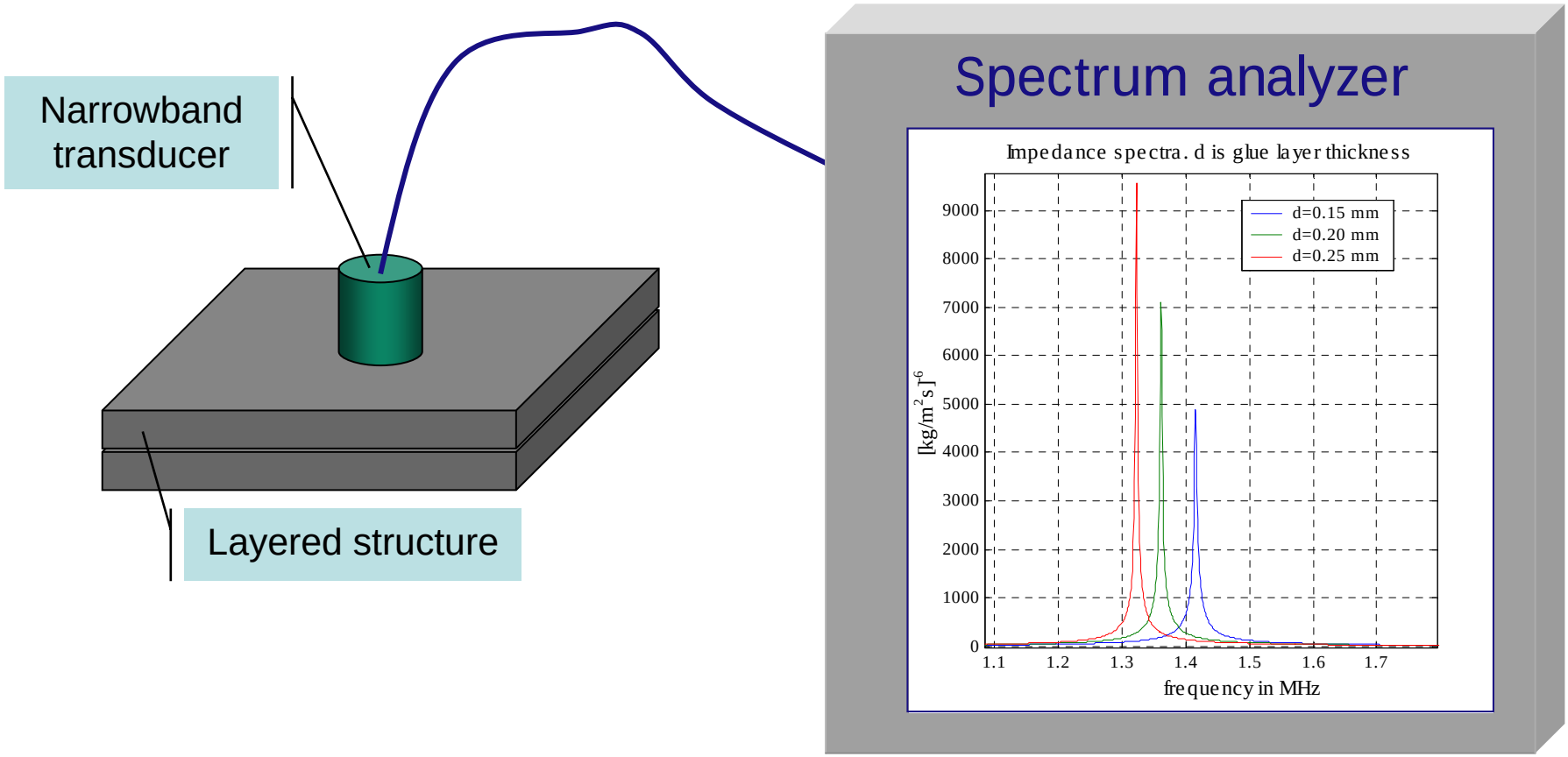
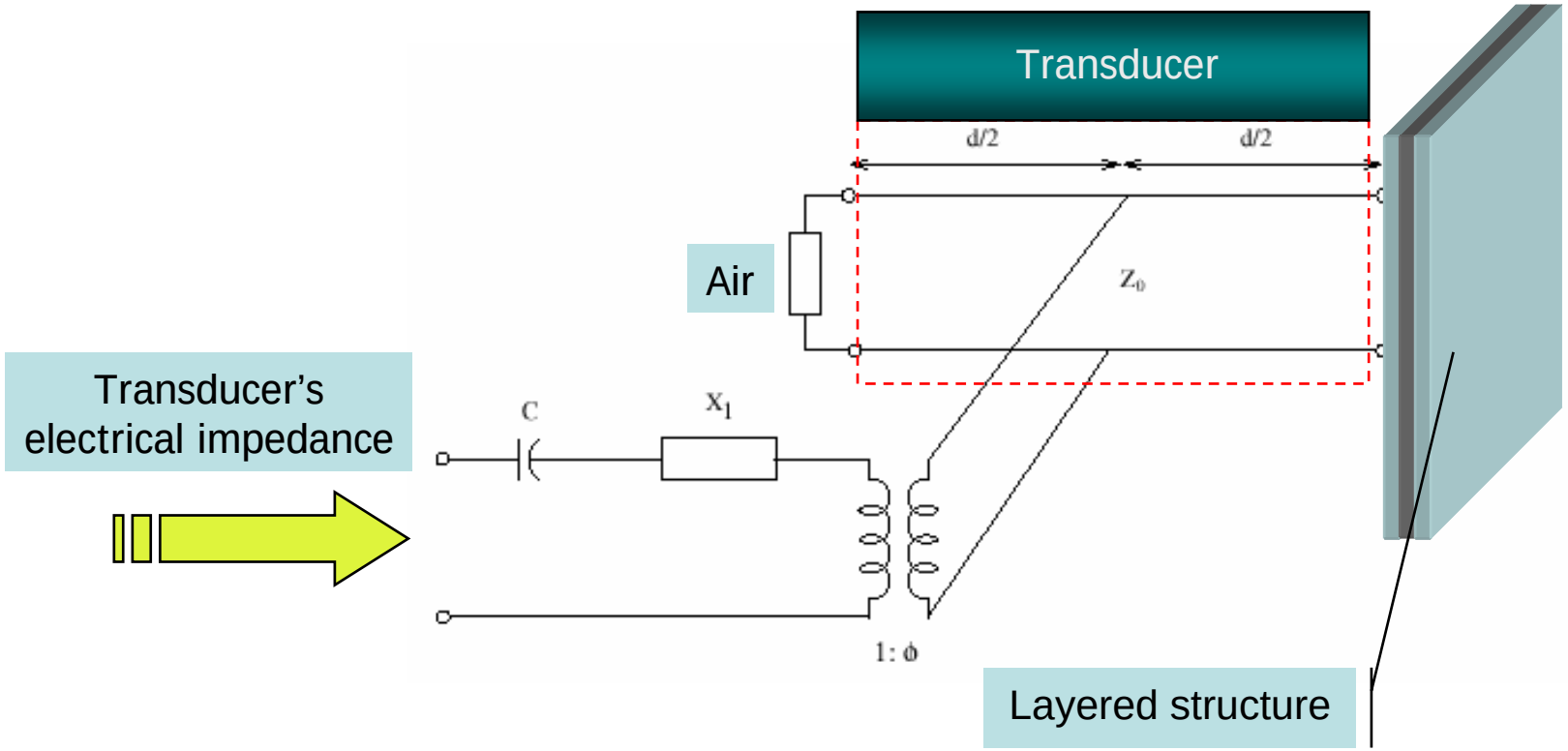
Narrow Band Ultrasonic Spectroscopy

