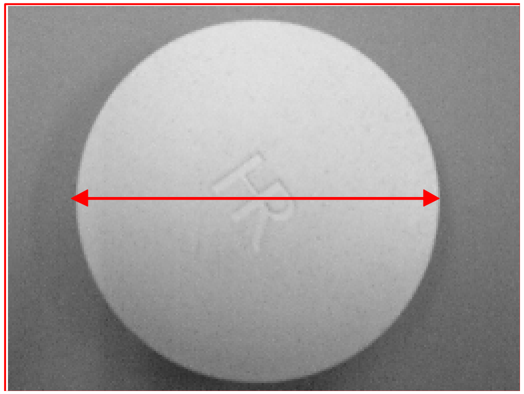
Basically, PT consists of briefly heating the specimen and then recording its temperature decay curve.

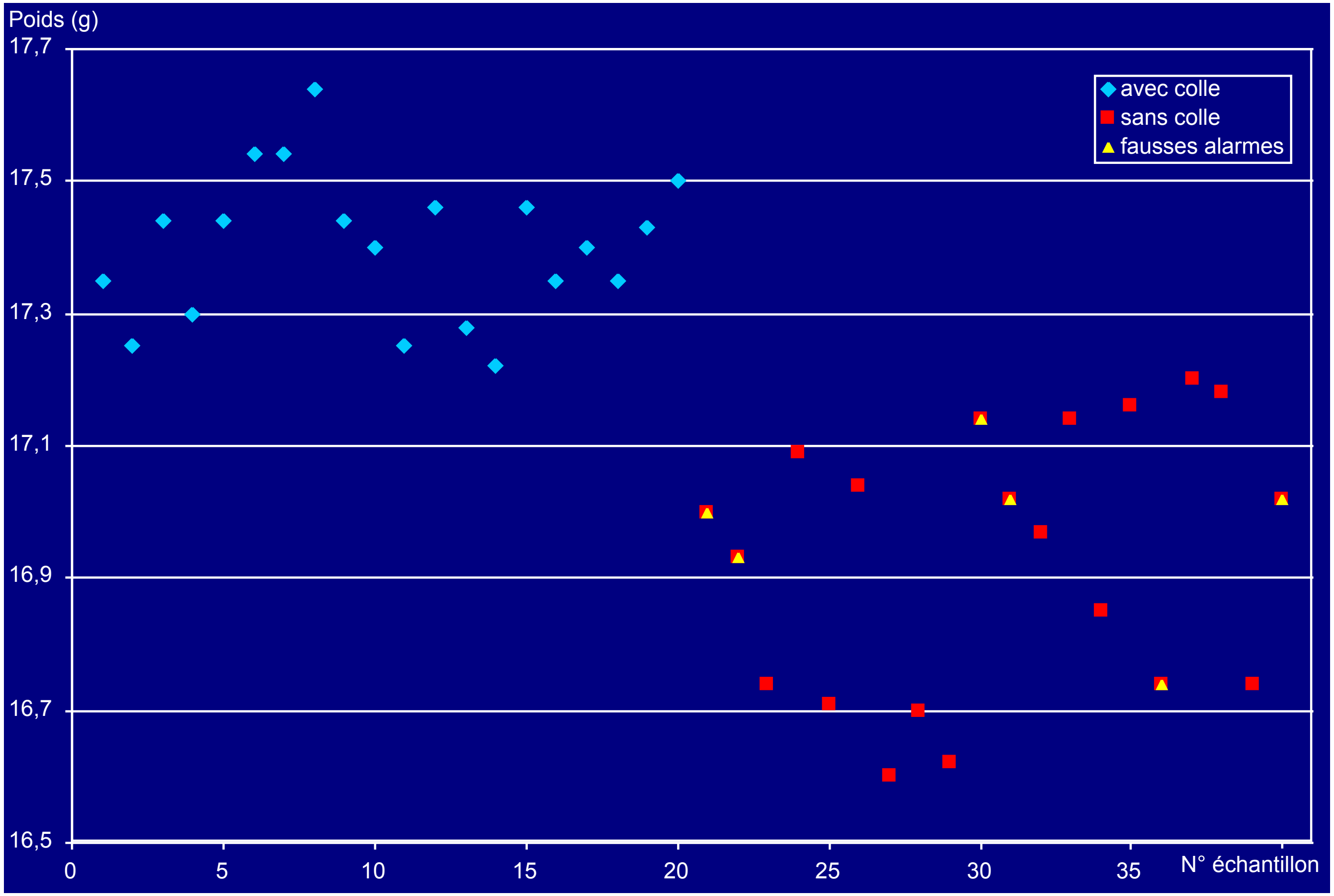
$$\boxed{t \sim z^2/\alpha}$$





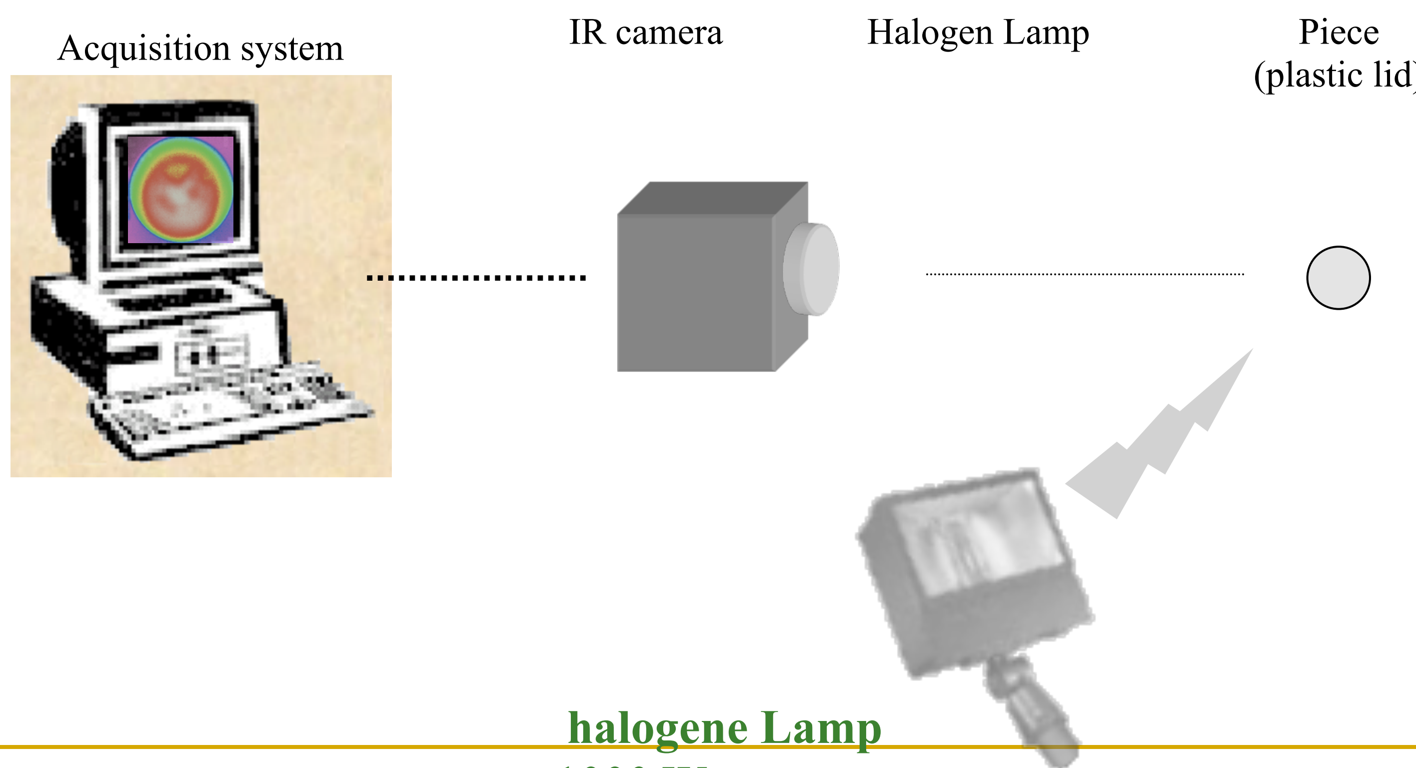



HR

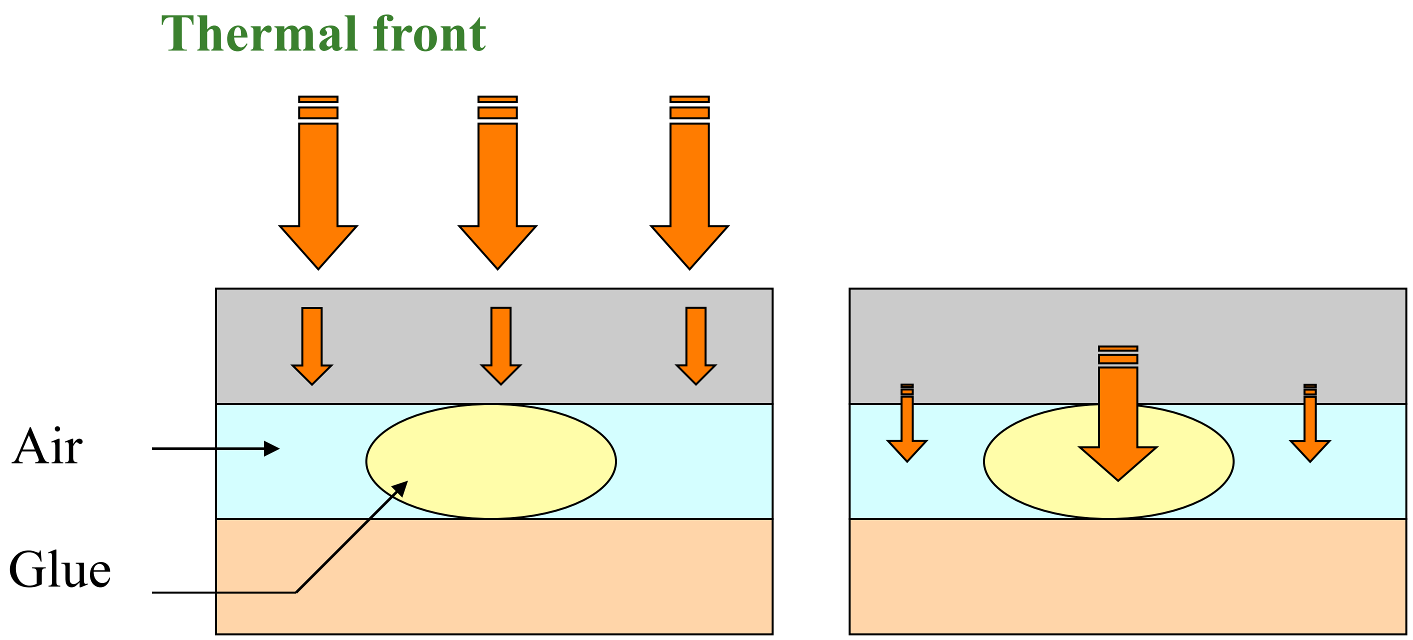


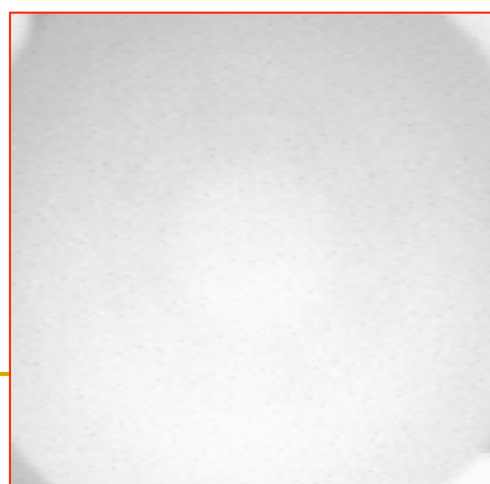
Poids (g)
17,7
17,5
17,3
17,1
16,9
16,7
16,5
0
5
10
15
20
25
30
35
N° échantillon
avec colle
sans colle
fausses alarmes

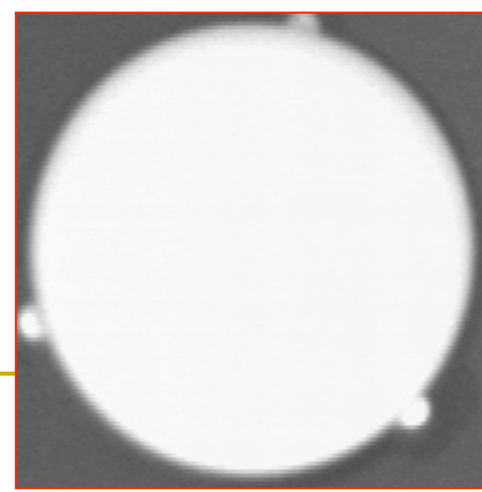
Infrared cameras - ElectroPhysics
3-14µm - 320*240 pixels
Pyroelectric BST Uncooled FPA
objective : 50 mm - 3-5µm
distance lid - camera : 50 cm

