

Pulsed & Lock-in Thermography

Dr. Nils A. Reinke (CTO)

Advantages of Coating Control

Increase
Profit



- Response to process deviations
- Reduction of running in times
- Efficient utilization of personnel

Eco-
Labels



- Reduction of the coating thickness (10-20%)
- Reduction of the ecological footprint

Prevent
Reliability Claims



- 100% Quality control

[Q&A](#)

CoatMaster ONE

nondestructive and noncontact
testing of coatings

Spezifikationen:

- Thickness: 5 – 500 μ m
- Measurement distance: 0.1 – 15 cm
- Spot-size: 2 mm
- Time of Measurement: 0.1 – 5 s

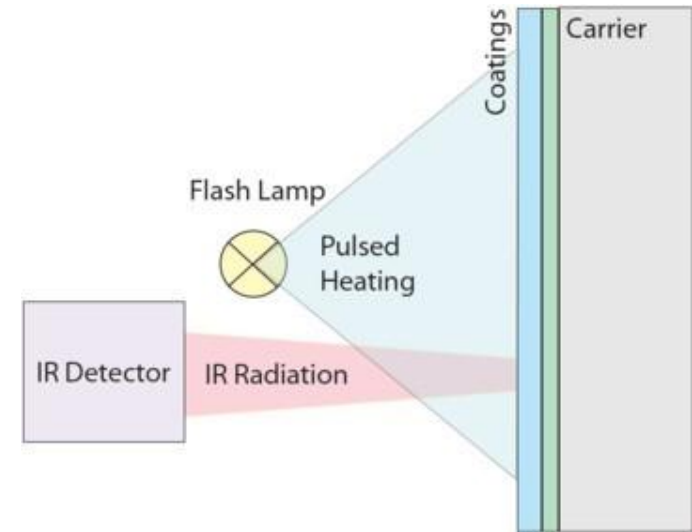


[Q&A](#)

Measurement Principle

- Gentle Heating of the coating
- Measurement of the surface temperature
- Analysis of the measured data by innovative algorithms

Fast, easy to use, nondestructive and noncontact determination of coating parameters



[Q&A](#)

CoatMaster testing turbine blades:
<http://www.youtube.com/watch?v=oK41PamlbjA>

[Q&A](#)

Thickness Measurements

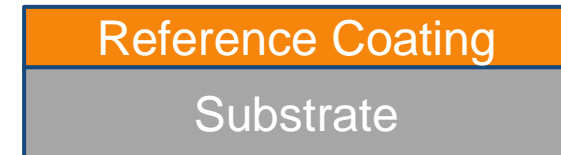
1. Step: Reference Measurement

- Measurement on reference sample
- Save reference measurement

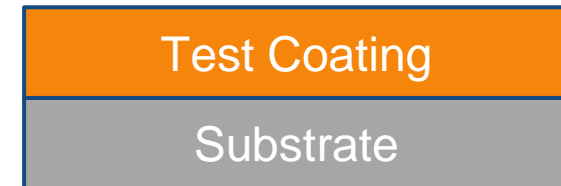
2. Step: Relative Thickness Measurement

- Measurement on test sample
- Relative coating thickness is displayed

No Calibration Needed!



Store Ref. 1

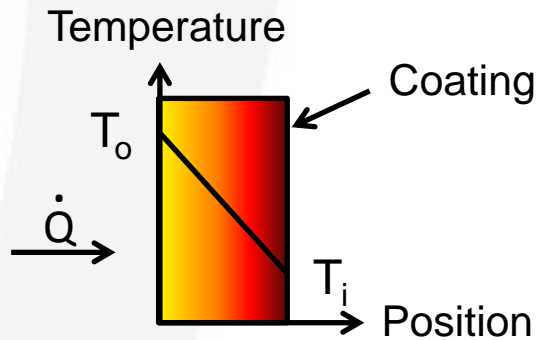


Relative
thickness 137%
(Ref. 1) [Q&A](#)

Measurement of Thermal Properties

Thermal Coating Resistance

- Temperature Difference = Thermal Coating Resistance * Heat Flow



The higher the thermal coating resistance, the better is the thermal isolation.

Material Properties:

- Thermal conductivity, heat capacity
- Diffusivity, effusivity

[Q&A](#)

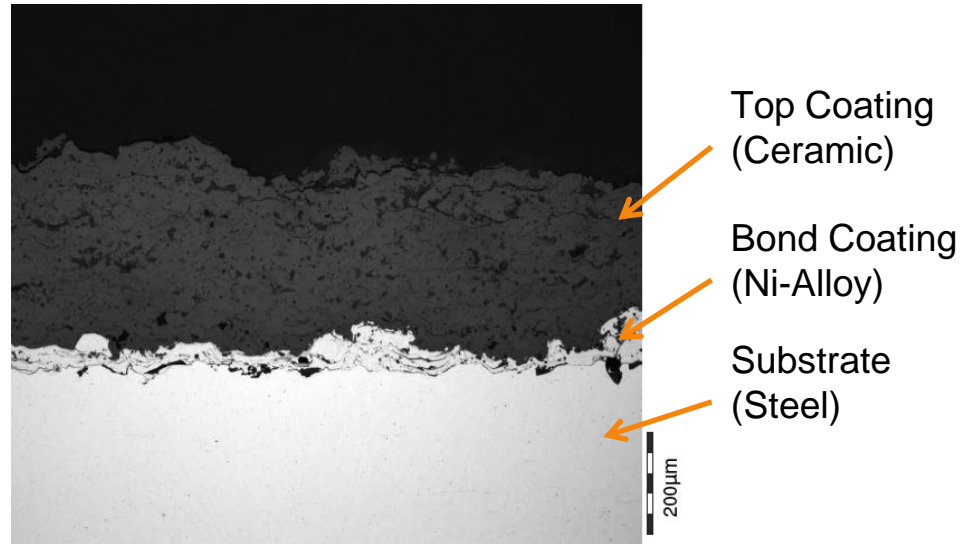
Application Example: Thermal Barrier Coatings

Purpose:

- Mechanical protection
- Thermal isolation

Measured Data:

- Porosity: 5-25 %
- Thickness: 75-500 μm
- Thermal Coating resistance:
50-1000 $\mu\text{Km}^2/\text{W}$



Sulzer Metco, Wohlen

[Q&A](#)

