

What are Terahertz (THz) / mm-waves?



Terahertz-Wavelength between Infrared and Microwaves

(Sub-)Millimeter waves ; Far-Infrared



What are Terahertz (THz) / mm-waves?

- Terahertz / Millimeter Waves are
 - electro-magnetic radiation (100 GHz – 10 THz)
 - similar to radio waves
 - fully harmless
- THz/mm-waves can look through:
 - cloth
 - paper, cardboard, most plastics, ceramics, ...
- THz/mm-waves cannot penetrate:
 - metal, liquids, human tissue, ...



Why care about Terahertz Waves?

NDT of Polymer Foams

Sample: (NASA Panel)

Space Shuttle Columbia Tragedy, Feb. 1, 2003



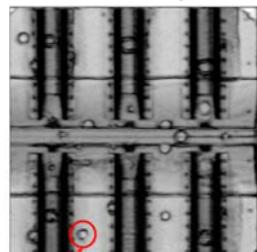
"The Columbia is lost; there are no survivors."

A theory that led to this tragedy is that insulation foam on the shuttle's fuel tank detached and struck the wing upon lift-off. Defects in the foam insulation likely caused the material to detach.

<http://www.rpi.edu/~zhangxc>



0.2 THz image



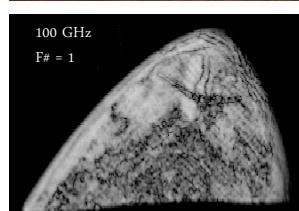
<http://www.rpi.edu/~zhanaxi>

Terahertz imaging identifies defects in foam structures



Why care about Terahertz Waves?

NDT of Glass Fiber Plastic Composites



Terahertz images the inside of glass fiber composites





On-line Measurement of the Thickness of Plastic Coatings



Example: Gas Pipeline Coating

Marketprice Polypropylen (PP): \$ 800 USD/ton

Cost Saving per 1000km: **\$ 4.5 Mio. USD**

(saving just 1 mm of PP coating)

Save Material = Save Cost

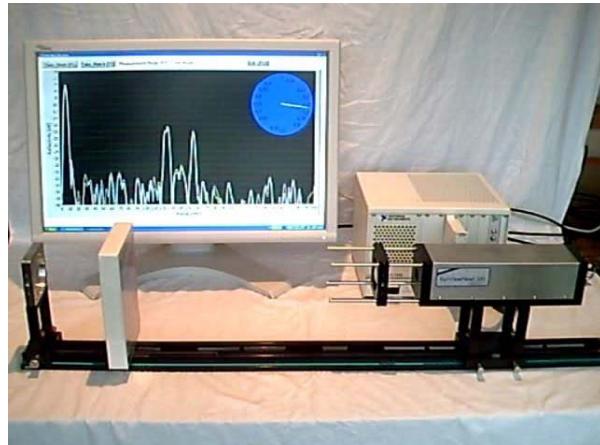


The SynView Technology

all-electronic, active, range imaging



SynView Range Measurement Head



SynViewHead

available at:

around 0,1 THz

and at

around 0,3 THz

other
frequencies
available
on request

Fast Measurement (full range information) in 240 μ s



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Advantages of (FMCW) Terahertz Imaging

FMCW Terahertz Imaging:

- provides the full 3D information especially of composite structures (visualization of the inner structure)
- non-destructive and contact-free
- safe
- flexible configuration
- very short measurement time (real-time possible)

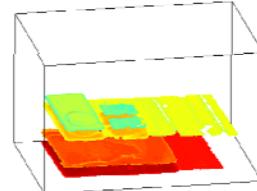
combined with

- an excellent image quality

a) Photo of sample:



b) 3D-THz data:



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SYNVIEW

Comparison of THz Imaging Systems

Other (Laser-based THz-TDS) and SynView (FMCW)