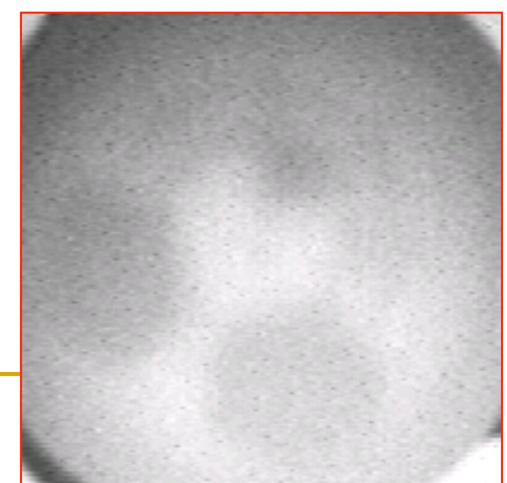


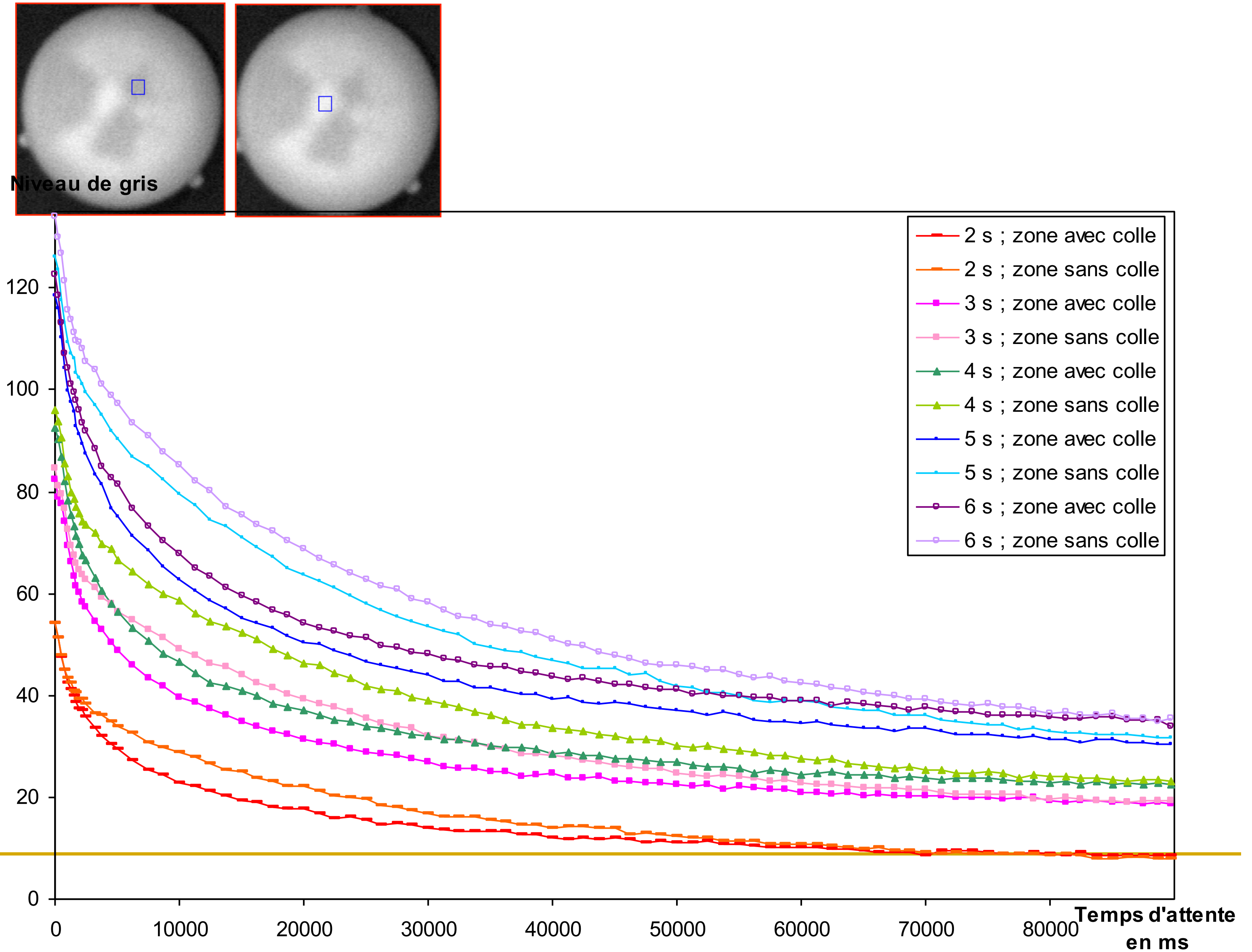
halogene Lamp
1000 W
Distance Lid - Lampe : 12cm