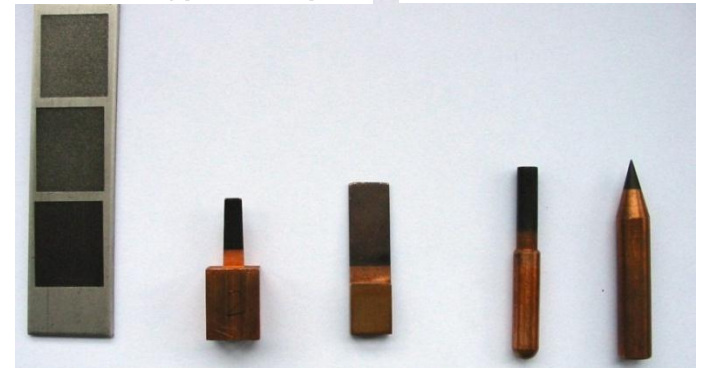
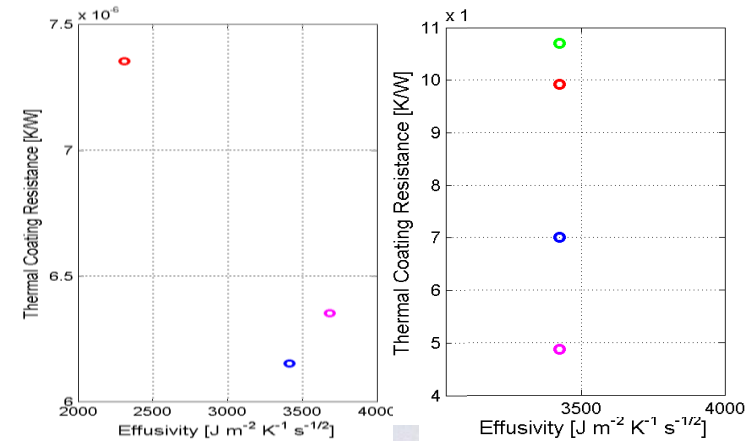
Application Example: Amorphous Carbon Coatings

Purpose:

- Surface hardening
- Thermal isolation

Measured Data:

- Thermal Coating Resistance:
3-20 $\mu\text{K}\text{m}^2/\text{W}$
- Thermal Material Properties



[Q&A](#)

Application Example: Non-cured Enamel-Powder

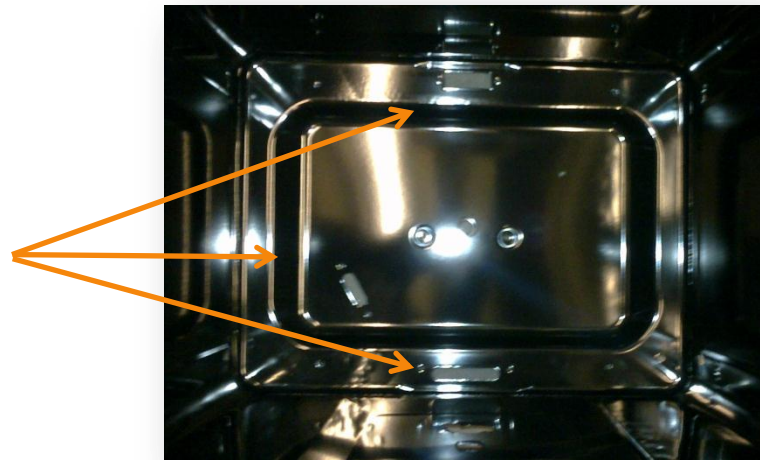
Purpose:

- Facilitates cleaning
- Protection against corrosion

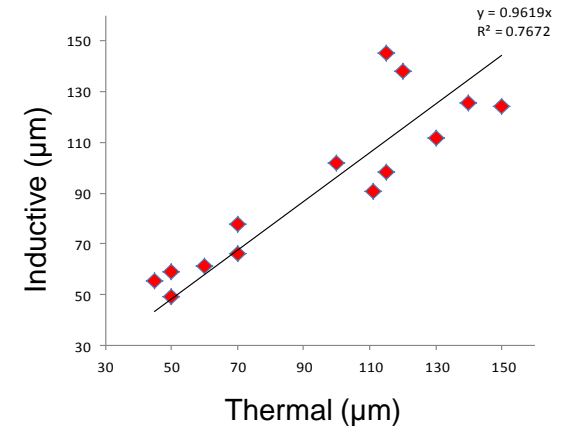
Measured Data:

