INSPECTION OF CFRP USING ACTIVE THERMOGRAPHY – STATE OF THE ART AND CHALLENGES

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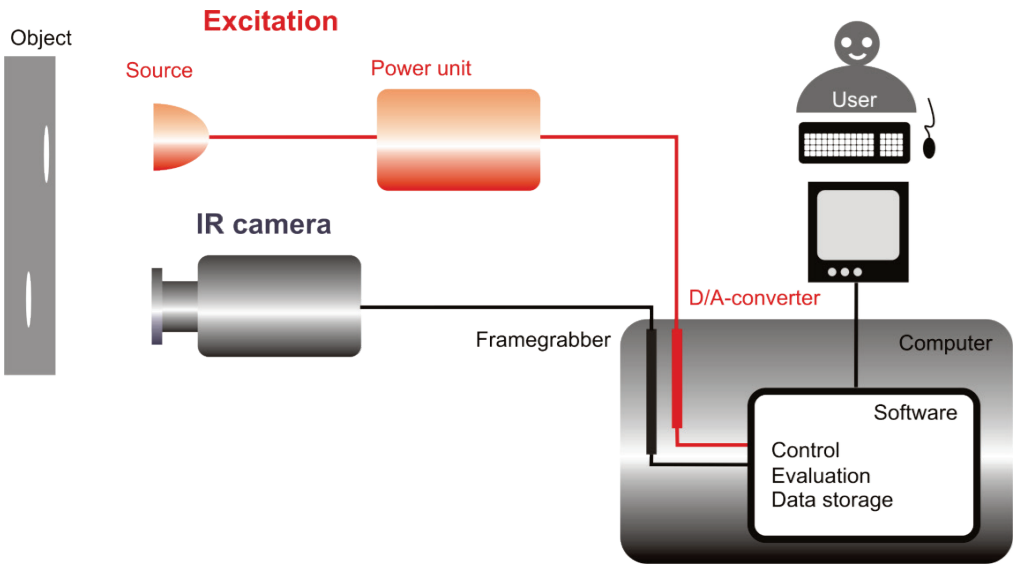
OUTLINE

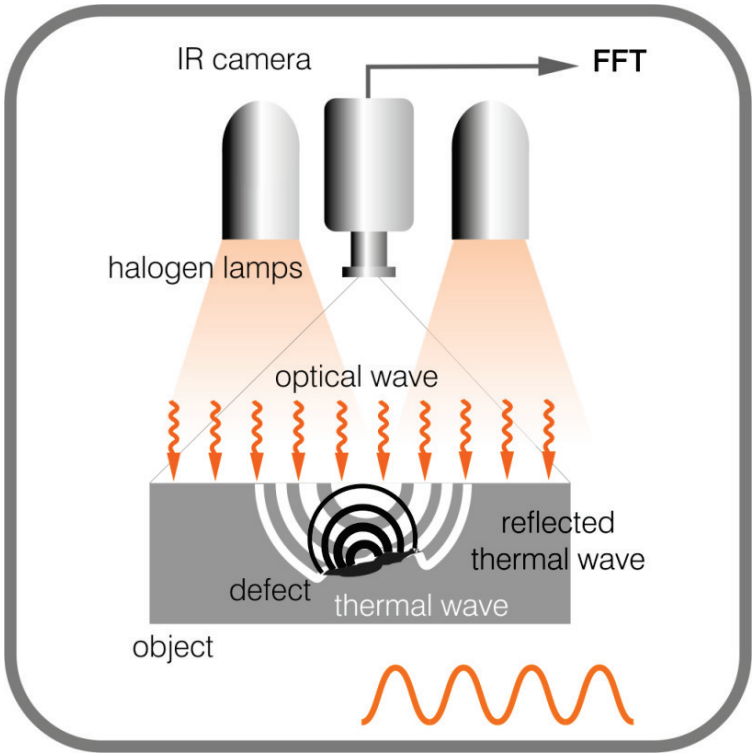
- What is Active Thermography?
- Properties of Optically Excited Thermography
- Applications in Manufacturing and Maintenance of CFRP components

ACTIVE THERMOGRAPHY



Using excitation sources in combination with infrared thermography is called “Active Thermography”

OPTICALLY EXCITED LOCKIN THERMOGRAPHY (OLT)