Thermal front
Air
Glue

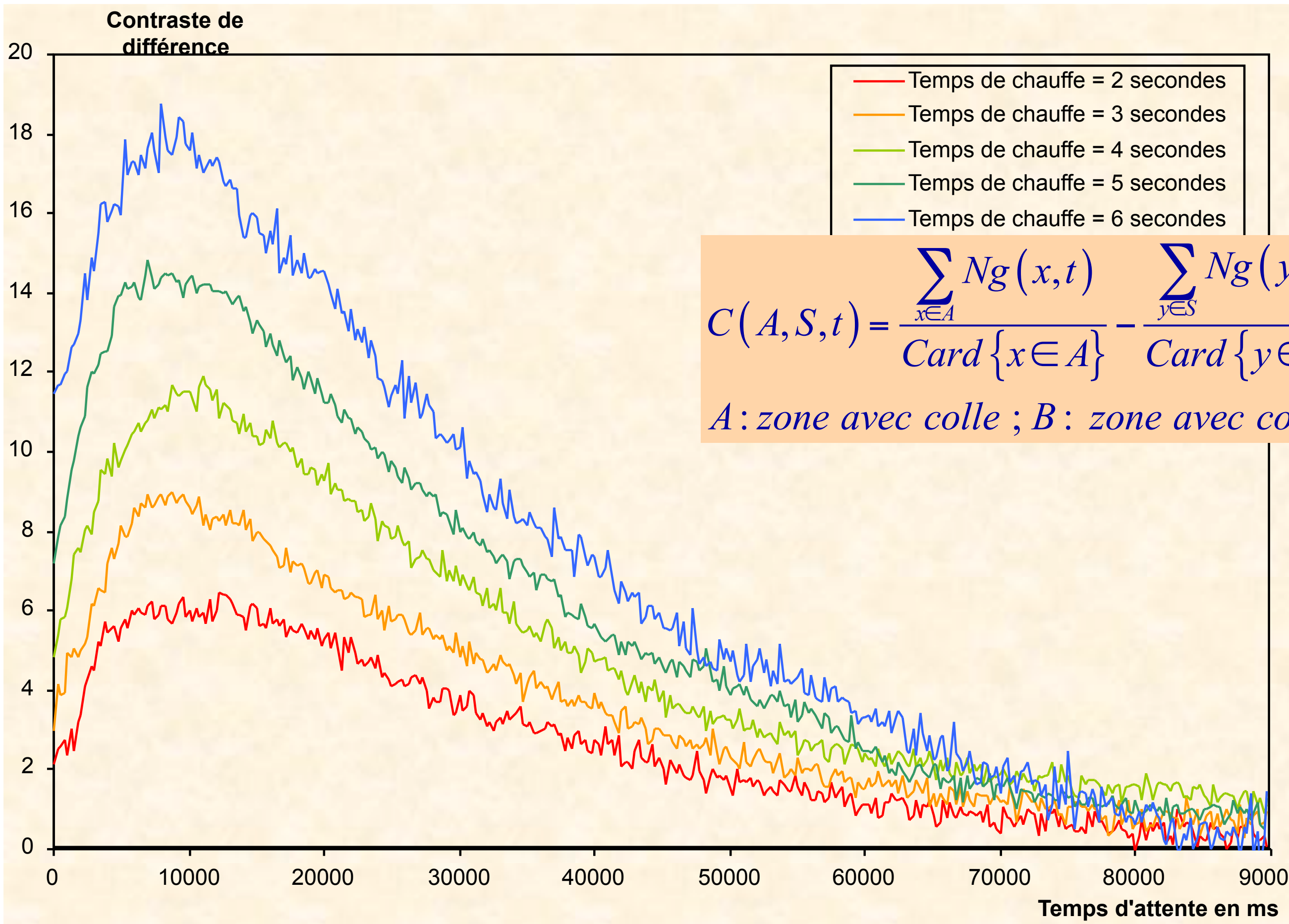








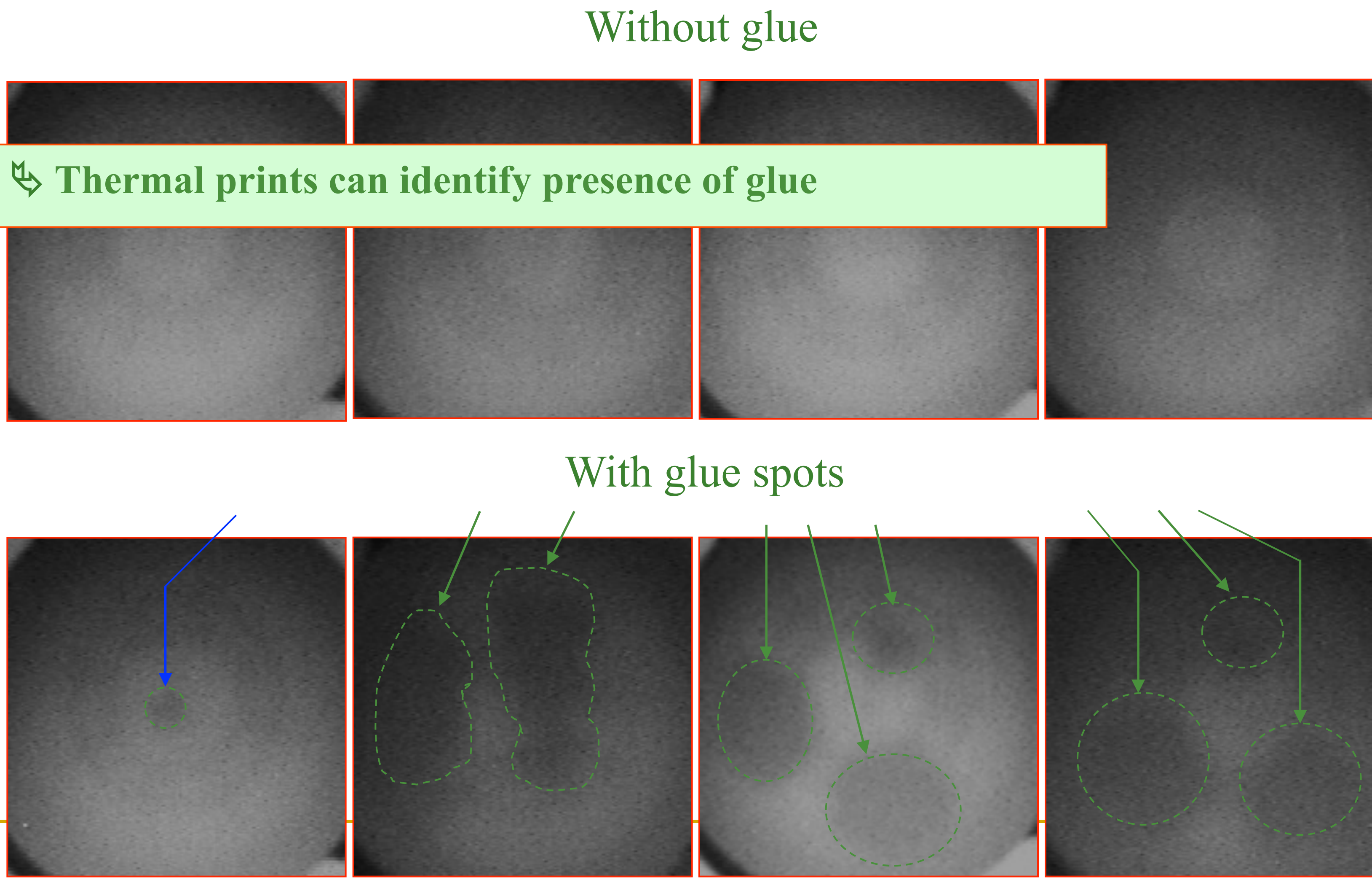
Niveau de gris
120
100
80
60
40
20
0
0
10000
20000
30000
40000
50000
60000
70000
80000
Temps d'attente en ms
2 s ; zone avec colle
2 s ; zone sans colle
3 s ; zone avec colle
3 s ; zone sans colle
4 s ; zone avec colle
4 s ; zone sans colle
5 s ; zone avec colle
5 s ; zone sans colle
6 s ; zone avec colle
6 s ; zone sans colle



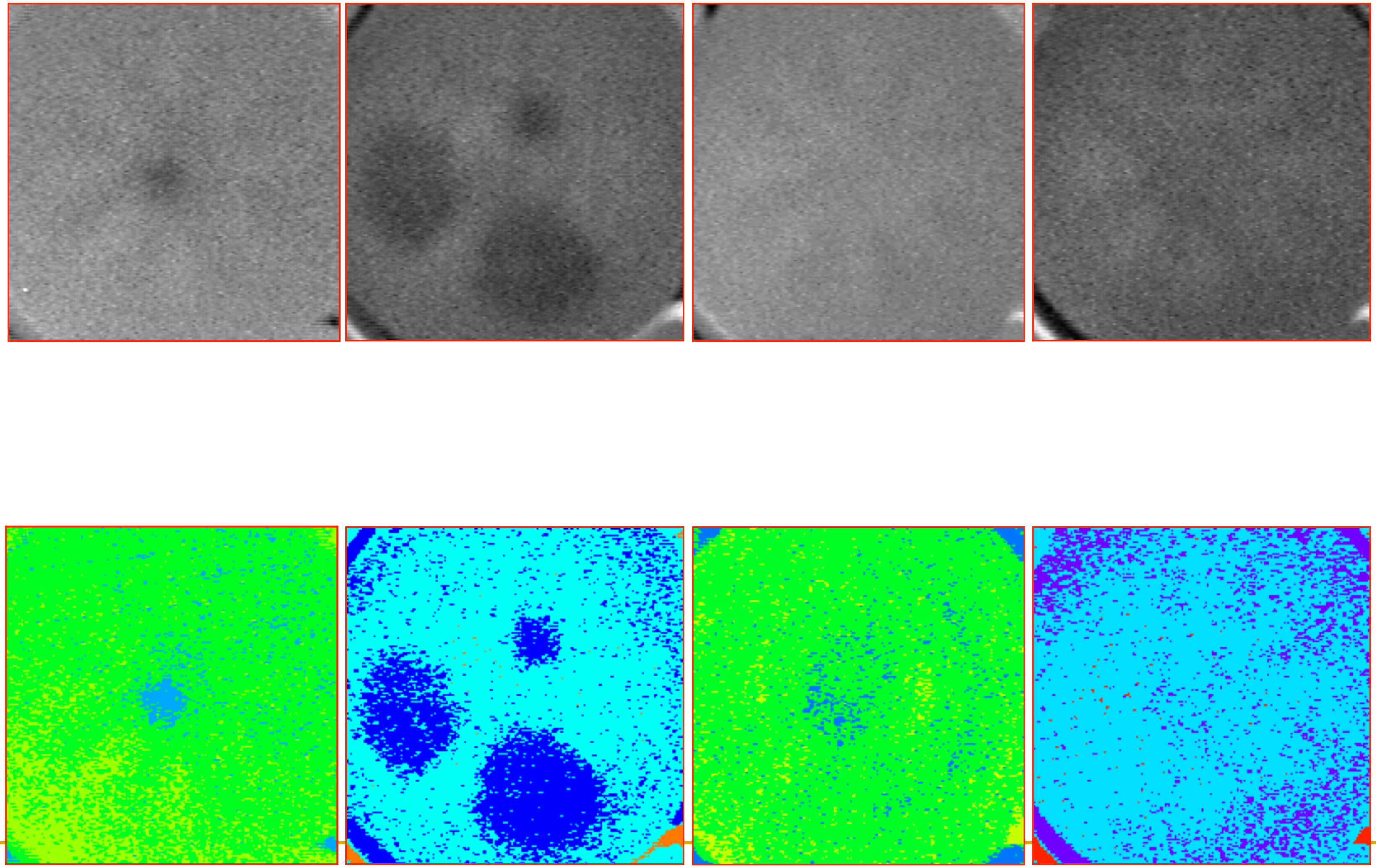
$$C\left(A,S,t\right)=\frac{\sum_{x\in A} Ng\left(x,t\right)}{Card\left\{x\in A\right\}}-\frac{\sum_{y\in S} Ng\left(y,t\right)}{Card\left\{y\in S\right\}}$$

$A : zone\ avec\ colle\ ;\ B :\ zone\ avec\ colle$