- Thickness: 40-200 μm
- Homogeneity of the coating

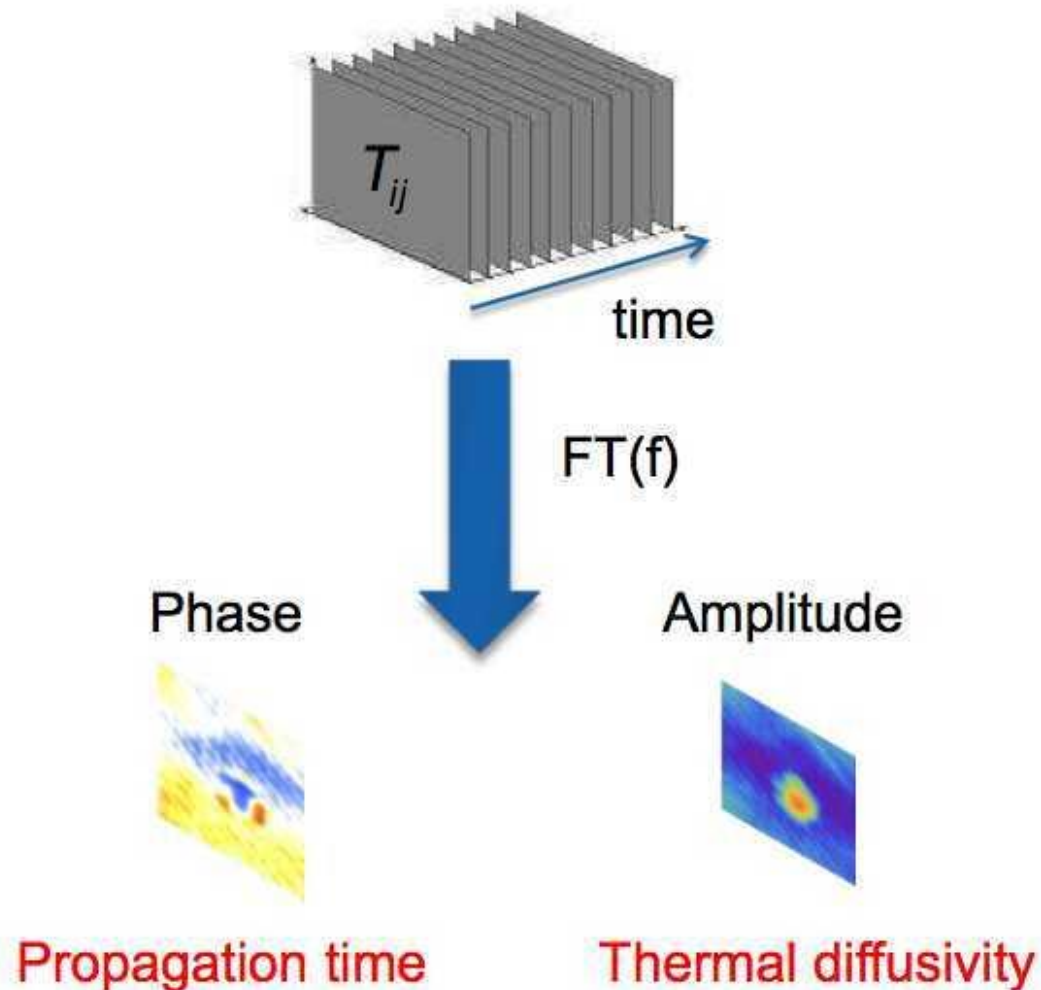
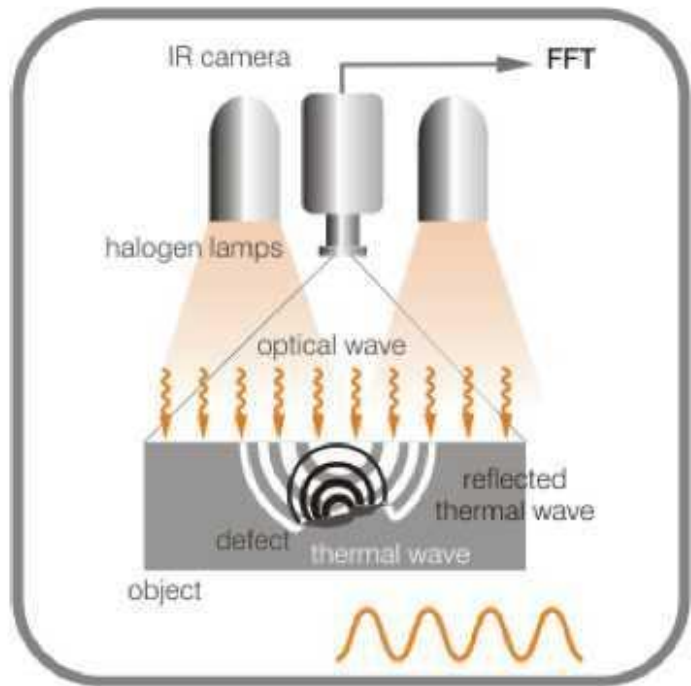
Kritische
Punkte