N-BUS

Narrowband Resonance Spectroscopy



Principle of narrowband spectroscopy

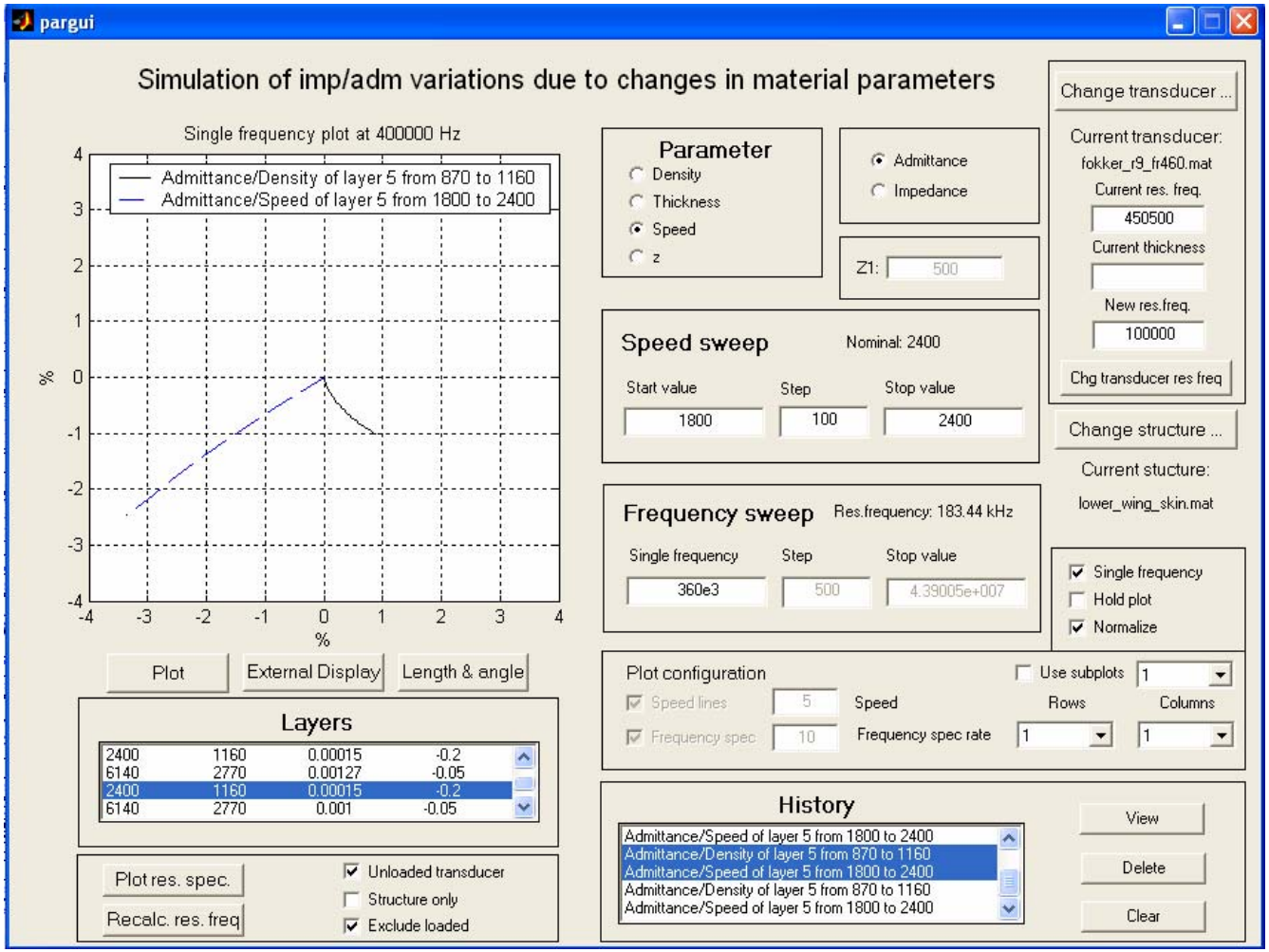


Narrowband spectroscopy of composite structures

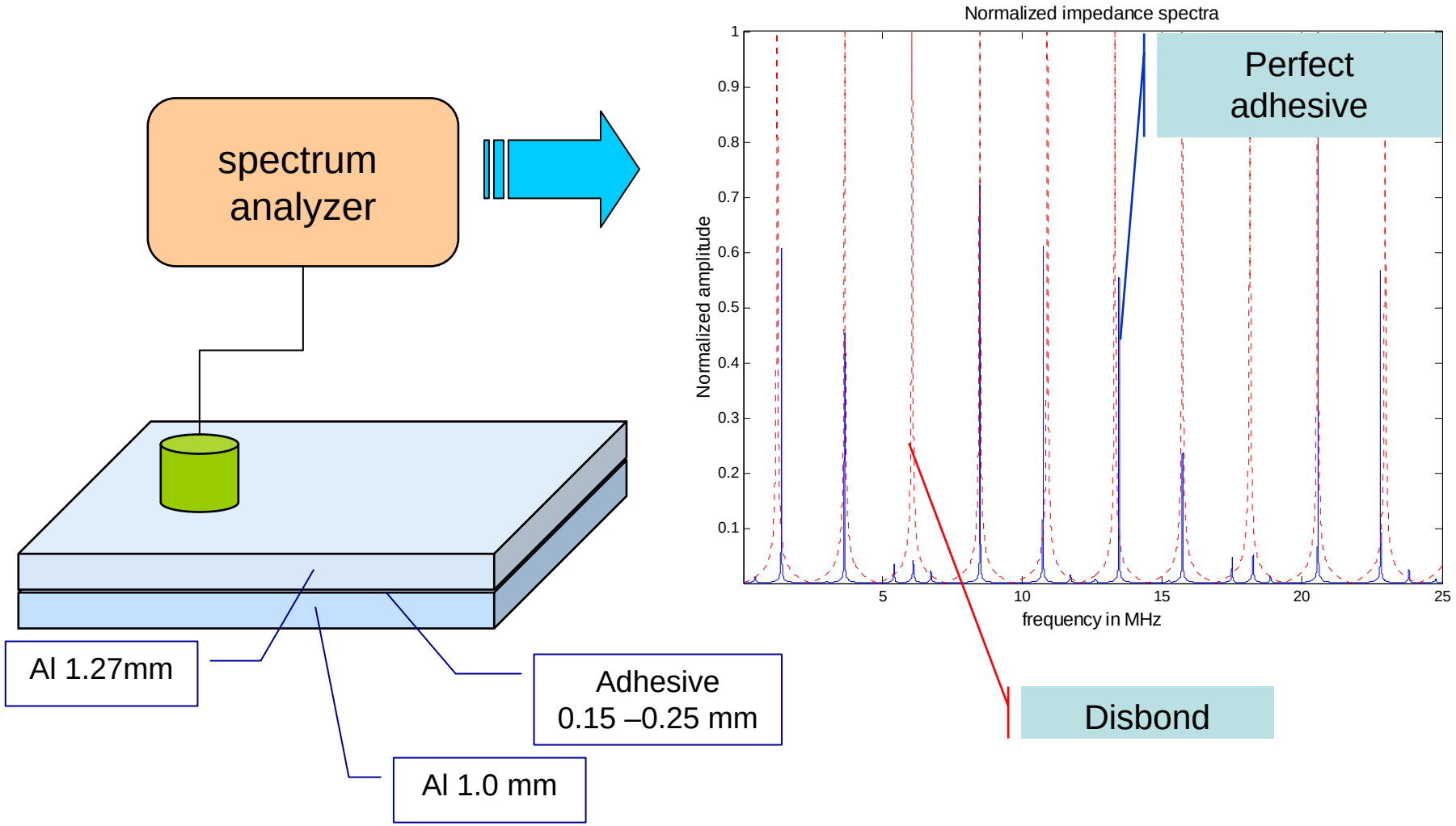
Why narrowband not broadband spectroscopy ?