Thermal images



Thermal prints can identify presence of glue



Active – Thermography

Principles

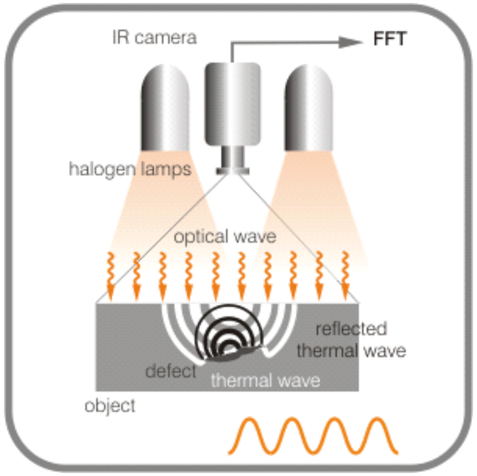
Pulse Thermography

Lock-In Thermography

Pulse-Phase Thermography

Derivative technics

Lock-in principle:



The principle of **lock-in thermography** consists of introducing periodically modulated heat into an object and monitoring only the periodic surface temperature modulation phase-referred to the modulated heat supply. Hence, if the surface temperature is measured via an infrared (IR) thermocamera, lock-in thermography means that the information of each pixel of the image is processed as if it were fed into a Lock in amplifier.