OPTICALLY EXCITED LOCK-IN THERMOGRAPHY

DEPTH RESOLVED MEASUREMENTS

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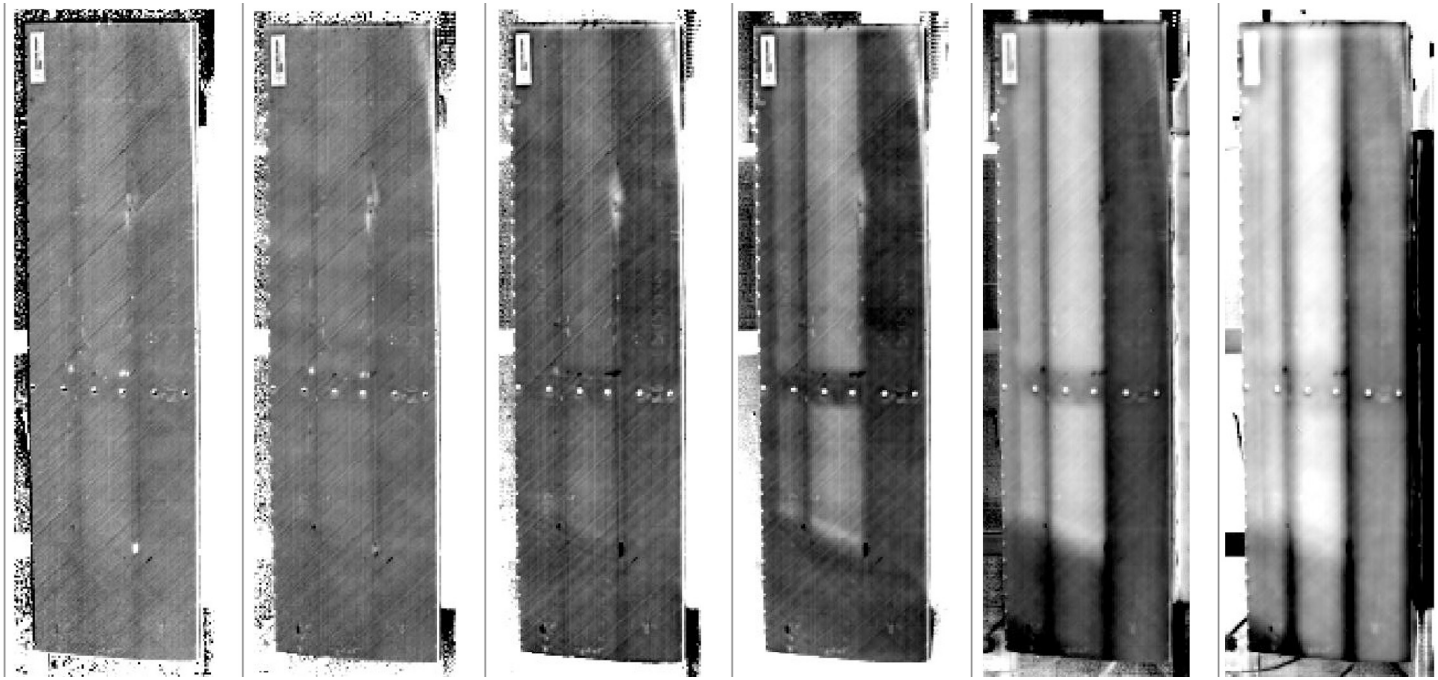
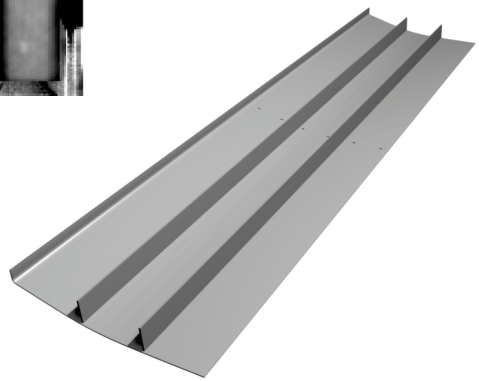
Landing flap measured at different modulation frequencies



decreasing modulation frequency



decreasing lockin frequency → increasing thermal diffusion length

PROPERTIES

Advantages

- Depth resolved measurement
- Non-contact
- one-sided access
- Fast
- Robust
- Independent of inhomogeneous heating
- Inspection of complex structures

Limitations

- Limited depth range, approx. up to 5 mm in CFRP
- Lateral resolution strongly deteriorates for larger depths
- Cracks perpendicular to the surface are usually not detectable
- Kissing bonds are usually not detectable
- Disbonds between honeycomb and skin are usually not detectable