**Coating Thickness Measurement
inductive (x) vs. CoatMaster (y)**



Generation of thermal waves



Penetration depth

Thermal diffusion length

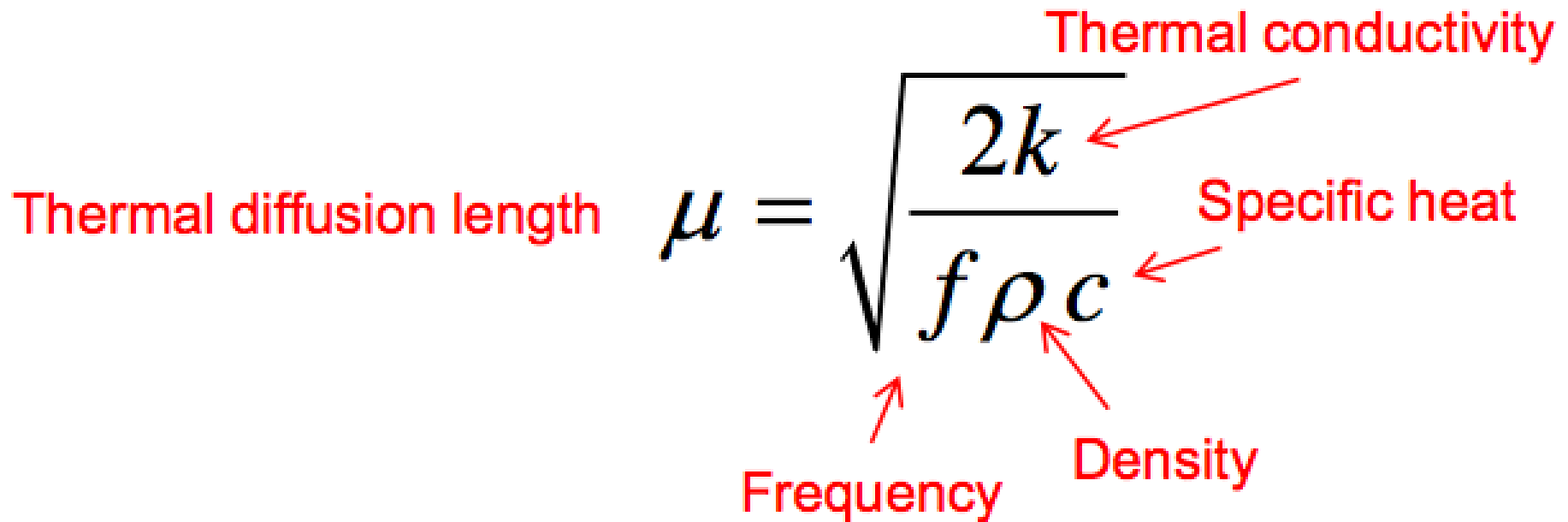
$$\mu = \sqrt{\frac{2k}{f\rho c}}$$

Thermal conductivity

Specific heat

Frequency

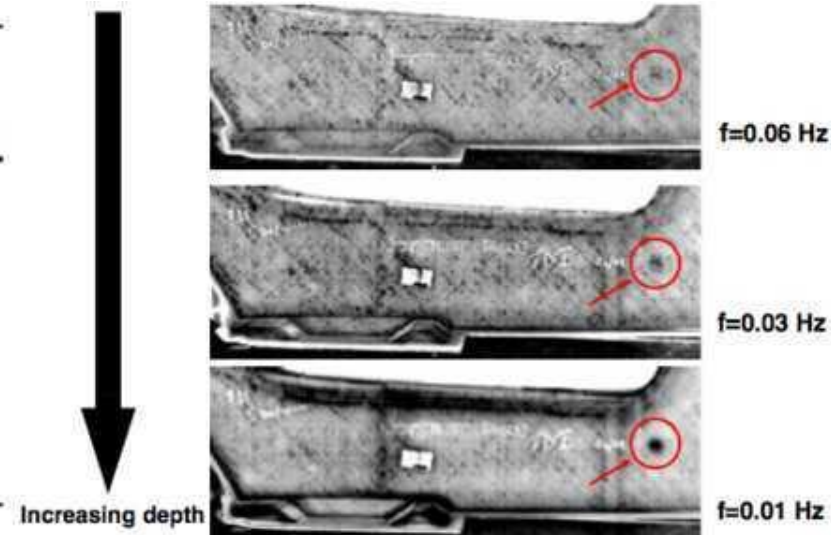
Density

The diagram shows the formula for thermal diffusion length, μ = √(2k / (fρc)). Red arrows point from labels to the variables: 'Thermal conductivity' points to 'k', 'Specific heat' points to 'c', 'Frequency' points to 'f', and 'Density' points to 'ρ'. The text 'Thermal diffusion length' is positioned to the left of the formula.

Penetration depth

Material	Density ρ [kg/m ³]	Specific Heat c_p [kJ/kg°C]	Heat Conduct. λ [W/m°C]	th. Diffusion Length Λ at 1 Hz [mm]
aluminium	2,707	0.896	204	5.17
copper	8,954	0.3831	386	5.98
nickel	8,906	0.4459	90	2.68
silver	10,525	0.234	407	7.25
nickel silver ^a	8,618	0.394	24.9	1.53
glass (window)	2,700	0.84	0.78	0.33
silicon	2,330	0.70	149	5.37
PVC	1,400	0.88	0.16	0.187

From Breitenstein



From Zöcke, Uni Saarbrücken

Penetration depth

Empirical rule of Thumb: «*The radius of the smallest detectable defect should be at least one to two times larger than its depth under the surface*»