- Local test preferred (high local sensitivity possible)
- Result easy to handle (no training data required)
- Simulation tool available
- Tradition in aircraft industry

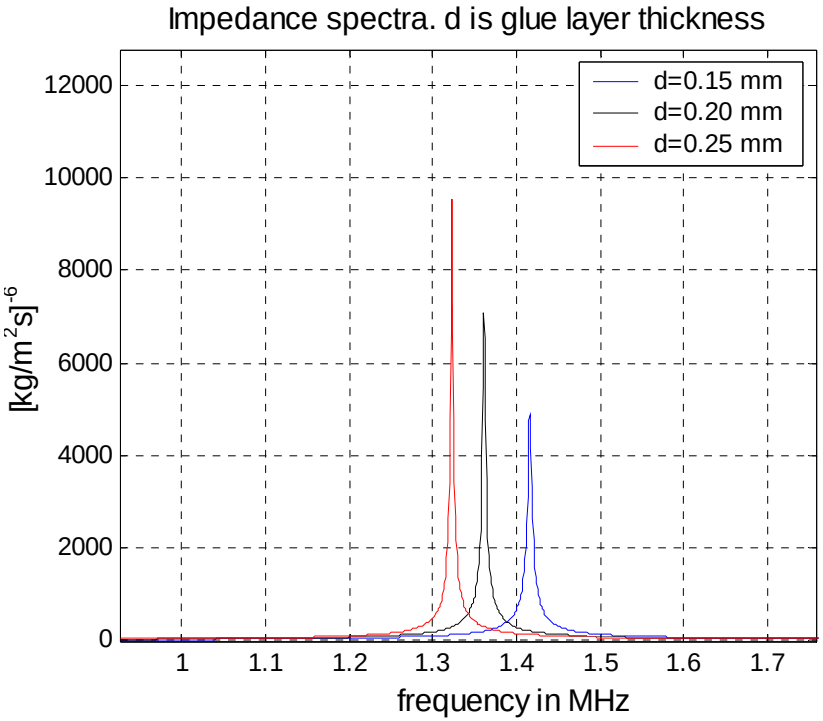
Simulation toolbox

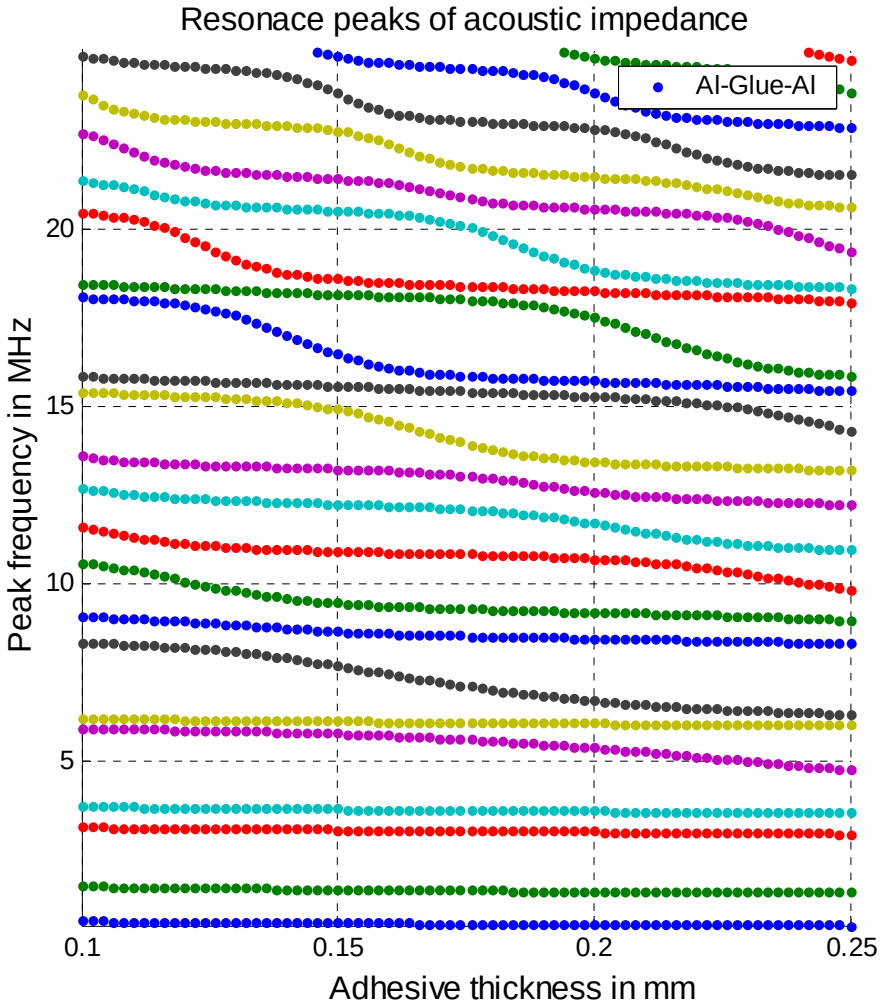