OPTICALLY EXCITED LOCK-IN THERMOGRAPHY

TESTING OF LARGE STRUCTURES

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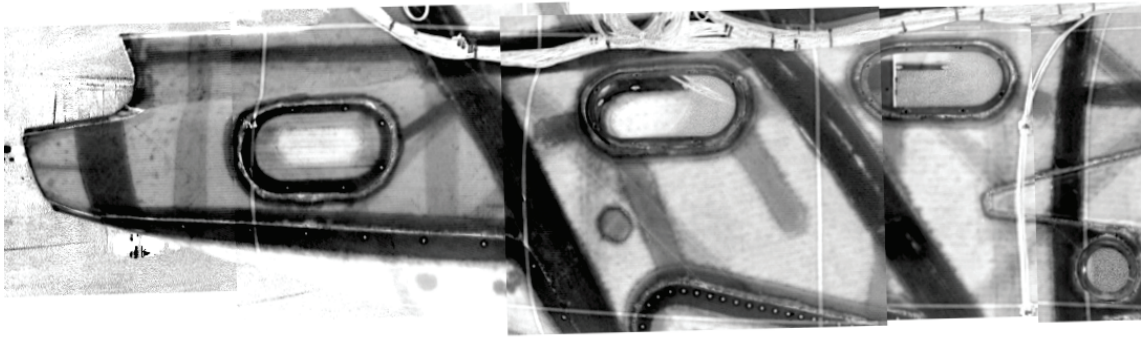

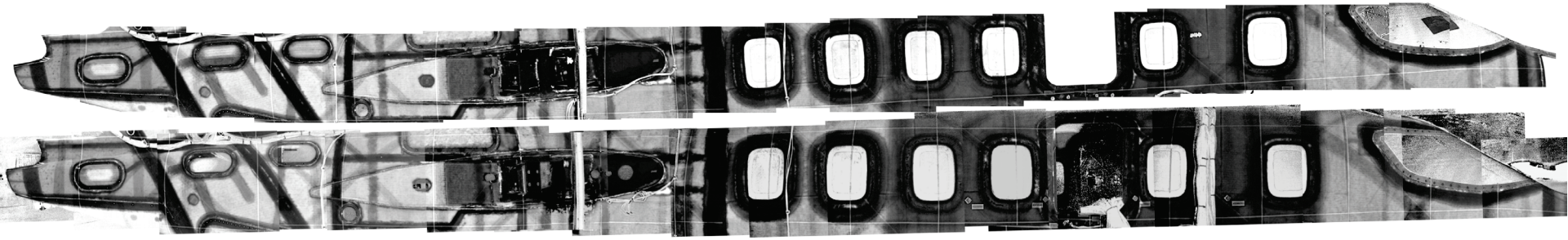

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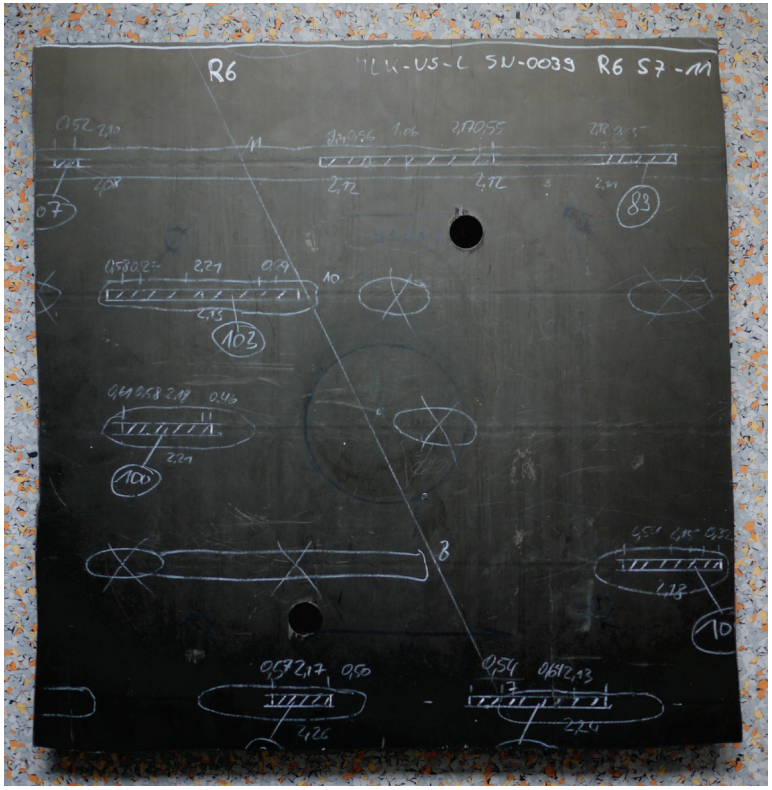
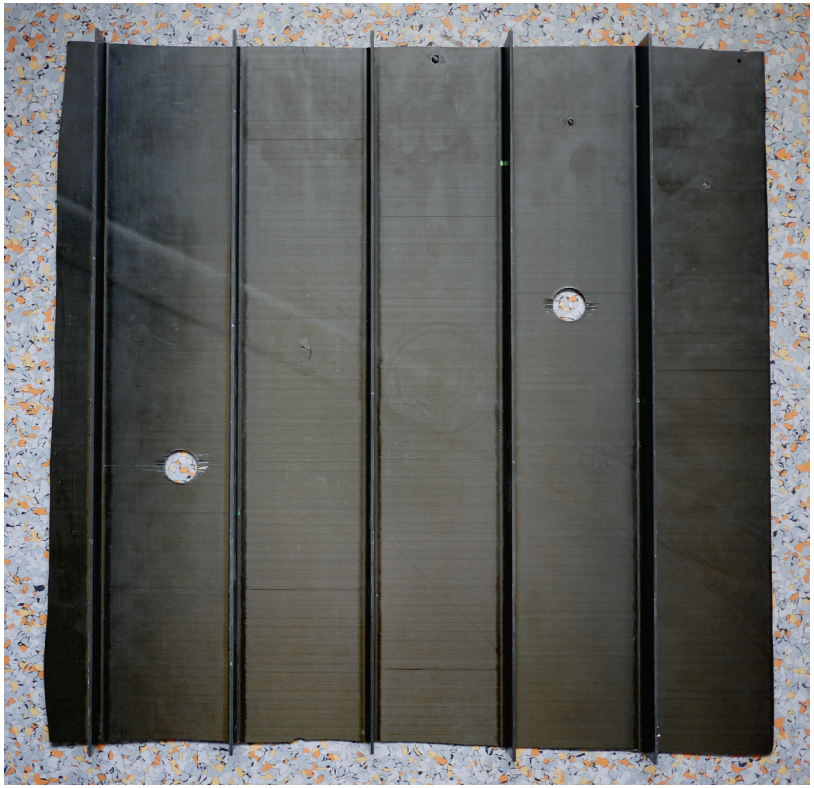
DETECTION OF SURFACE-NEAR VOIDS