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Imaging Systems	THz-TDS	FMCW
	= Time Domain System	= Frequency Modulated Continuous Wave
Measurement	pulsed	swept frequency
Frequency range	100 GHz – 2.5 THz (typ.)	60 – 110 GHz or 230 – 320 GHz (SynView)
Spatial res.	300 µm typ.	3 mm or 1 mm
Technology	Opto-Electronic (fs-Laser-based)	All-electronic
Measurement time / (range) pixel	30 ms up to a few seconds	< 250 µs (SynView)
Depth range	mm to cm	30 – 50 cm (SynView)
Dynamic range	20 – 40 dB	50 – 70 dB (SynView)
Range resolution	10 – 20 µm	10 – 20 µm (SynView)
Layer + Interface separation	0.5 mm (typ.)	6 mm or 2 mm (SynView)

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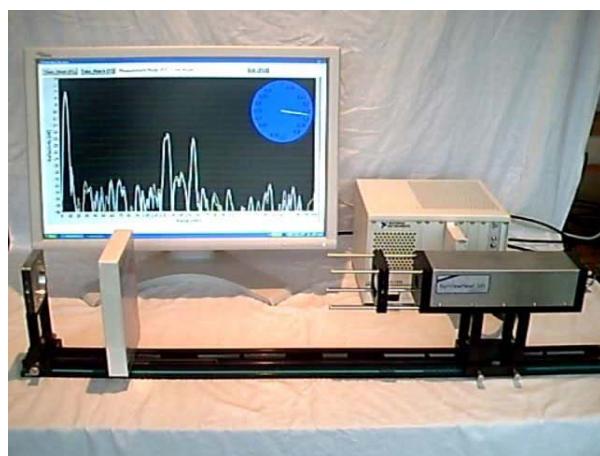
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SYNVIEW

FMCW Range Measurement Head

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SynViewHead

available at:

around 0,1 THz

and at

around 0,3 THz

other

frequencies

available

on request

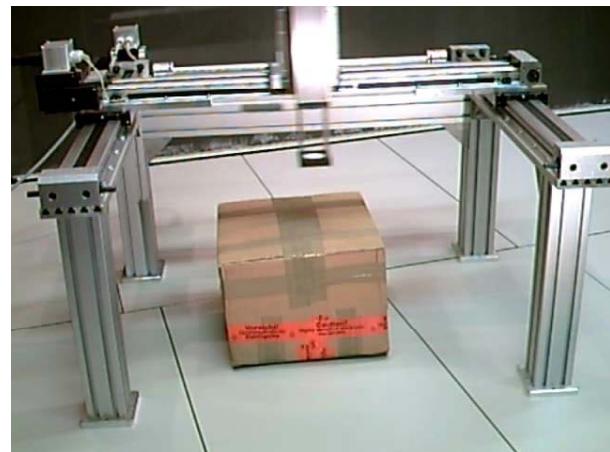
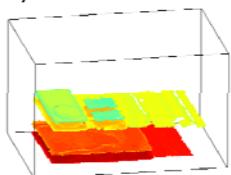
Fast Measurement (full range information) in 240 µs