Example: two-layered Al structure

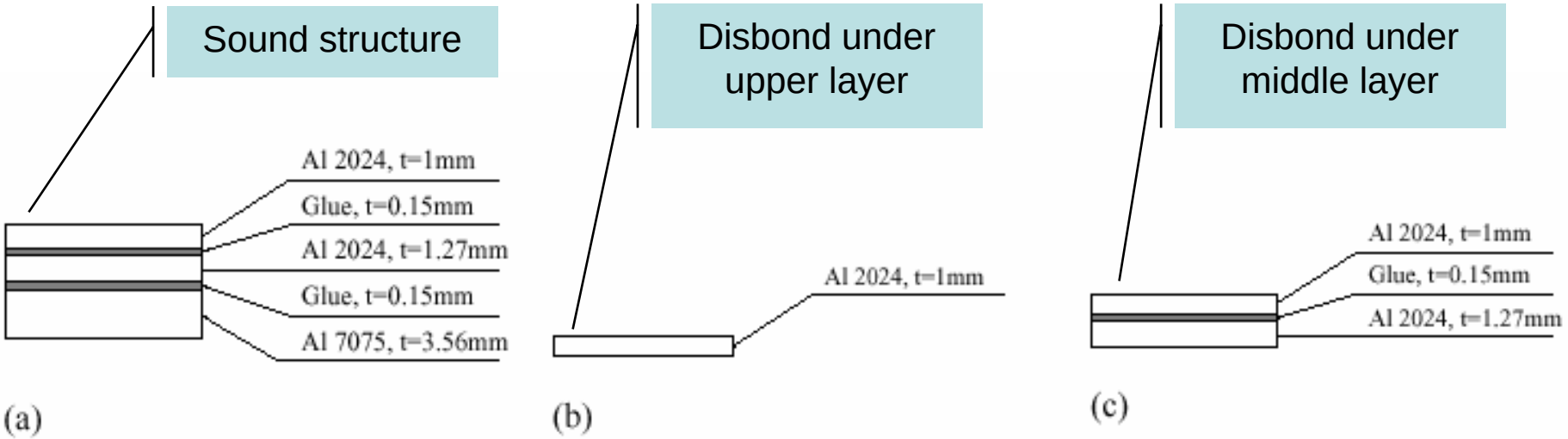


Influence of adhesive layer thickness

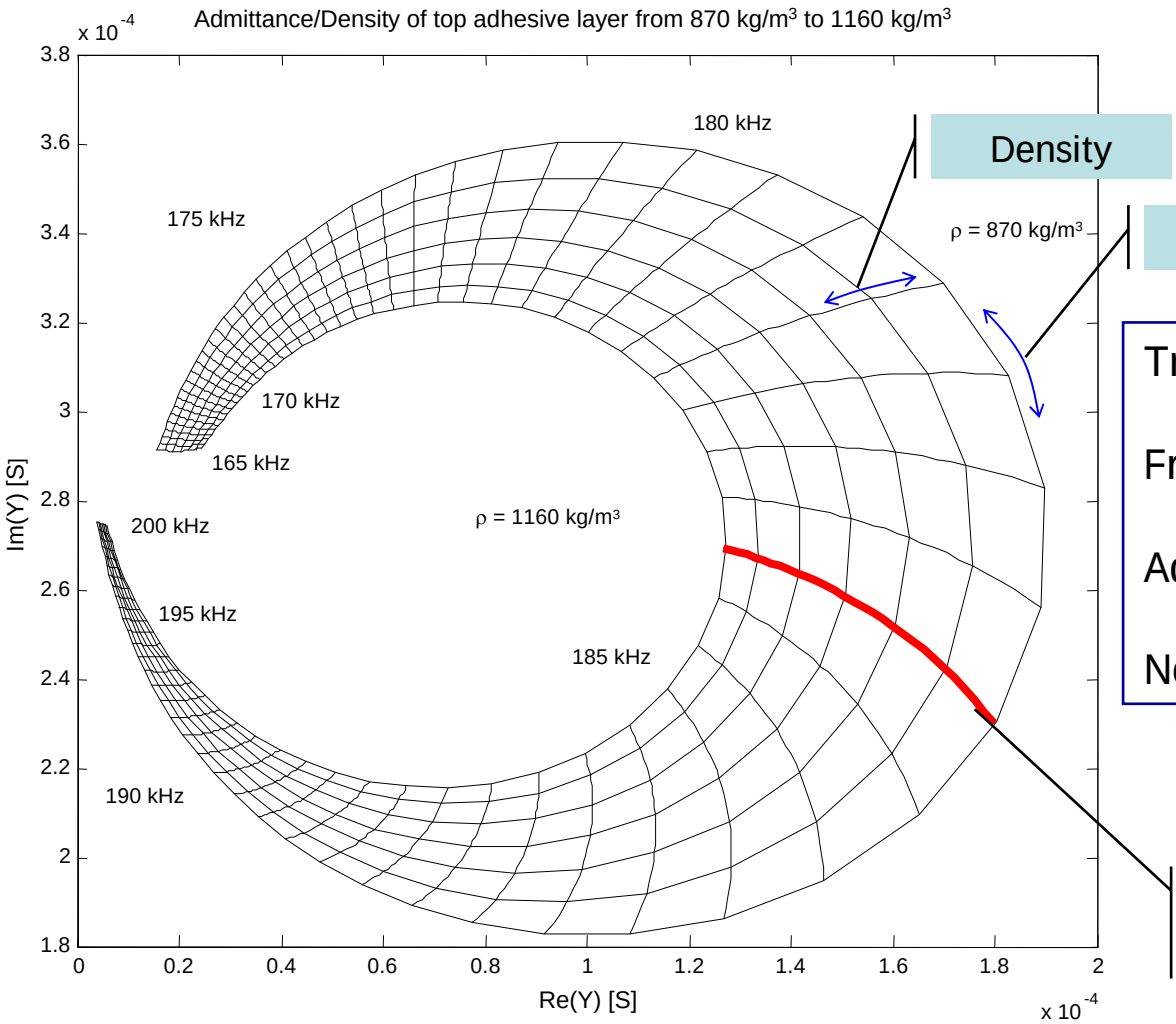




Impedance: three-layered Al structure



Electrical impedance on three-layered Al structure



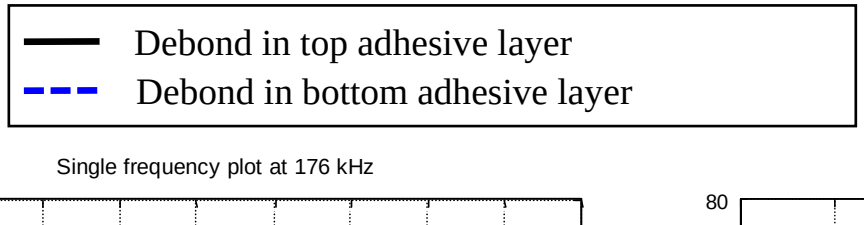