Tested object:
Stringer-reinforced CFRP panel with hidden voids and porosity



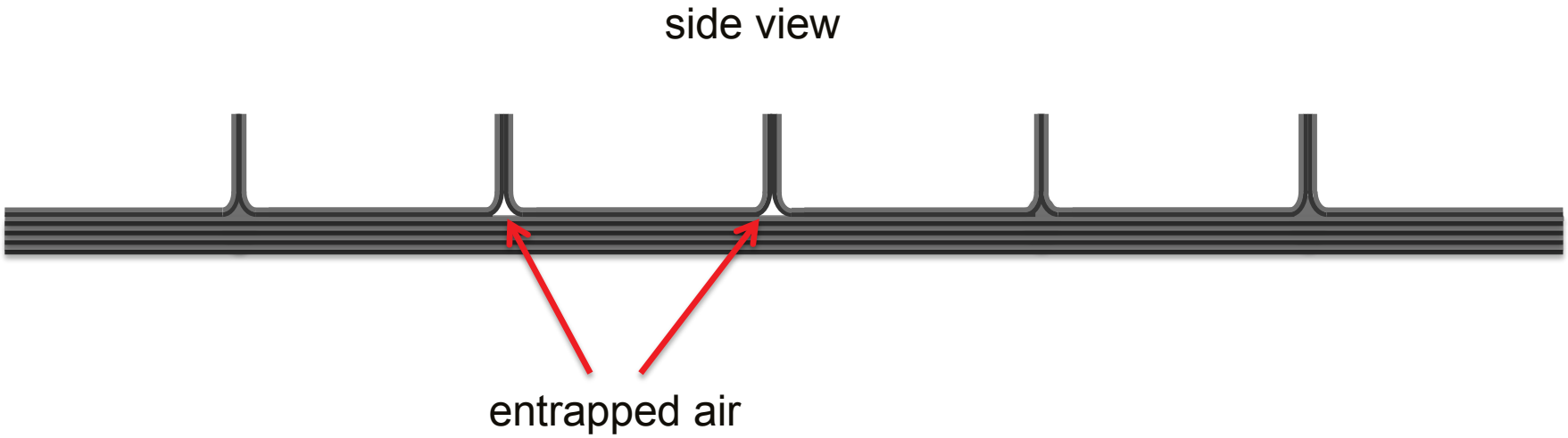
Front side



Back side

DETECTION OF SURFACE-NEAR VOIDS

Tested object:
Stringer-reinforced CFRP panel with hidden voids and porosity



OPTICALLY EXCITED THERMOGRAPHY

DETECTION OF SURFACE-NEAR VOIDS