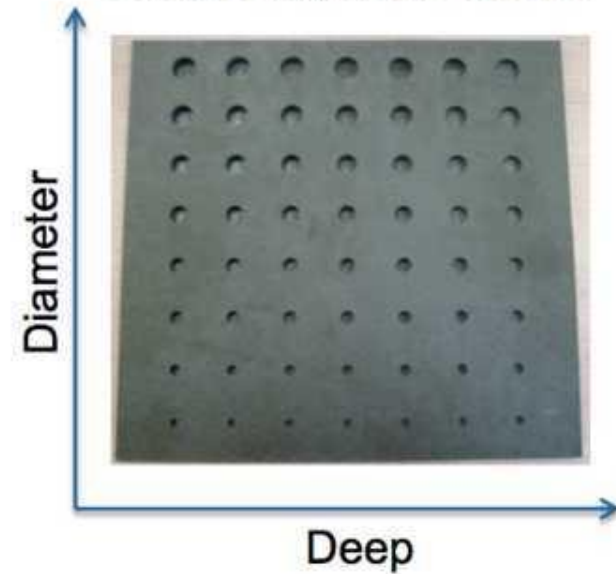
OK



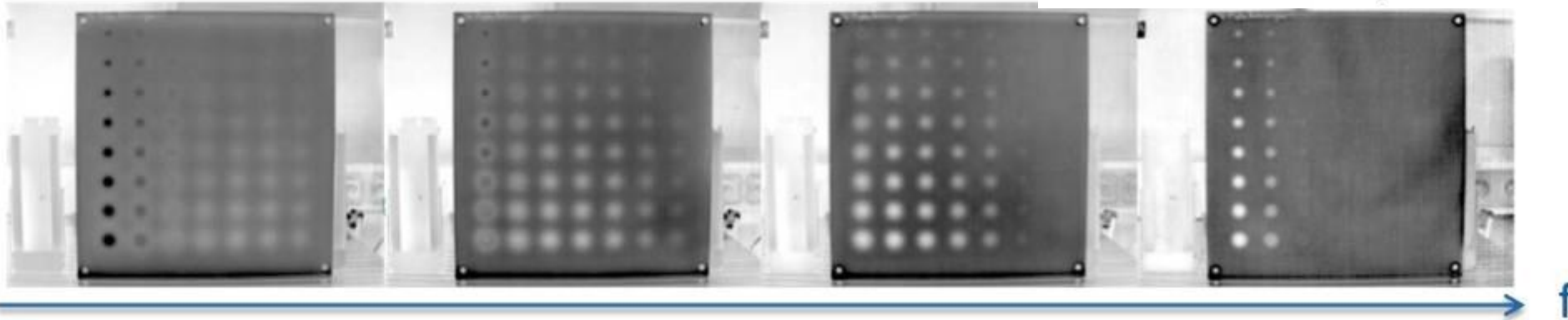
Not achievable

Penetration depth

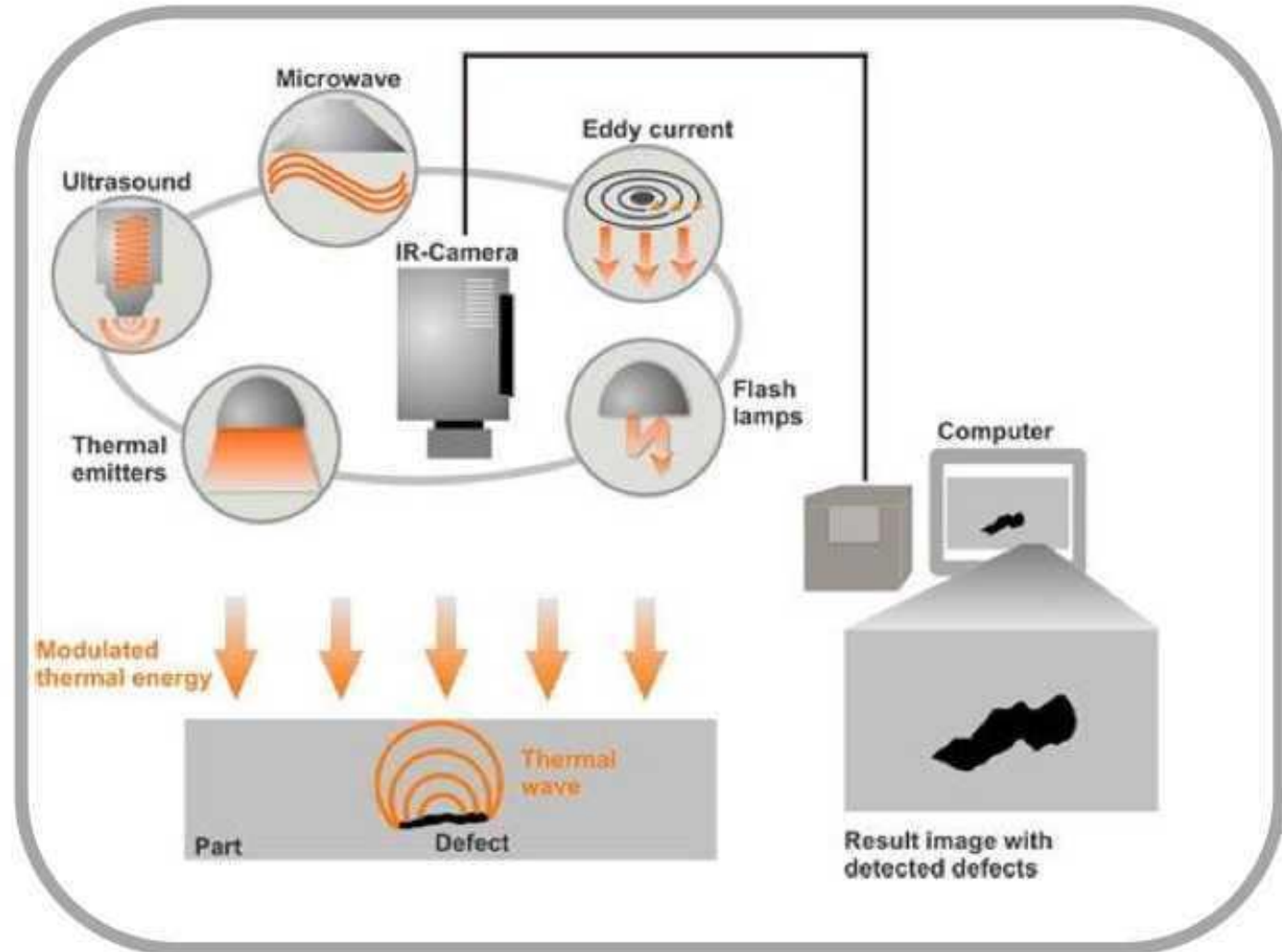
Back side, visible image



Front side, Amplitude images



Excitation Sources

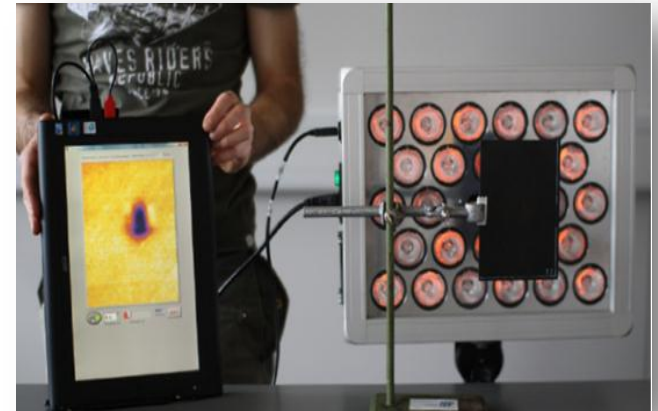


Tracer

Nondestructive and
noncontact testing of coatings

Specifications:

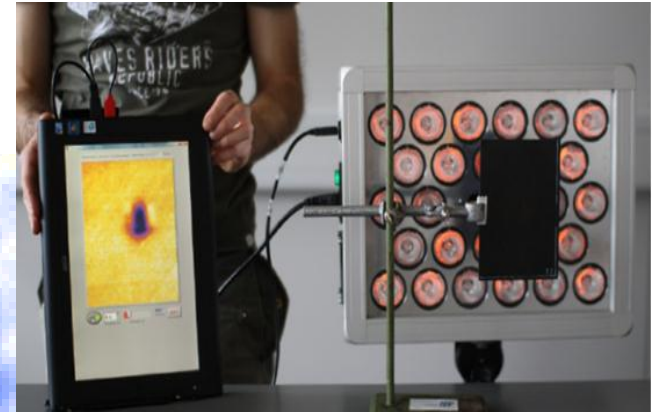
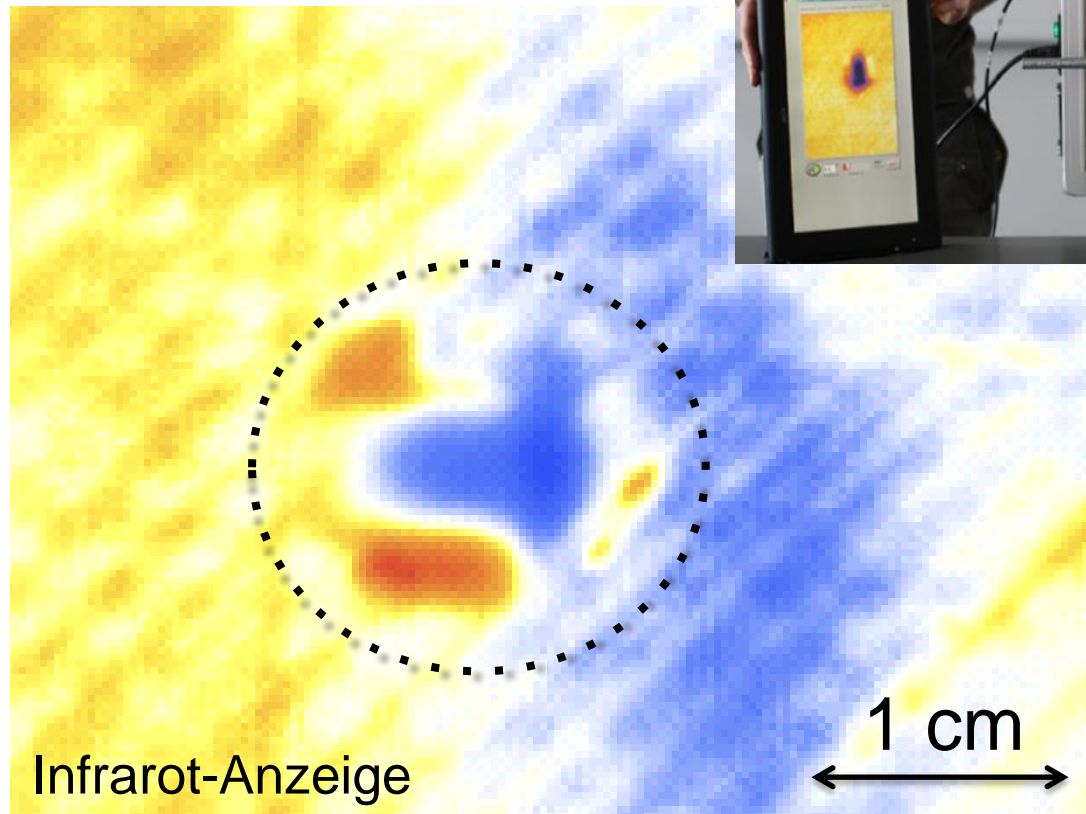
- Thickness: 60 – 2000 μ m
- Distance: 5 - 20 cm
- Testing Area: 150 mm x 100 mm
- Testing Time: 1 – 20 s