Density

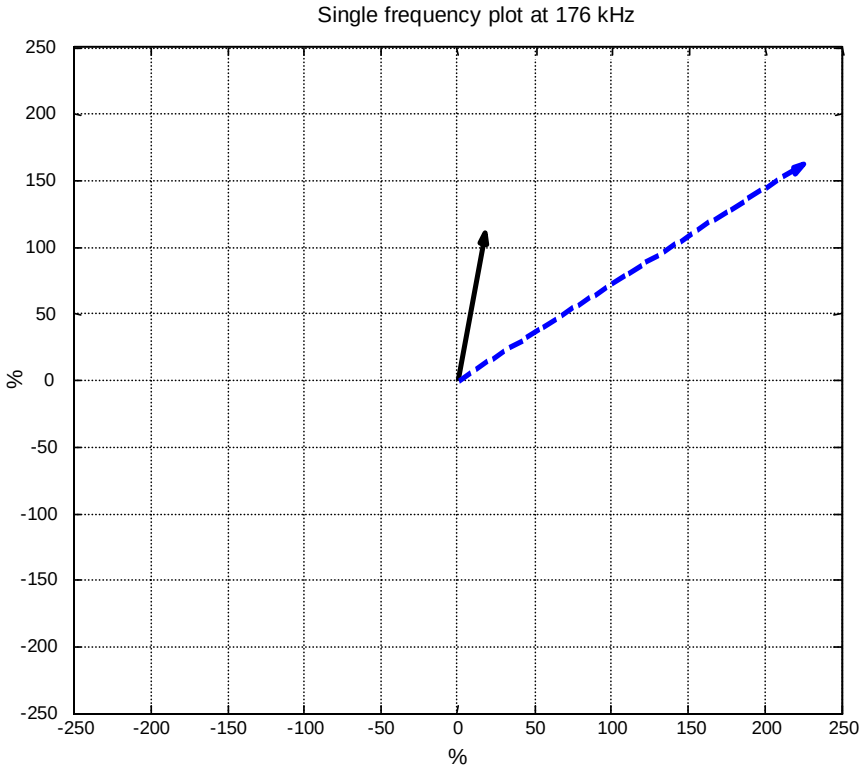
Frequency

Transducer's resonance:
176 kHz
Frequency sweep:
165 – 200 kHz
Adhesive density variation:
870 – 1160 kg/m^3
Nominal density: 1160 kg/m^3

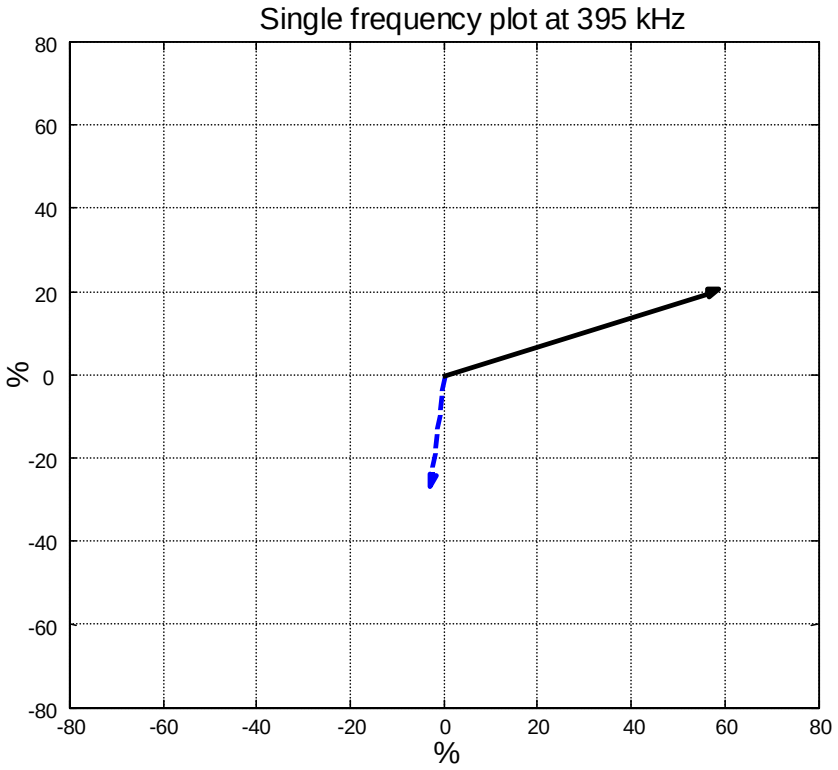
Maximum impedance deviation at 183.5 kHz