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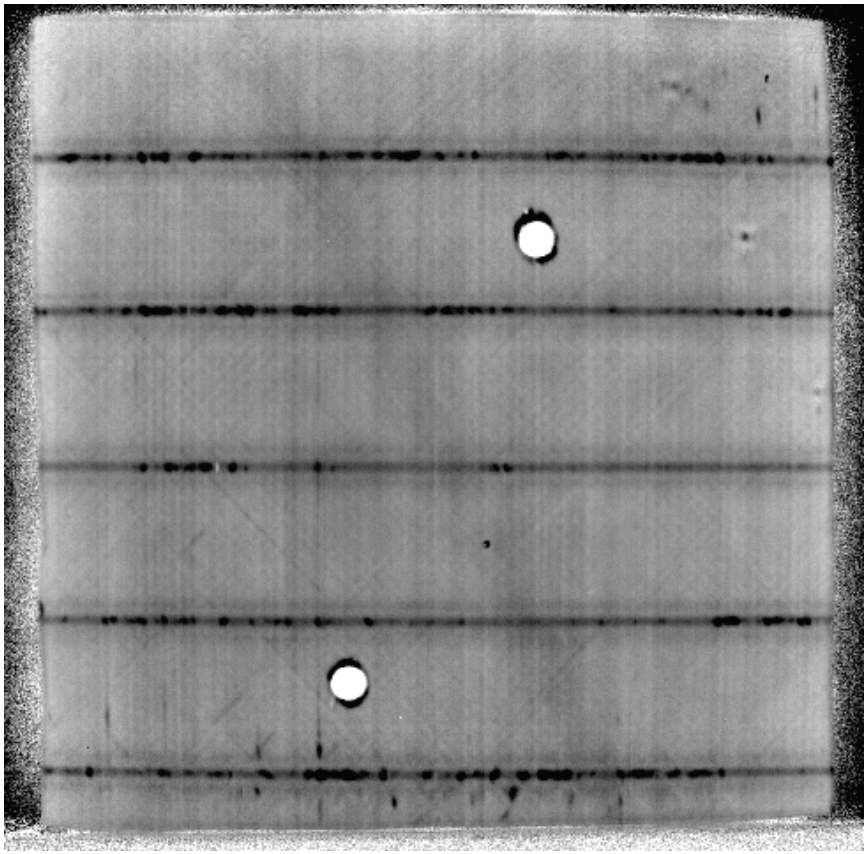
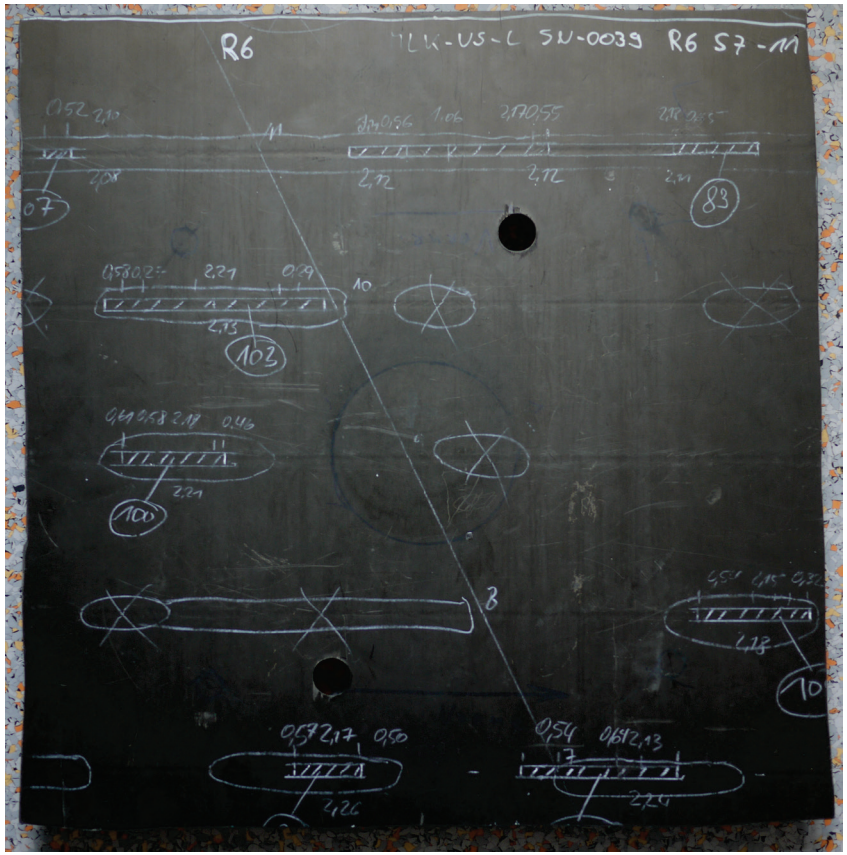
Thermography



Manual ultrasound testing



OPTICALLY EXCITED THERMOGRAPHY

IMPACT DETECTION

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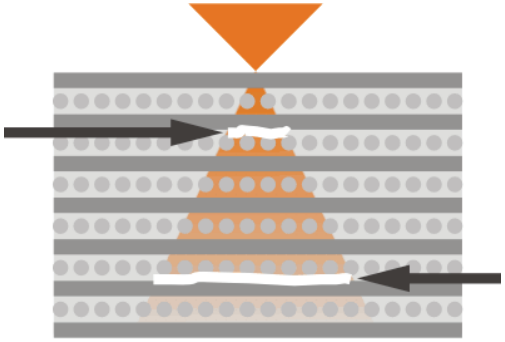