[Q&A](#)

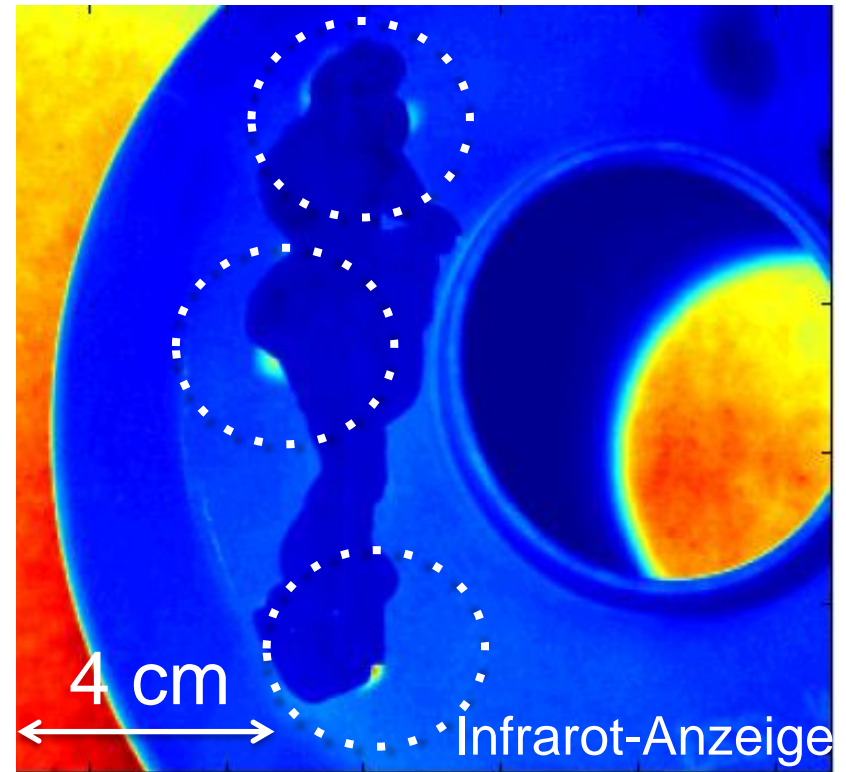
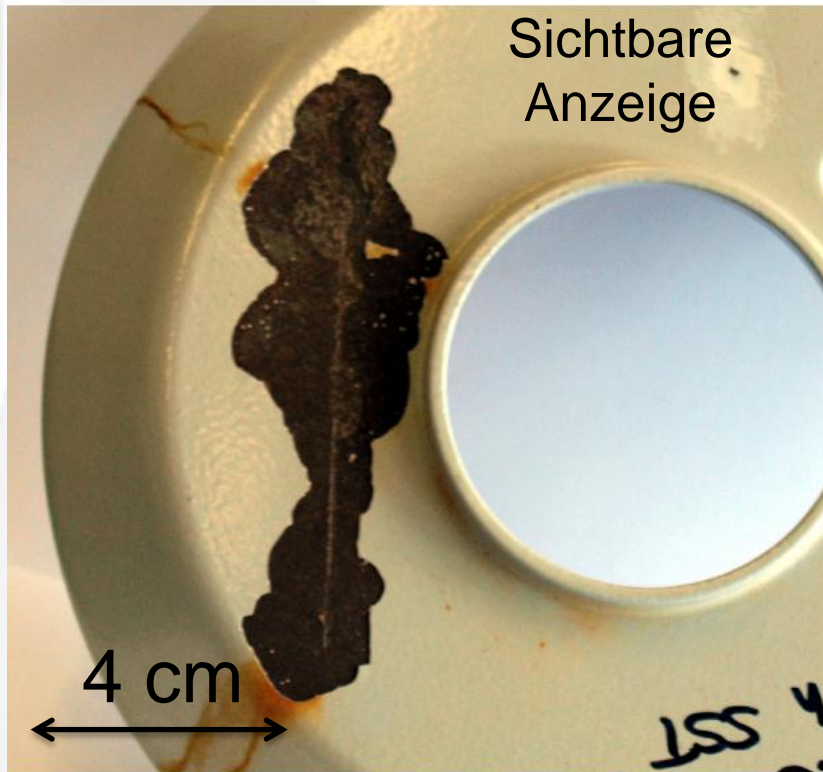
Tracer