Selection of frequency





Transducer's resonance at 176 kHz

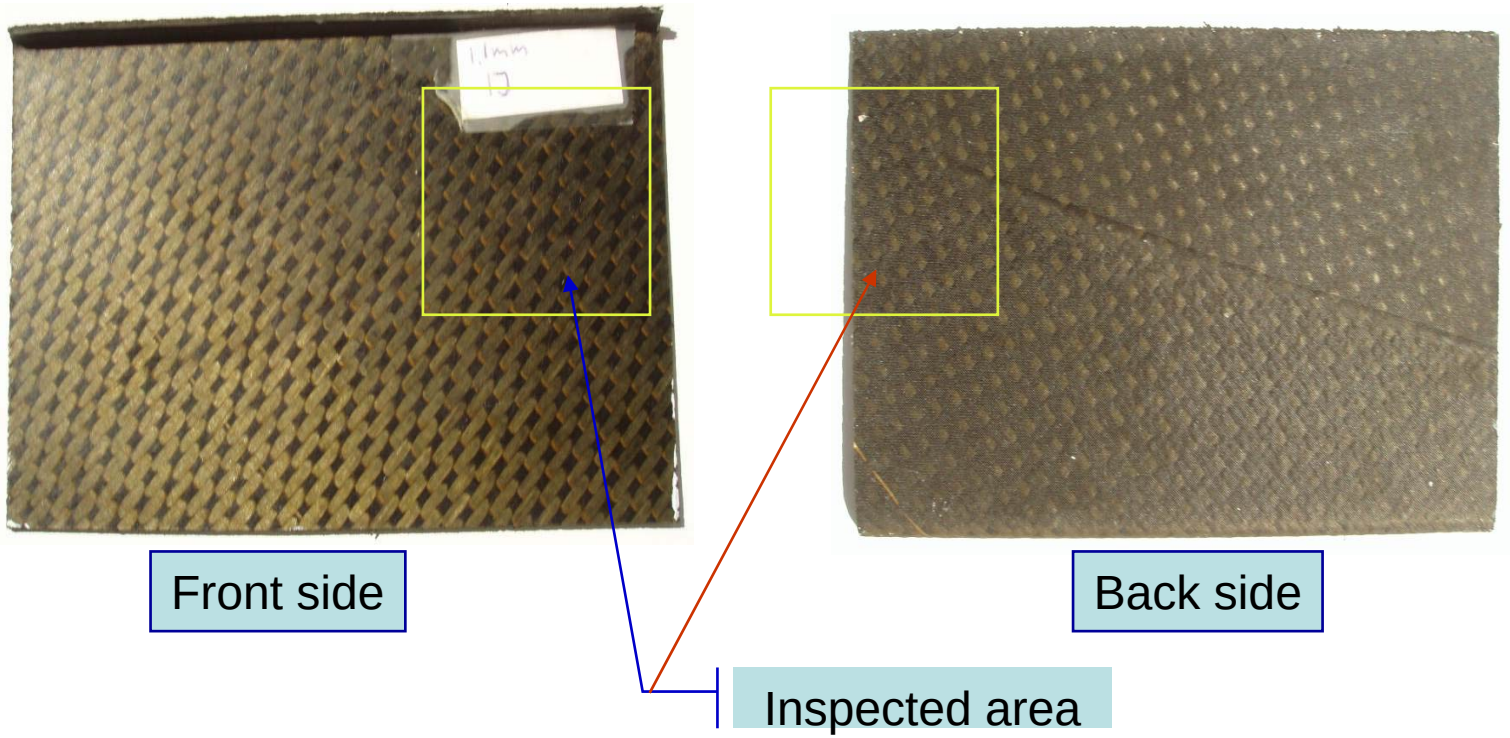


Transducer's resonance at 439 kHz

APEX RESEARCH TECHNOLOGIES

CFRP specimen with 1J impact

CFRP specimen with impact and local variation in thickness

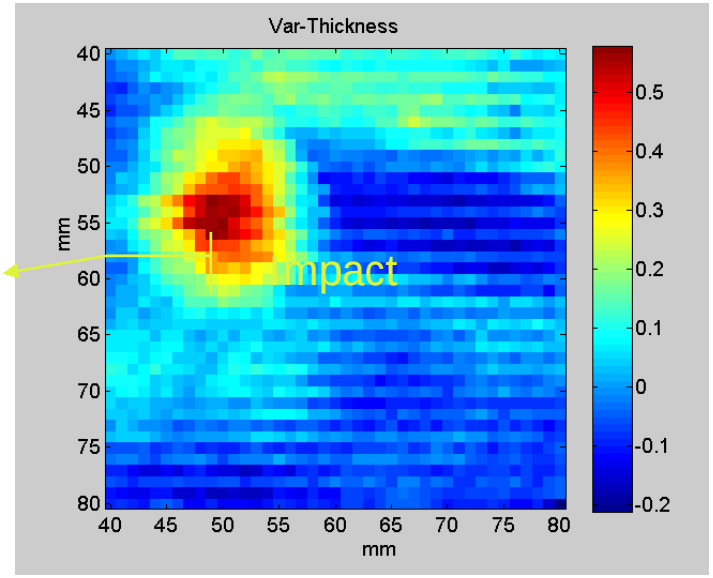


APEX RESEARCH TECHNOLOGIES

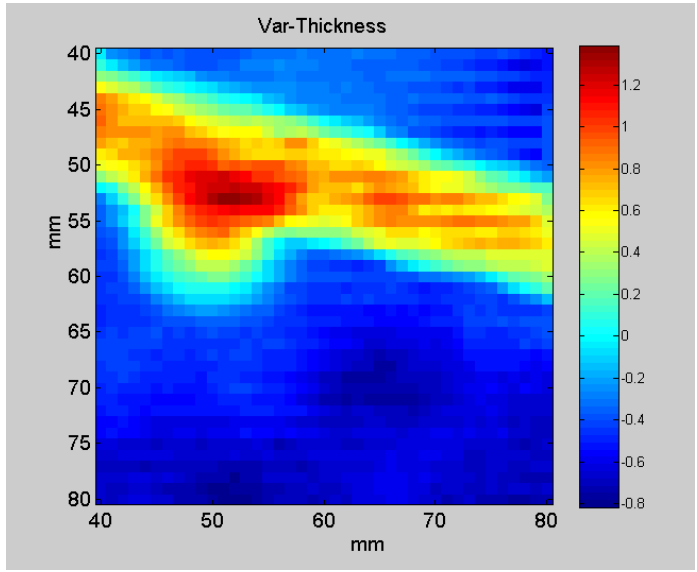
CFRP specimen with 1J impact