Benefits of Lockin Thermography

1. Non contact
   - On large structure
   - On small objects down to 1mm

2. Full field
   - Complex structures

3. Easy to use
   - Real components
   - Sine load
   - Random loading

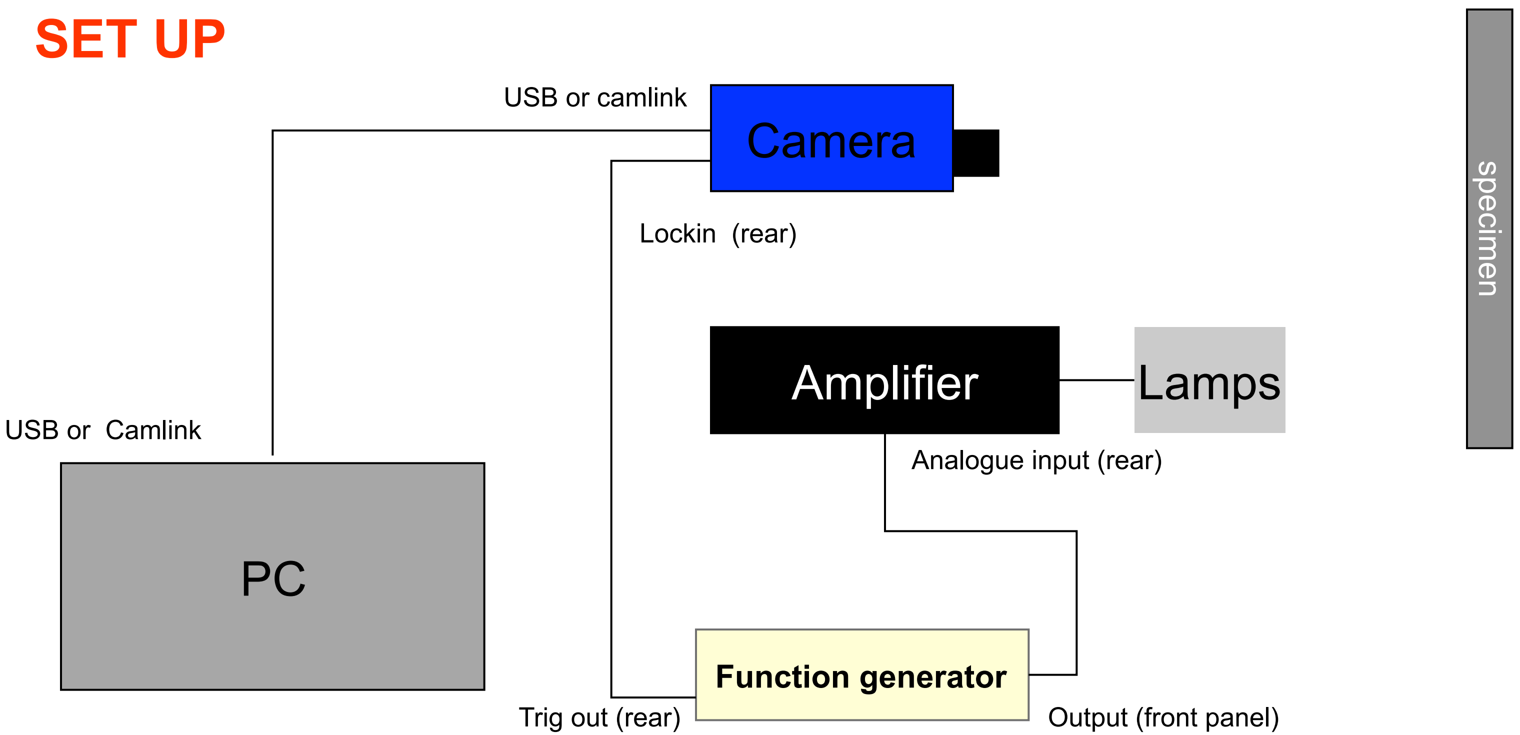
4. Fast to set up
   - black paint on metal. No paint on composites

5. Wide spectral range
   - up to 20kHz

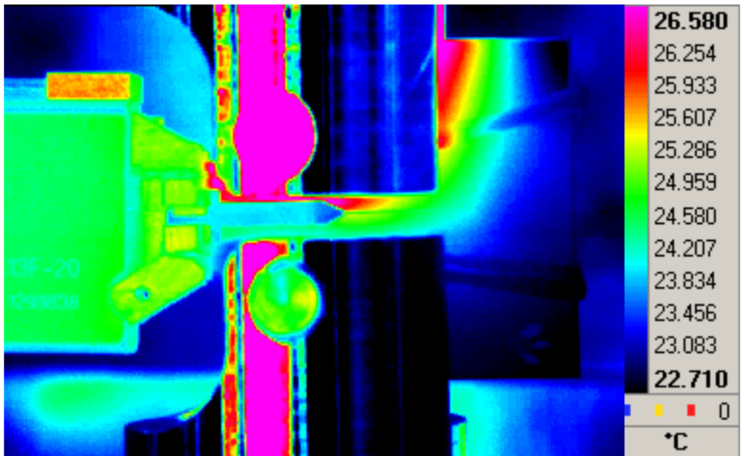
6. Energy measurement
   - Plastic and dissipated energy

NDT Lockin Thermography

- **SET UP**



Example : Stress analysis fracture mechanics

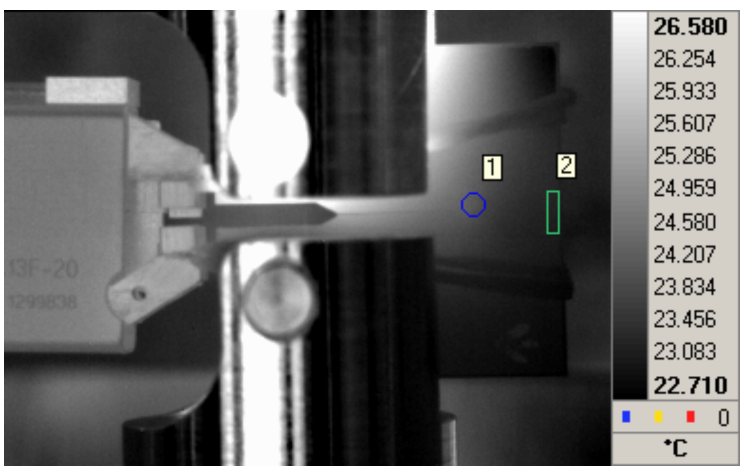


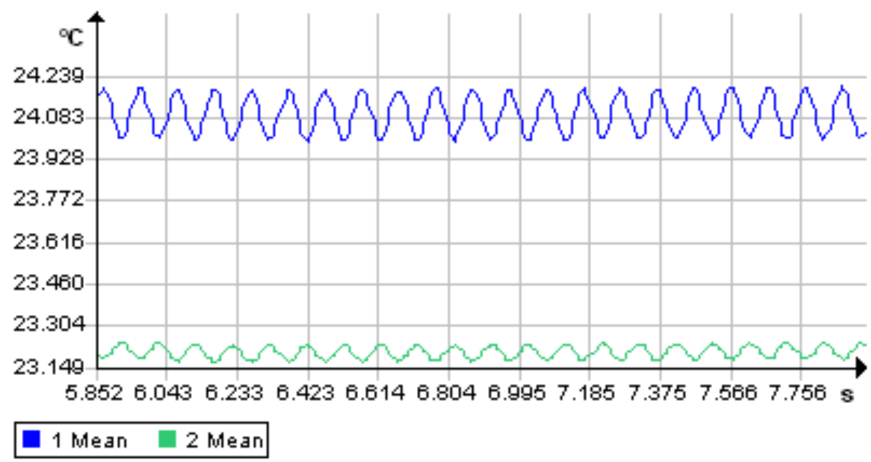
Thermal image movie (Colors)

Load Frequency 10 Hz.