Image guided testing of delaminations
& fibre-orientations in CFRP



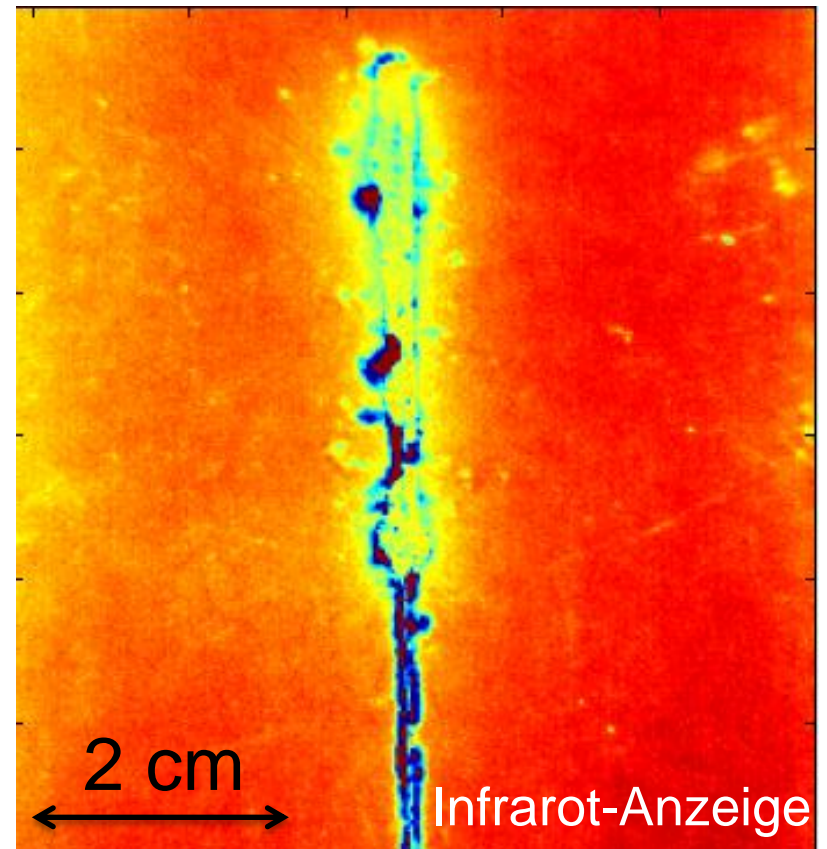
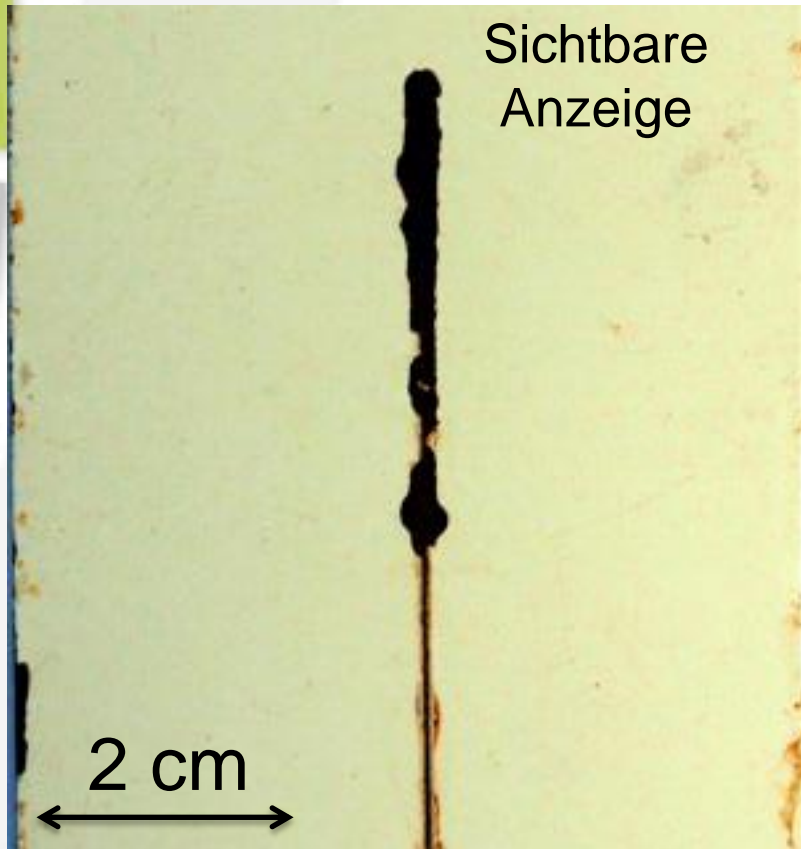
Tracer