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FMCW 3D Imaging

a) Photo of sample:**b) 3D THz data:**

SynViewScan 3D THz scanner for single-element evaluation



FMCW 3D Imaging Setups



Customized setup for each application

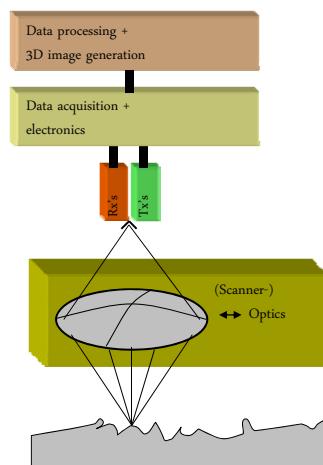


Faster Imaging; Real-Time Operation

Phased Array, Synthetic Aperture



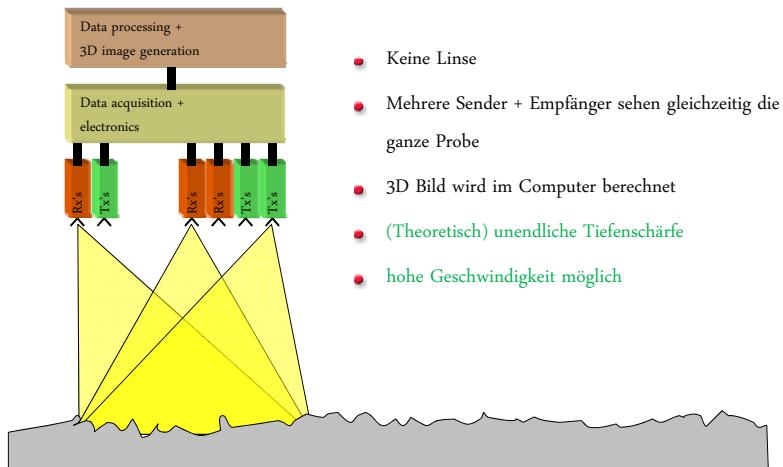
Reale Abbildung



- Abbildung mit Linse (wie Photographie)
- Je Messkopf nur ein Tiefenprofil
an einem Punkt
- Mehr Punkte
durch mechanisches scannen
- Begrenzte Tiefenschärfe



Synthetische Abbildung



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Für industrielle Anwendungen: SynViewEdge

SynViewEdge mit
Synthetic Viewing Technologie
für das Produktionsumfeld

- =
- mehrere SynViewHeads
 - schnelle Bildwiederholrate bis hin zu Echtzeit
 - flexible Architektur erlaubt
 - Anpassung an die Anwendung
 - Kosteneffiziente Lösung



Lösung für das Produktionsumfeld

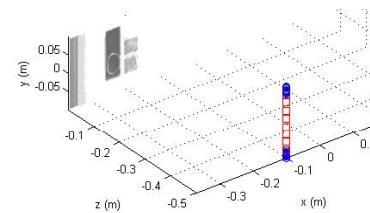
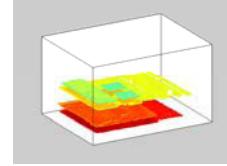
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Simulation der erreichbaren Bildqualität

1. Generierung realer Messdaten mit SynViewScan
2. Definition des Arrays (Anzahl und Position der Sender und Empfänger; Frequenz)
3. Simulation der Empfängerdaten auf Basis der realen Messdaten
4. Berechnung (Rekonstruktion) des Messobjektes / der realen Messdaten aus den Empfängerdaten



Numerisches Designtool für SynViewEdge

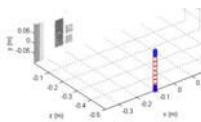


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Simulationsparameter

- SynViewEdge für Produktionslinie:
=> Bewegtes Objekt wird zeilenweise abgetastet
- Zeilenweise synthetische Bildrekonstruktion
- Tx Sender + Ry Empfänger (z.B. T8 R16)
- Breite Produktionslinie 20 cm
- Arbeitsabstand 50 cm
- Frequenzbereich 220 – 325 GHz (SynViewEdge 300)
und 75 – 110 GHz (SynViewEdge 100)



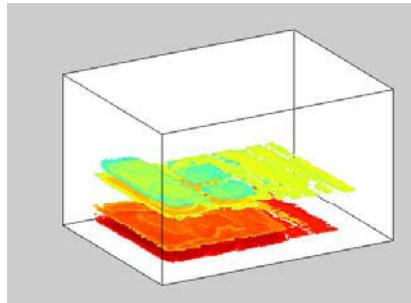
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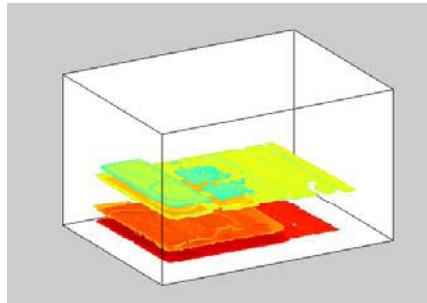
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Simulationsergebnisse

SynViewEdge 100 T16+R16



SynViewEdge 300 T16+R16

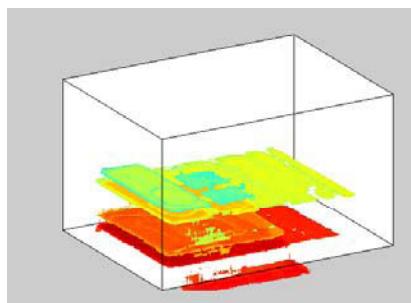


Bildqualität in Abhängigkeit der Frequenz (Wellenlänge)