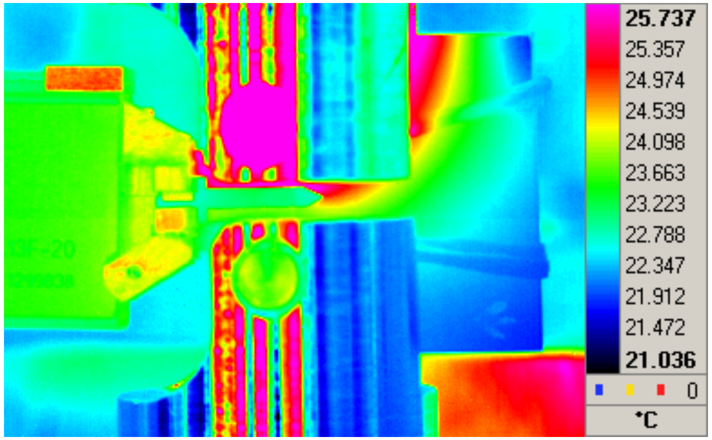
The lines in data graph show time history of the image's in the B&W image.

Note that camera is calibrated in absolute temperature, and shows small amplitude temperature swings of 100 mK and 45mK.

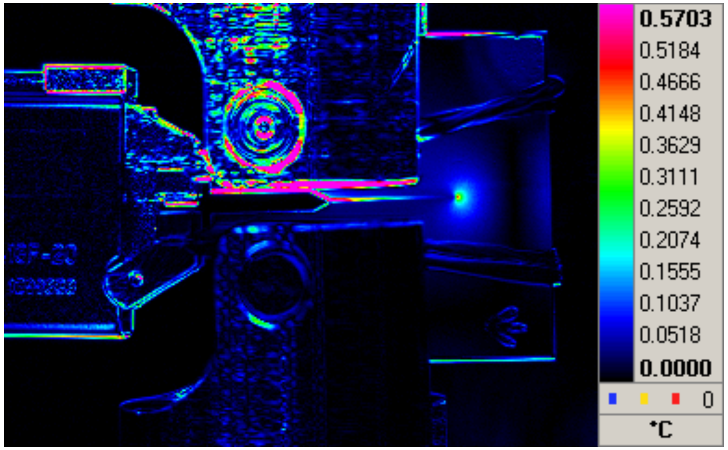




Thermal image (B&W)

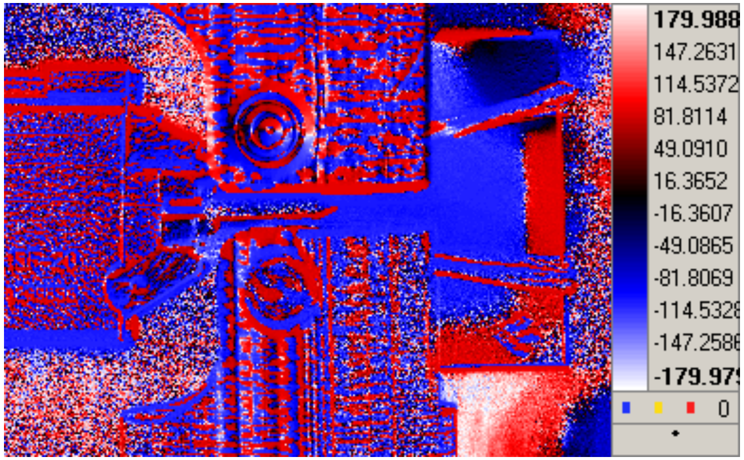


Thermal image



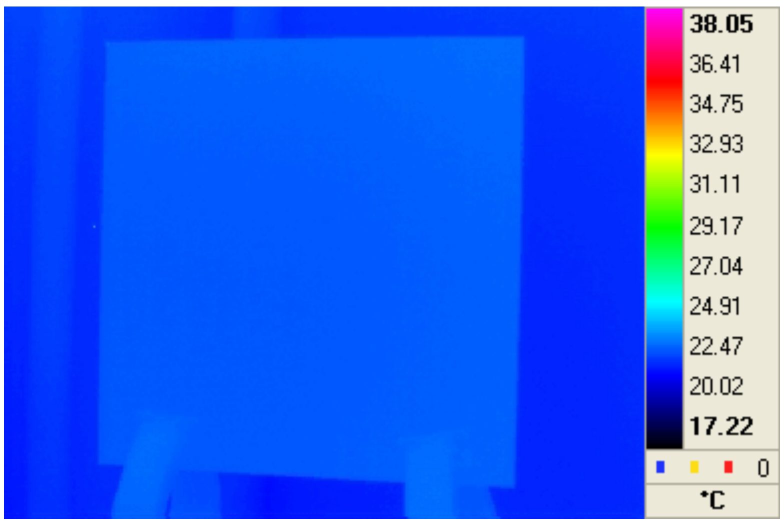
Map of amplitude in °C

Frame rate	:	140Hz Full-frame
Frame accumulation:		1000 frames
Processing Time	:	7 seconds
Lockin Frequency	:	10 Hz



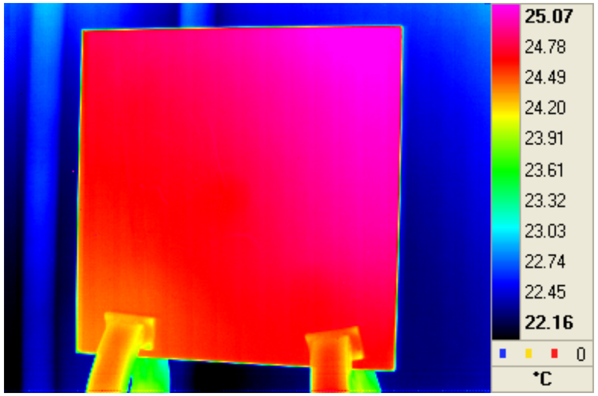
Map of phase in degrees

Lockin Thermography test

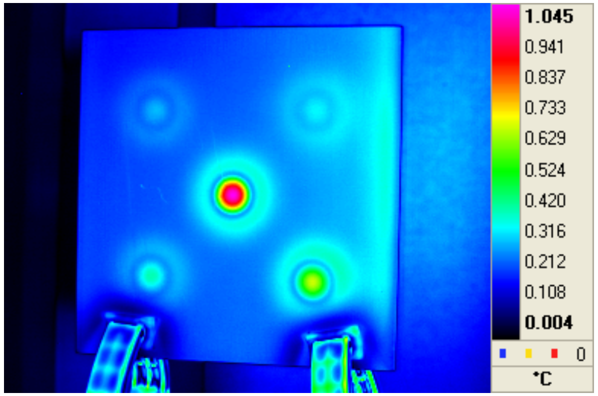


m:

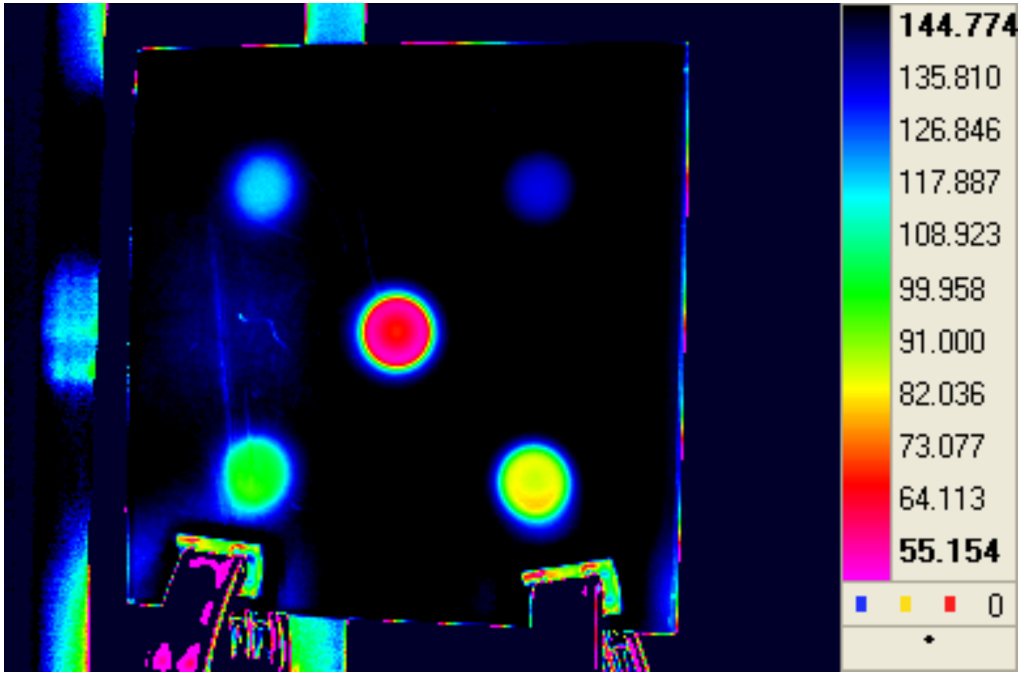
Results - LIT



Average image during the test

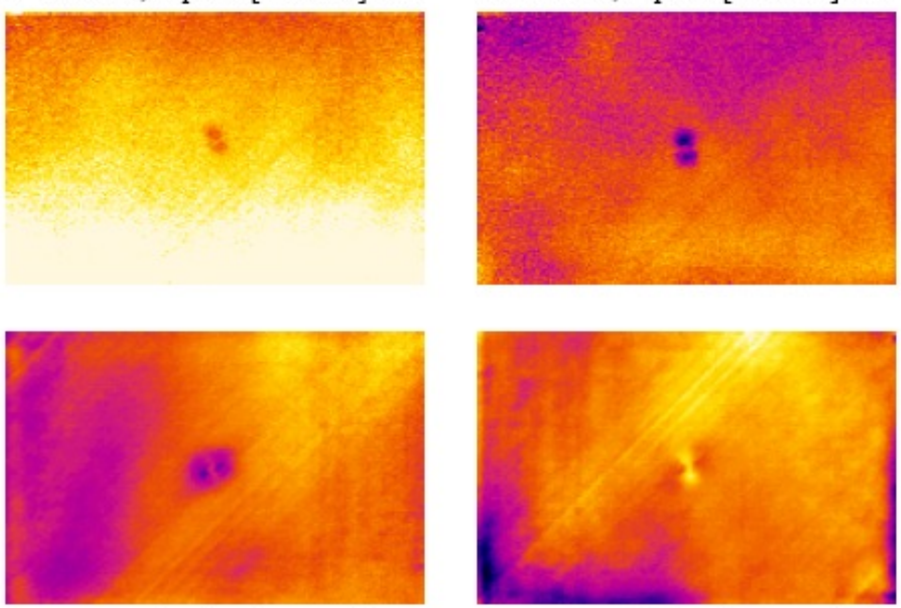


Magnitude image



Phase image

f = 0.94 Hz, depth ~ [0.3 - 0.7] mm f = 0.47 Hz, depth ~ [0.7 - 0.9] mm



f = 0.12 Hz, depth ~ [0.9 - 1.4] mm f = 0.06 Hz, depth ~ [1.4 - 1.5] mm

Active – Thermography

Principles

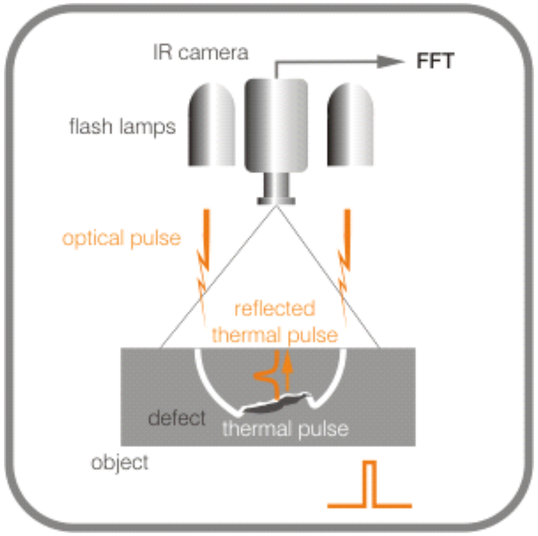
Pulse Thermography

Steap Heating Thermography

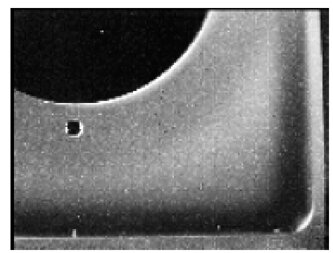
Lock-In Thermography

Pulse-Phase Thermography

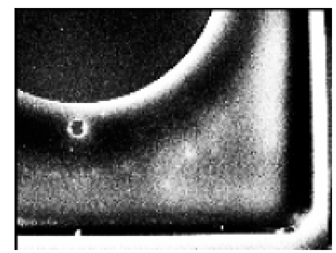
Derivative technics

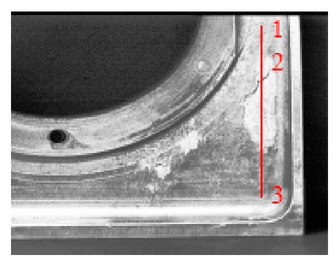


maximum thermal contrast image

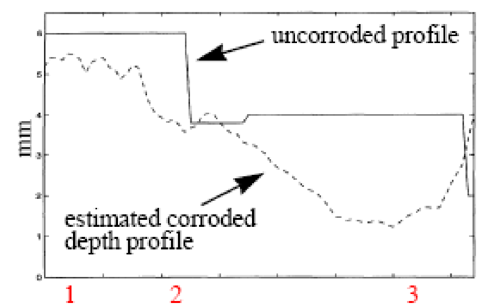


PPT phase image (f = 0.89 Hz)





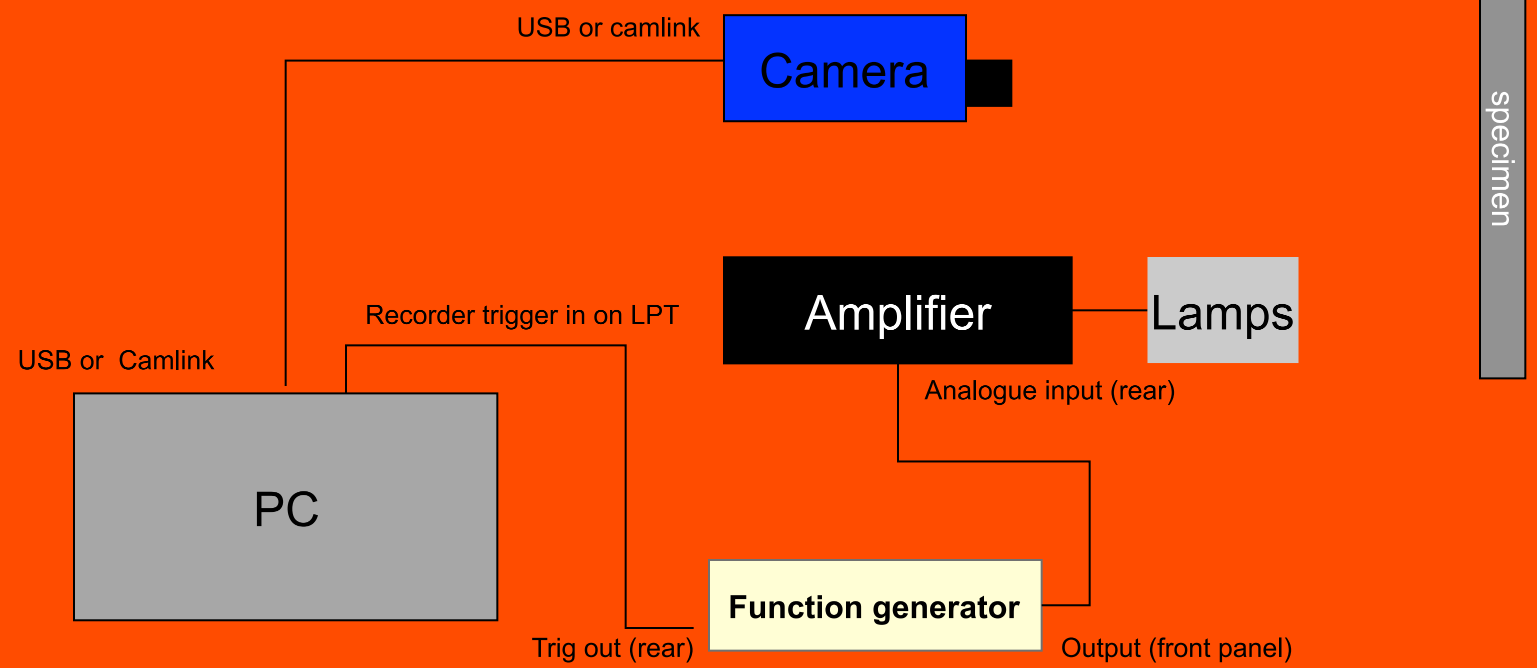
visible picture of rear face
of aircraft component