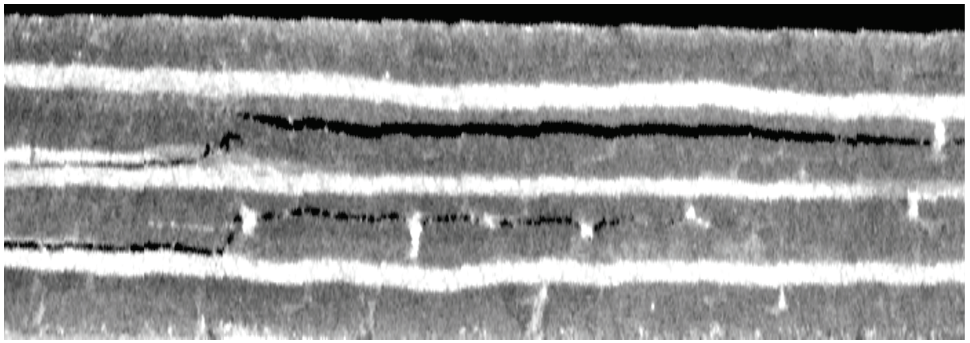

OPTICALLY EXCITED THERMOGRAPHY

IMPACT DETECTION AT TAIL ROTOR AXLES

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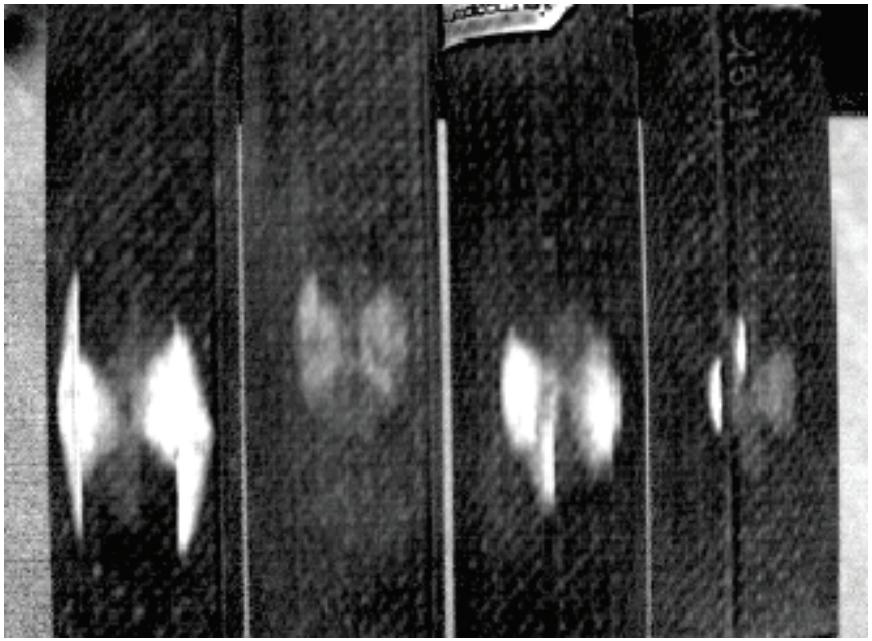
CFRP tubes at different impact energies