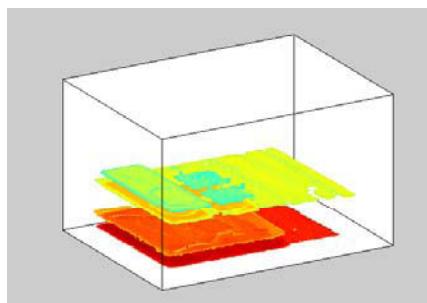


Simulationsergebnisse

SynViewEdge 300 T8+R16

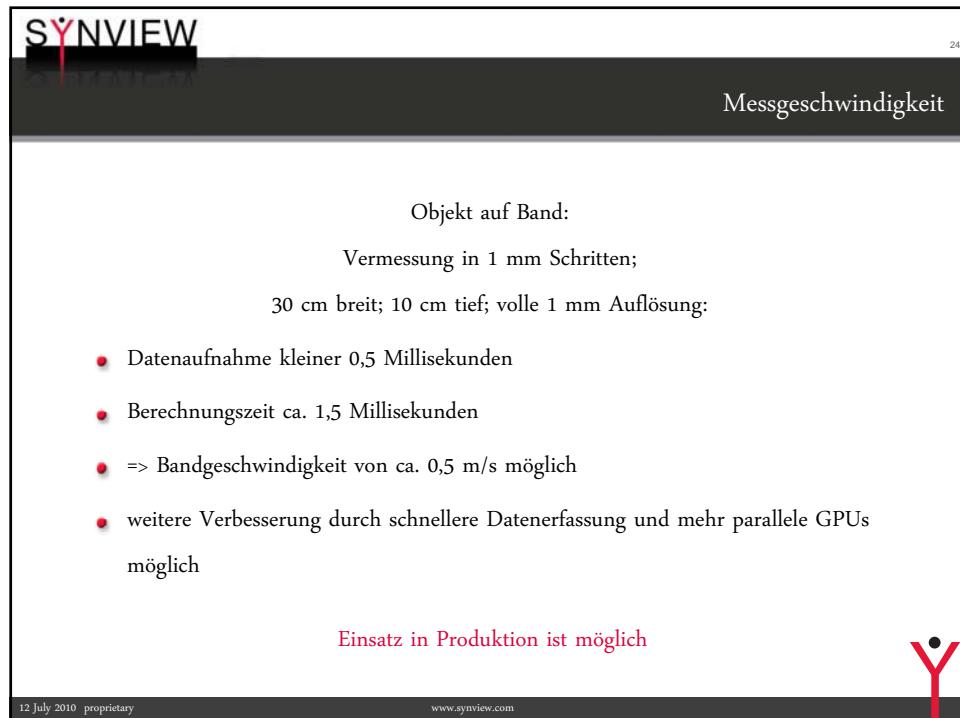
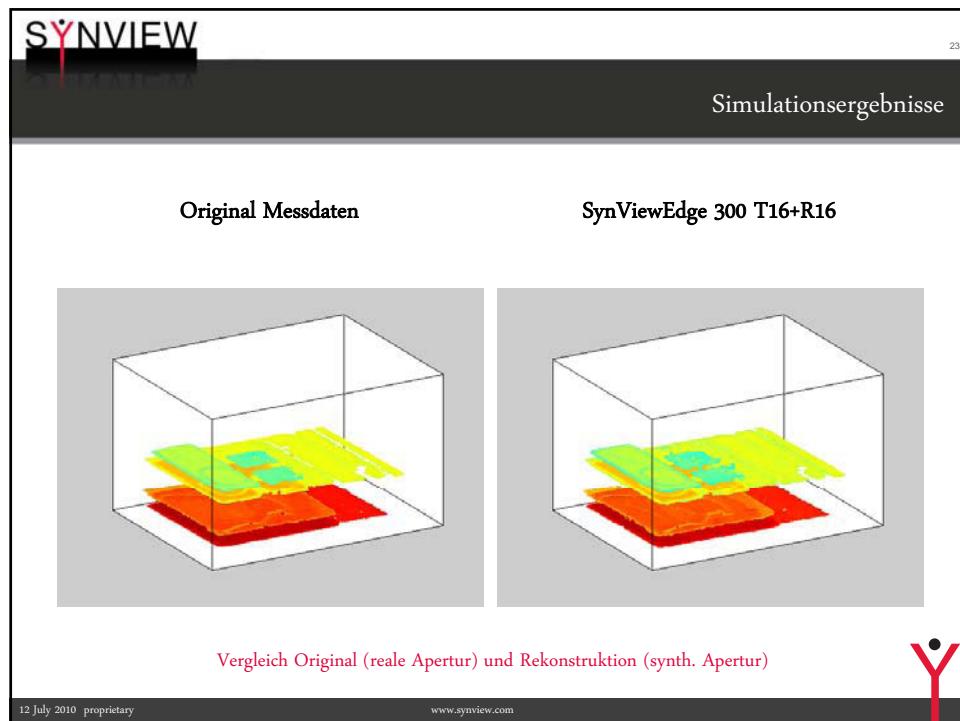