Image guided testing of corrosion



Tracer

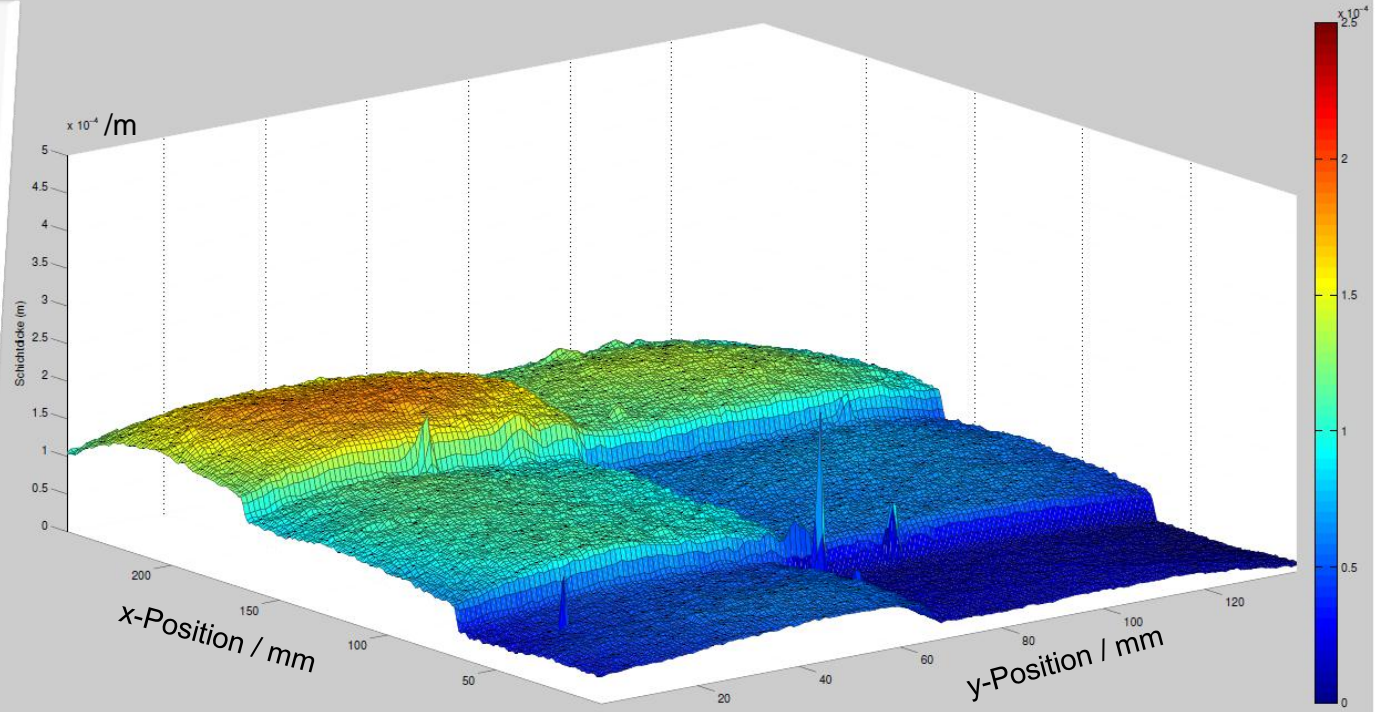
Image guided testing
of corrosion



Tracer

Image guided measurement of coating thicknesses

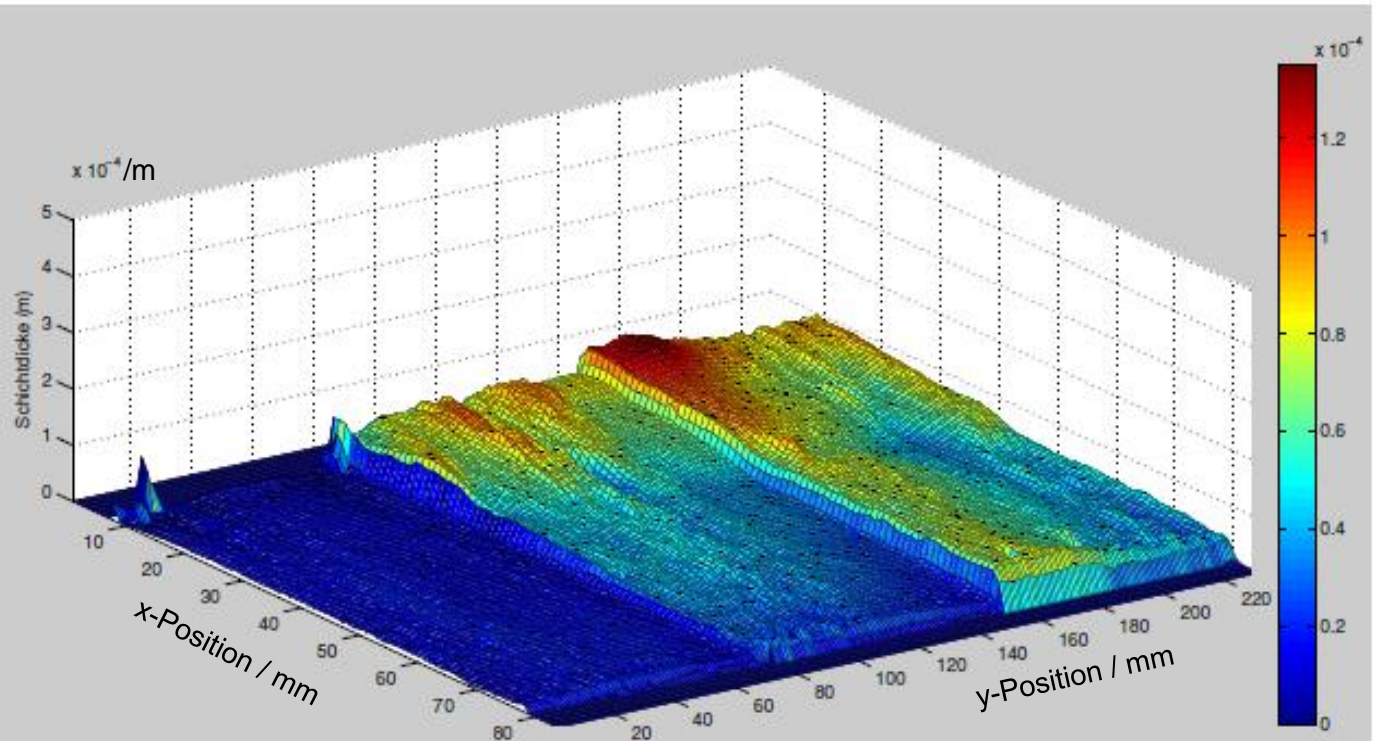
Acrylic Lacquer on Aluminium



Tracer

Image guided measurement of coating thicknesses

Acrylic Lacquer on Stone



Awards

- Heuberger Finalist (5. November)
- Ausgewählter Aussteller «Swiss Innovation Booth» an der Innovation Japan 2011 Tokyo (unterstützt durch die Schweizer Botschaft und KTI)
- Ausgewählter Aussteller Fraunhofer Allianz Vision [Sonderschau Berührungslos Messen](#) (Control 2011 Stuttgart)
- [Ausgewählter Aussteller Swiss Pavillon](#), Top 20 Innovation Award (Hannover Messe 2011)
- Venture Leaders Award 2011
- [Venture Kick I, II, III](#)
- [Electrosuisse ITG Innovationspreis 2010](#)
- Ausgewählter Aussteller für die Schweizer Fachhochschulen bei der [Future Expo 2010](#) ([Swiss Innovation Forum](#))
- Ausgewählter Aussteller Fraunhofer Allianz Vision [Sonderschau Berührungslos Messen](#) (Control 2010 Stuttgart)
- [Success-Story 2009 CTI-Technologies-Event](#)

[Q&A](#)

Thank you for your attention!

Further Information:

<http://www.winterthurinstruments.ch>
info@winterthurinstruments.ch

Nils.Reinke@WinterthurInstruments.ch