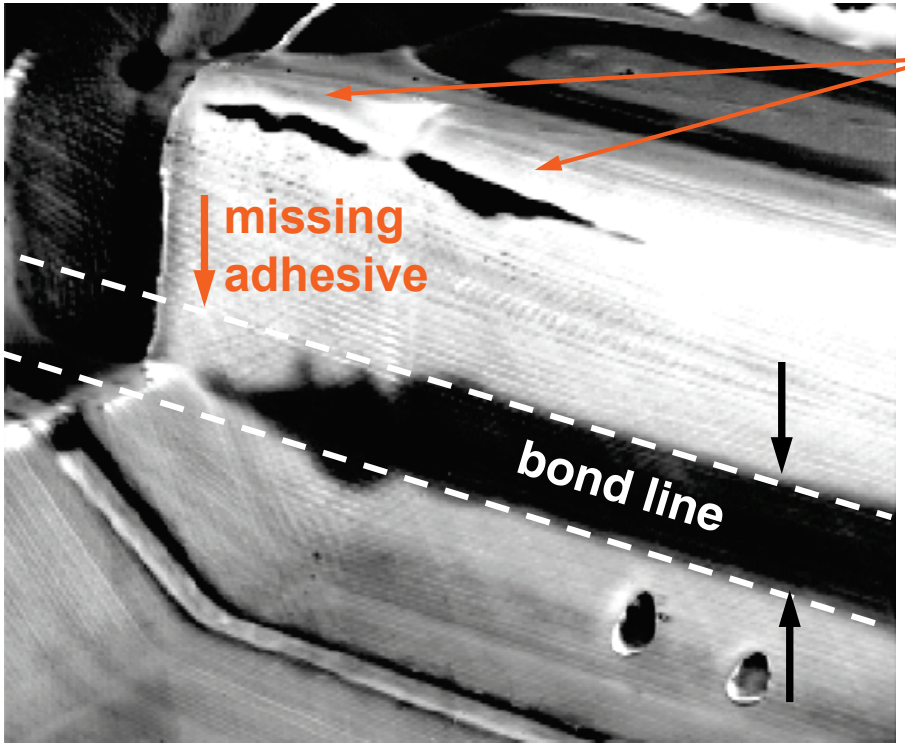
Samples of EADS - Eurocopter

lock-in thermography phase image



OPTICALLY EXCITED THERMOGRAPHY

TESTING OF ADHESIVE JOINTS

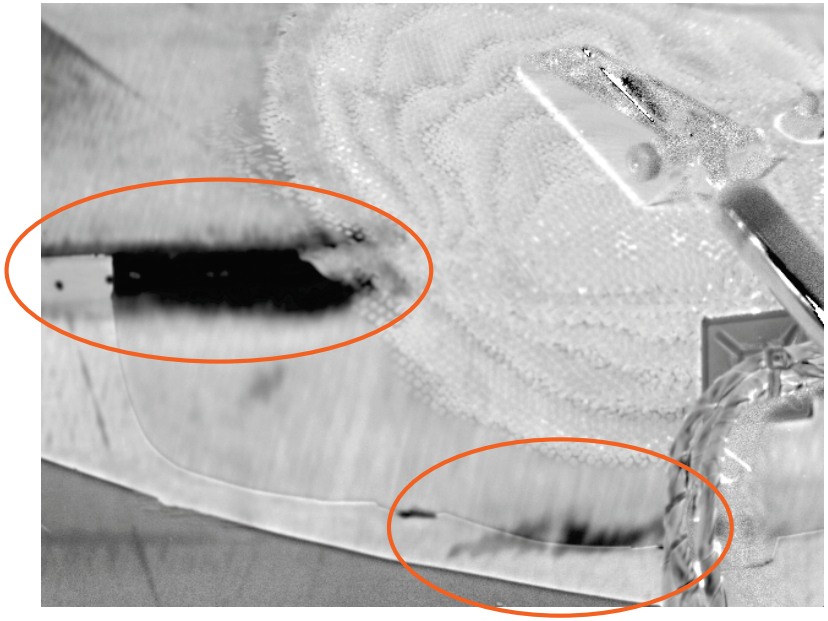


dry fibers – absence of resin

CFRP car body (foot space)
OLT Phase image at 0.01 Hz

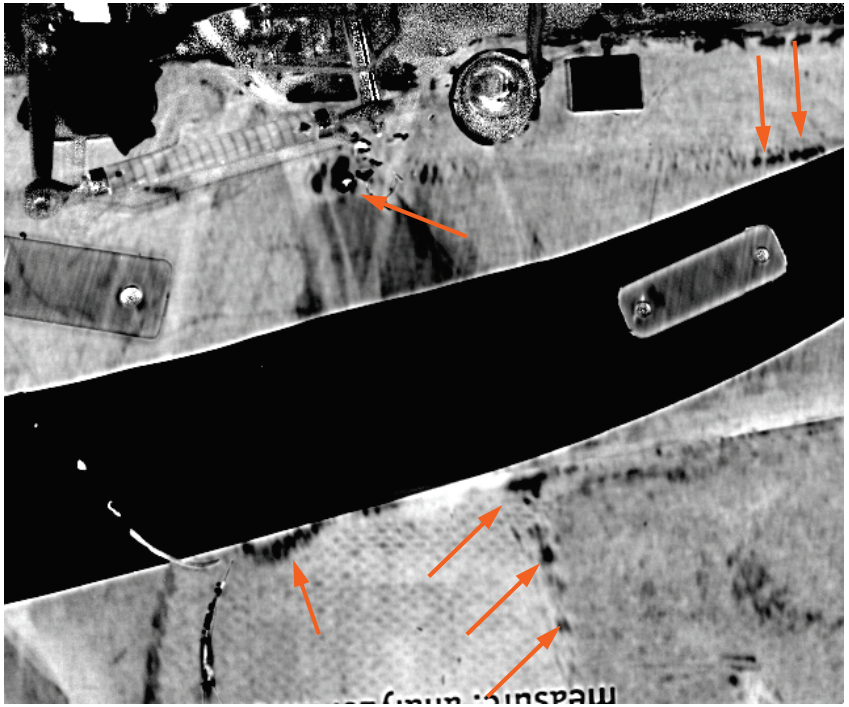
MONOCOQUES TESTING

VOIDS AND POROSITIES



wheel suspension area

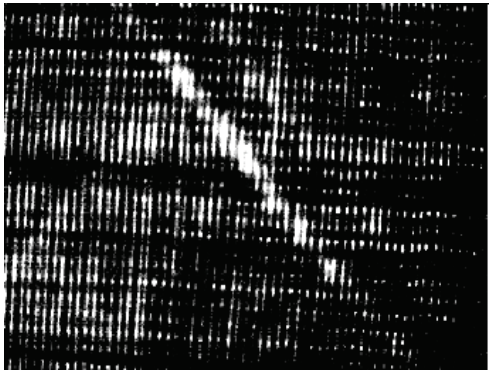
monocoque, side view



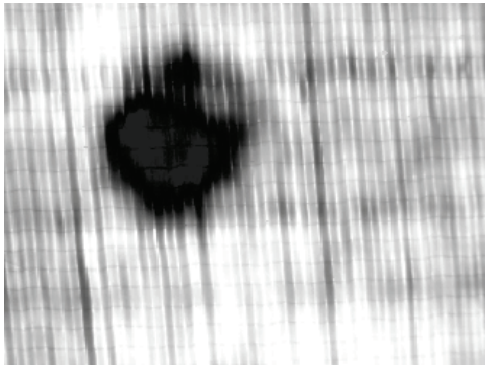
OPTICALLY EXCITED THERMOGRAPHY

CHARACTERIZATION OF CARBON FIBER PREFORMS

Carbon fibre preforms are made of
Stitch bonded fabrics
(multi-axial interlaid complexe of non crimped fabrics (NCF))



Detection of a gap (missing roving in the – 45° direction)



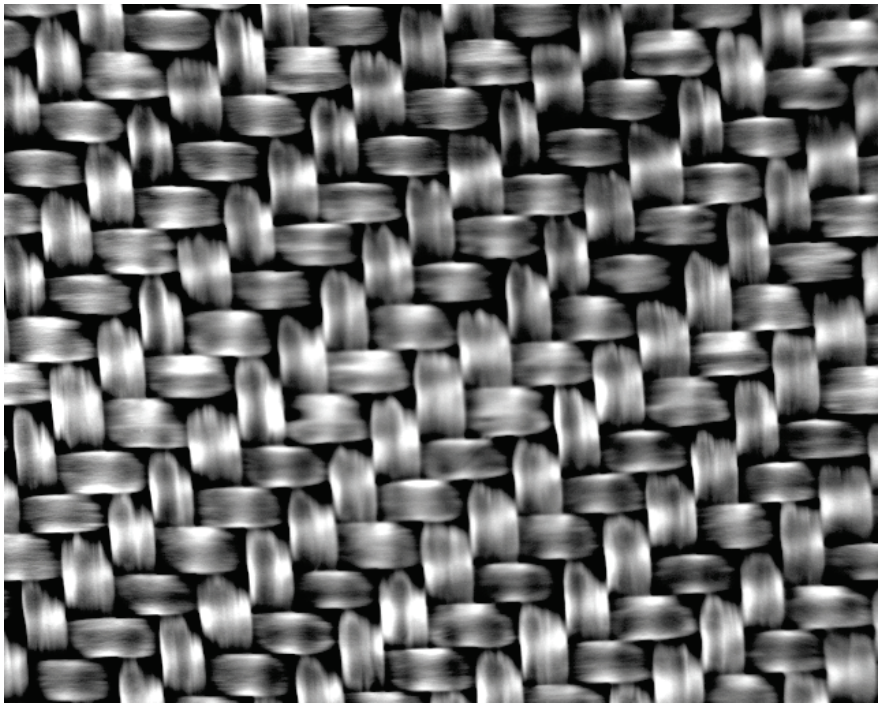
Detection of stitched fuzz ball

OLT Phase signatures at 0.1 Hz

OPTICALLY EXCITED THERMOGRAPHY

FIBER ORIENTATION MEASUREMENTS (FIRST PLY)

Fiber orientation hardly detectable in the visible region of the spectrum



Very good contrast in the infrared

CONCLUSIONS

- Optically excited thermography is applicable to a wide range of applications
- The method is limited in its depth range but very sensitive near the surface
- CFRP components can be tested during manufacturing and maintenance
- Applications range from testing of inserts, characterization of repaired areas, testing of fiber preforms, thickness measurements, detection of voids, detection of dry areas, detection of undulation, testing of fiber preforms, etc.

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THANKS FOR LISTENING!

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