SynViewEdge 300 T32+R32



Bildqualität in Abhängigkeit der Anzahl der Sender+Empfänger





Zusammenfassung

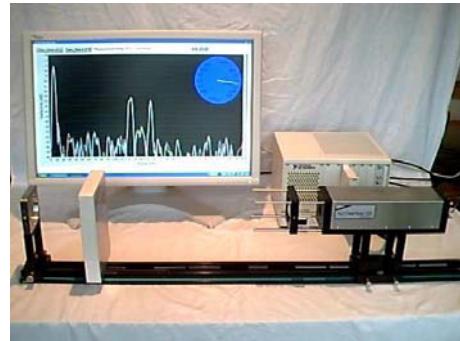


Zusammenfassung

- Terahertz-Bildgebung ermöglicht diverse neue Anwendungen im Bereich der ZfP
- Vollelektronische Lösungen ermöglichen eine hohe Messgeschwindigkeit bei hoher Bildqualität
- Phased Array / Synthetische Apertur ermöglicht
 - gleiche Bildqualität wie reale Apertur
 - sehr hohe Messgeschwindigkeit bei großen Flächen
- Industrieller Einsatz möglich



Danke für Ihr Interesse!



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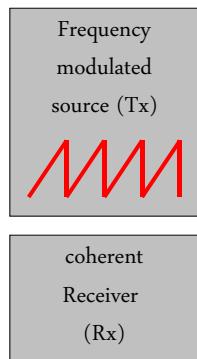
info@synview.de | www.synview.de



BACKUP



FMCW Principle



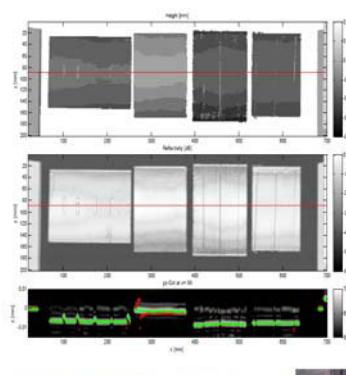
=> difference between Tx and Rx frequency
is proportional to the distance
=> signal intensity is proportional to the reflectivity



SynView Products



Mobile Measurement: SynViewHead

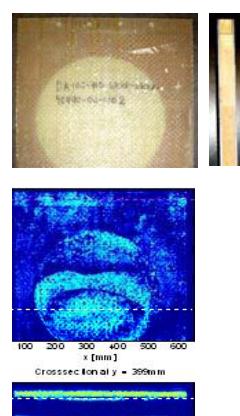


- 3D THz measurement head
- outstanding dynamic range
- measurement time of 240 μs
- first products sold

THz Measurement Head



Table Top System: SynViewScan



- 3D THz scanner
- outstanding image quality
- scan Time: ~ 10 min
- first products sold

3D THz scanner for single-element evaluation



Industrial System: SynViewEdge

SynViewEdge with
Synthetic Viewing Technology
for the production environment

=

- several SynViewHead
- fast image refresh rate:
close to real-time
- flexible architecture to
 - allow application oriented setup
 - ensure cost-efficient solutions



Solution for the production environment