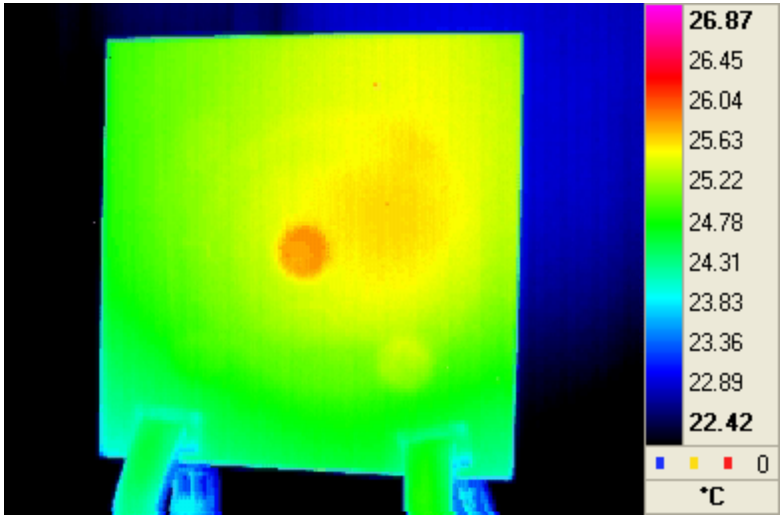


retrived depth profile from PPT phase image

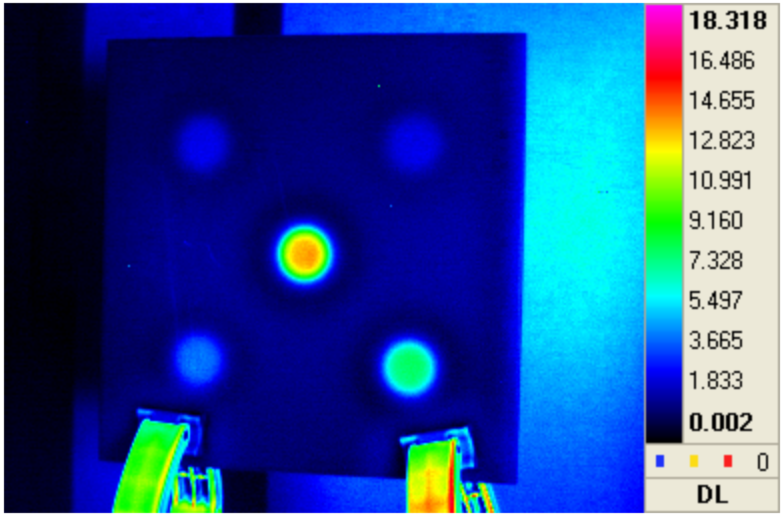
NDT Phase Pulse Thermography

- SET UP

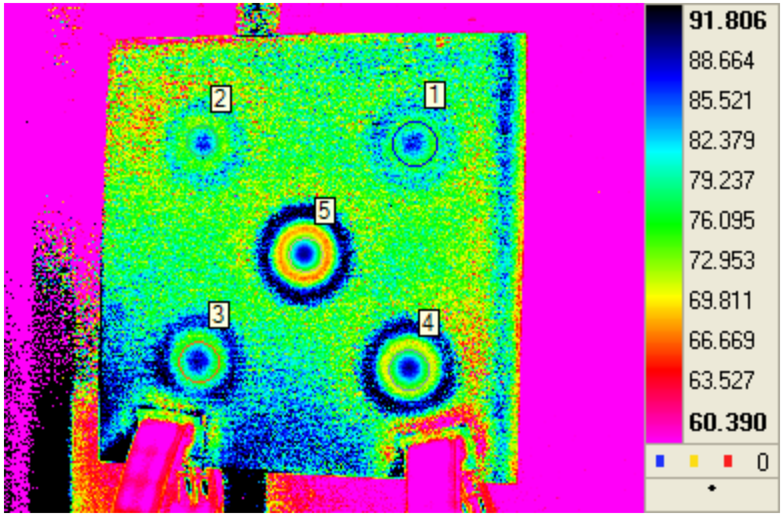



26.87
26.45
26.04
25.63
25.22
24.78
24.31
23.83
23.36
22.89
22.42
0
°C


SILVER



Magnitude image

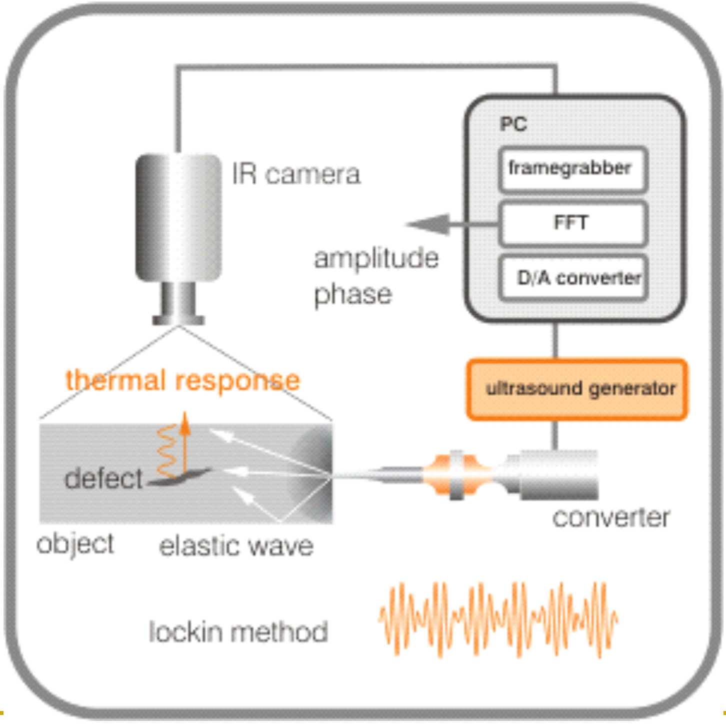


Phase image

Frequency : 0.087

Steel plate thickness

VIbrothermography (VT)



Areas of active thermography

Electronics, Electricity and microelectronics.

Mechanics

Plastic industry

Automotive industry

Aeronautics

Medical diagnosis

Biology

Habitat industry, architectural surfaces and material evaluation, road inspection

Food industry:

predictive maintenance in the newspaper industry petroleum facility

Chemistry industry : inspection of tank and vessels.

Arts : paintings, cultural heritage conservation, frescoes.

Textile, paper industry, pharmacetics, wood industry , cosmetics