Inspection of CFRP specimen with impact and local variation in thickness

Transducer's frequency 1 MHz

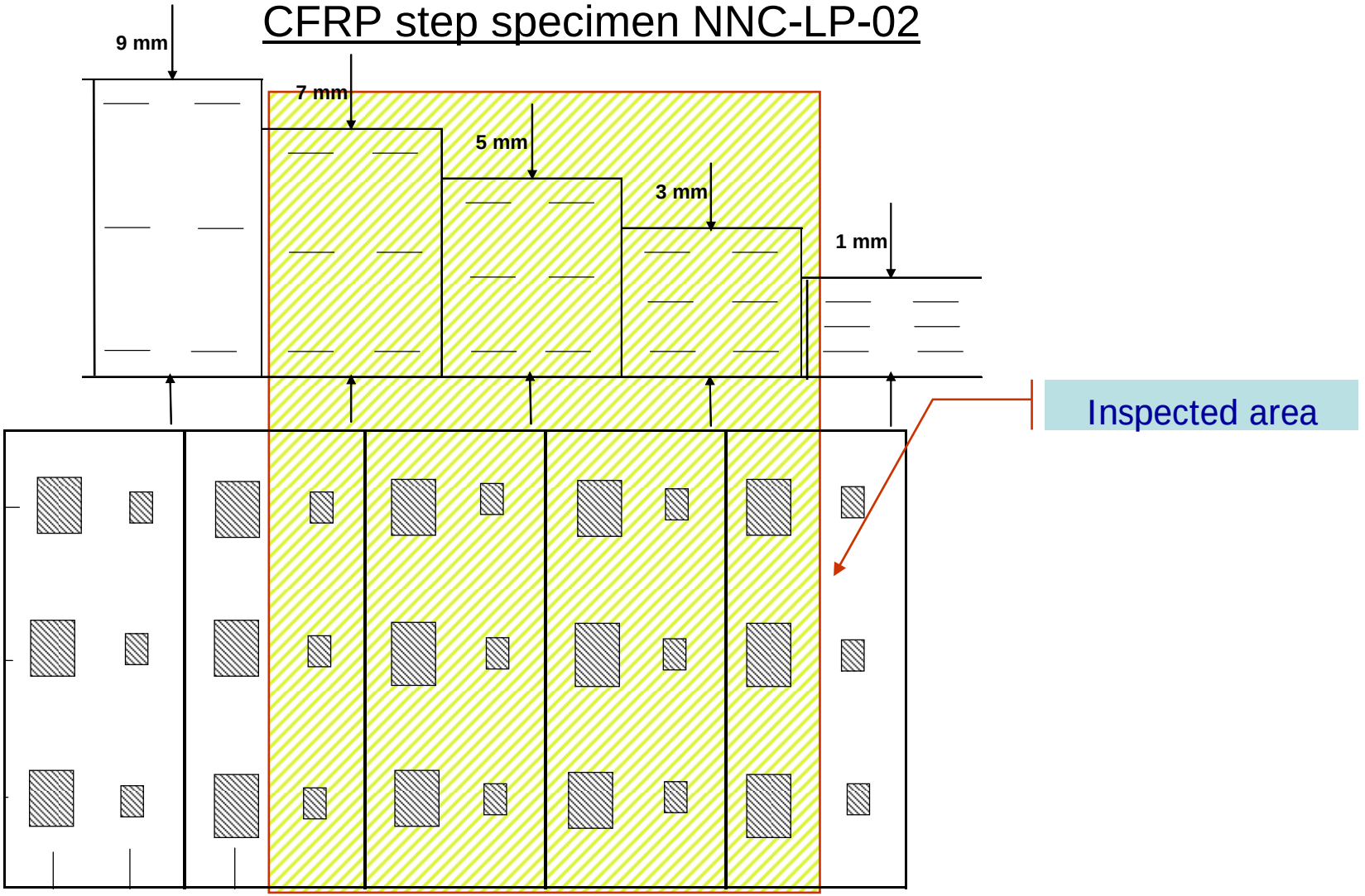


Transducer's frequency 2 MHz



APEX RESEARCH TECHNOLOGIES

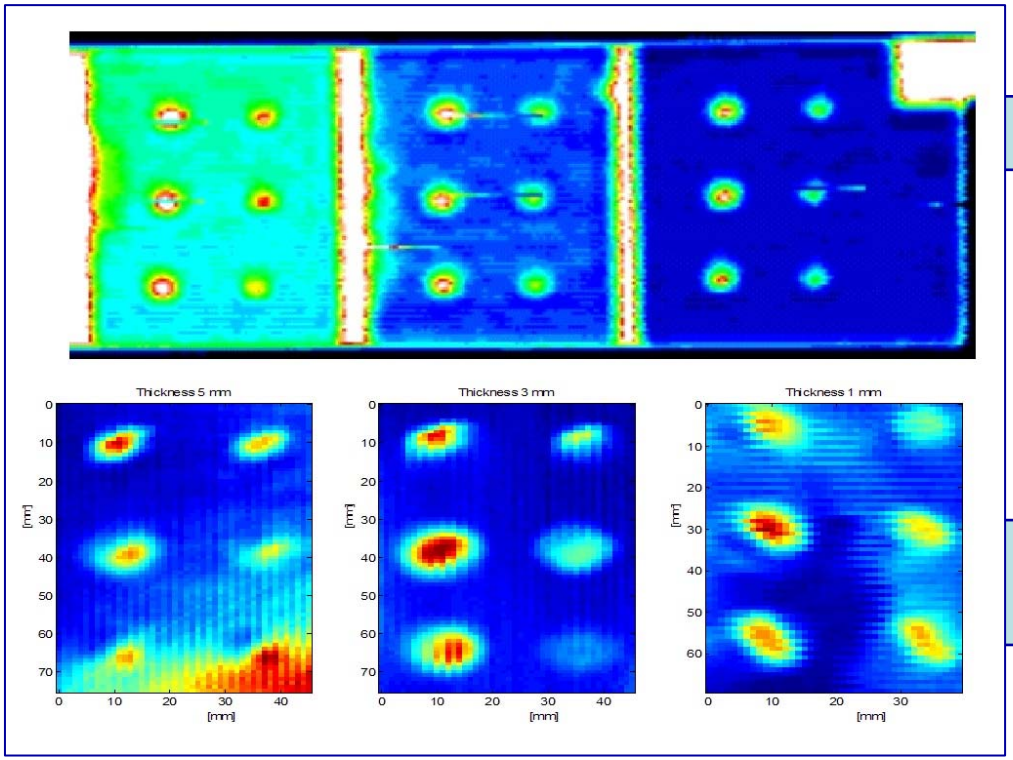
CFRP step specimen NNC-LP-02



APEX RESEARCH TECHNOLOGIES

CFRP step specimen NNC-LP-02

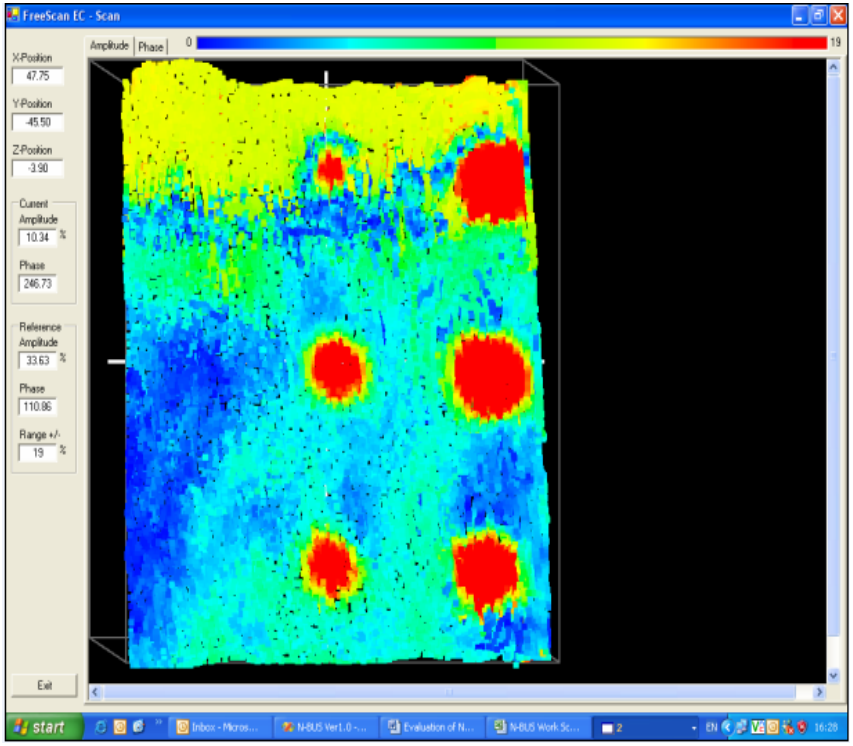
Inspection of CFRP step specimen NNC-LP-02 with artificial defects

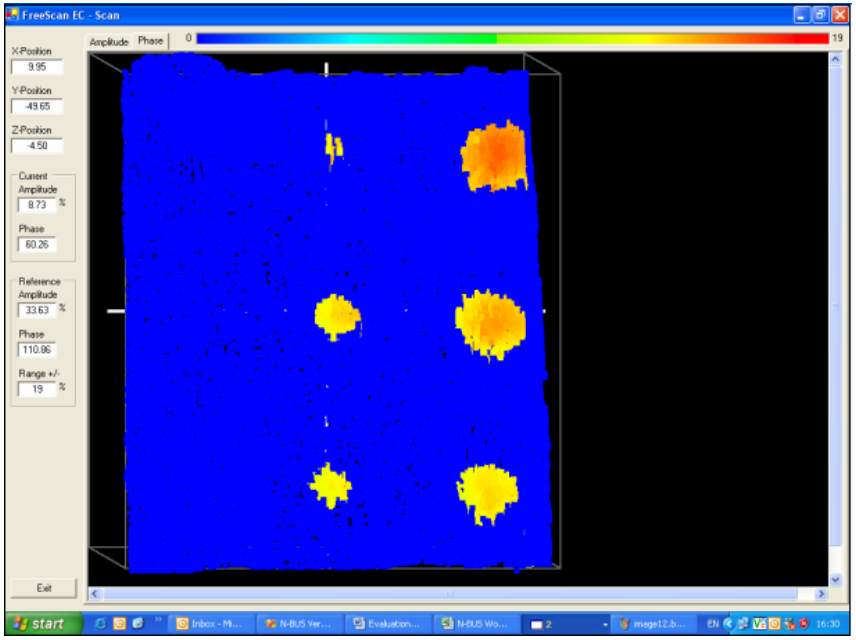


UT C-scan, transmission

Spectroscopy C-scan, one side inspection

FreeScan N-BUS (CFRP)





Case Study

Detection of defects in new Low Density Carbon – Carbon composite material

Conclusion : N-BUS with FreeScan is ideal solution for in-service inspection of C-C parts because in-situ defect detection can be carried out

Defect Detection in thin C-C composites

Objectives

- To determine the capabilities of N-BUS instrument with FreeScan system for detection of defects in Unknown Carbon – Carbon Composite Samples

- To compare N-BUS results with Ultrasonic immersion C-Scan in through transmission mode

- To compare N-BUS results with Ultrasonic immersion C-Scan in pitch catch mode

Details of Samples

- Defects in 1.35 mm Thick Plate Sample

Thickness of the Sample: 1.35 mm

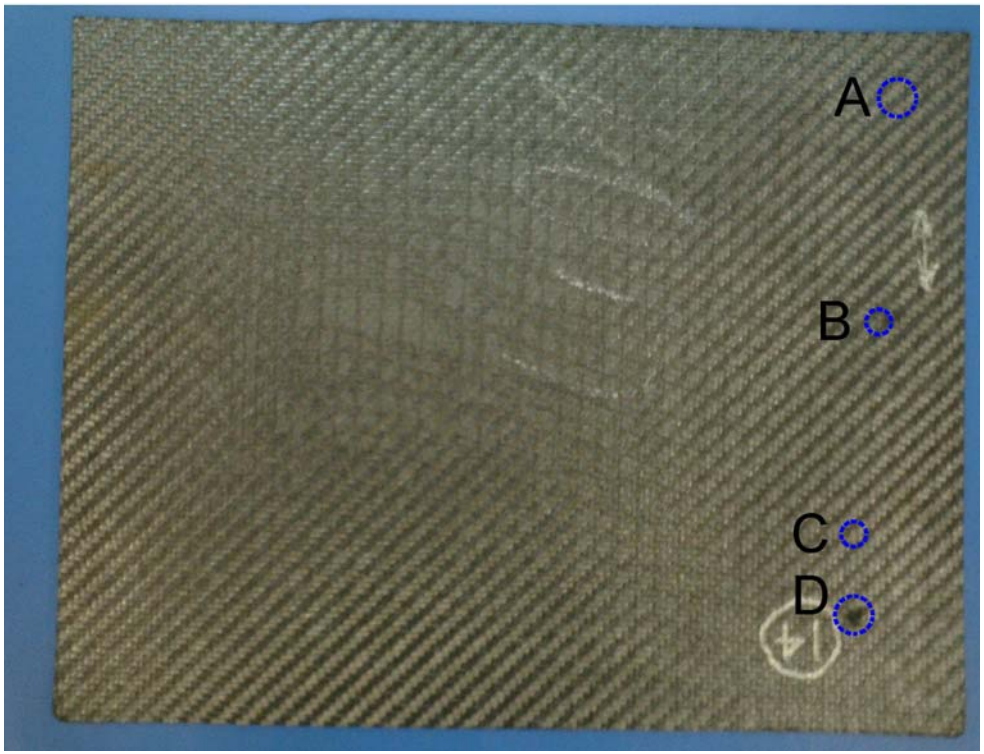
Defects' details:

A. deep: 0.25 mm, diameter: 1 mm

B. deep: 0.23 mm, diameter: 4 mm

C. deep: 0.18 mm, diameter: 1 mm

D. deep: 0.38 mm, diameter: 7 mm



Details of Samples

- Defects in 2.79 mm Thick Plate Sample

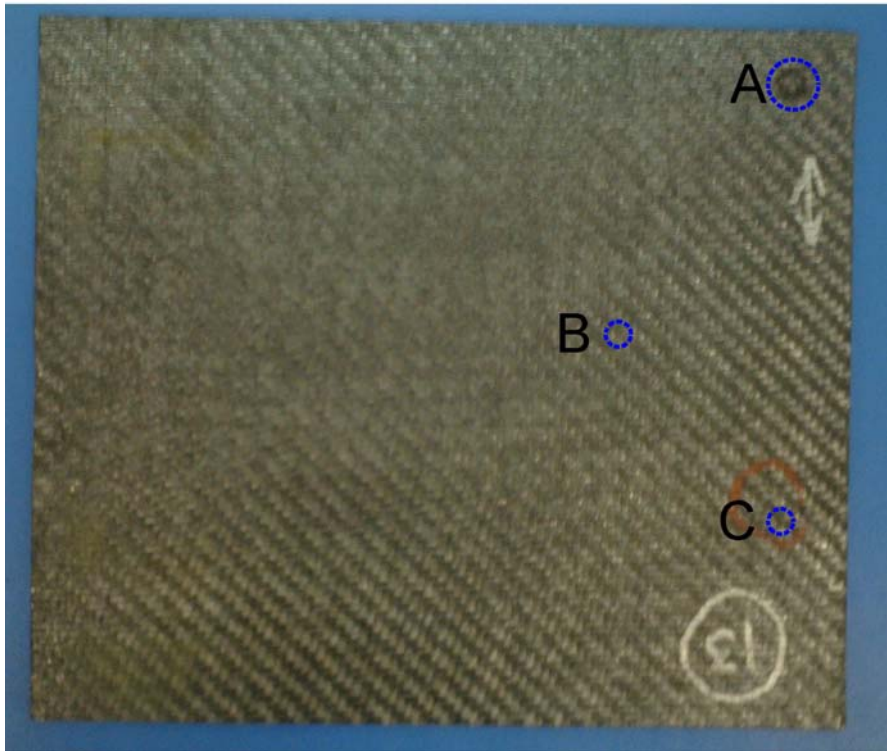
Thickness of the Sample: 2.79 mm

Defects' details:

A. deep: 0.18 mm, diameter: 6 mm

B. deep: 0.29 mm, diameter: 2.6 mm

C. deep: 0.05 mm, diameter: 4 mm

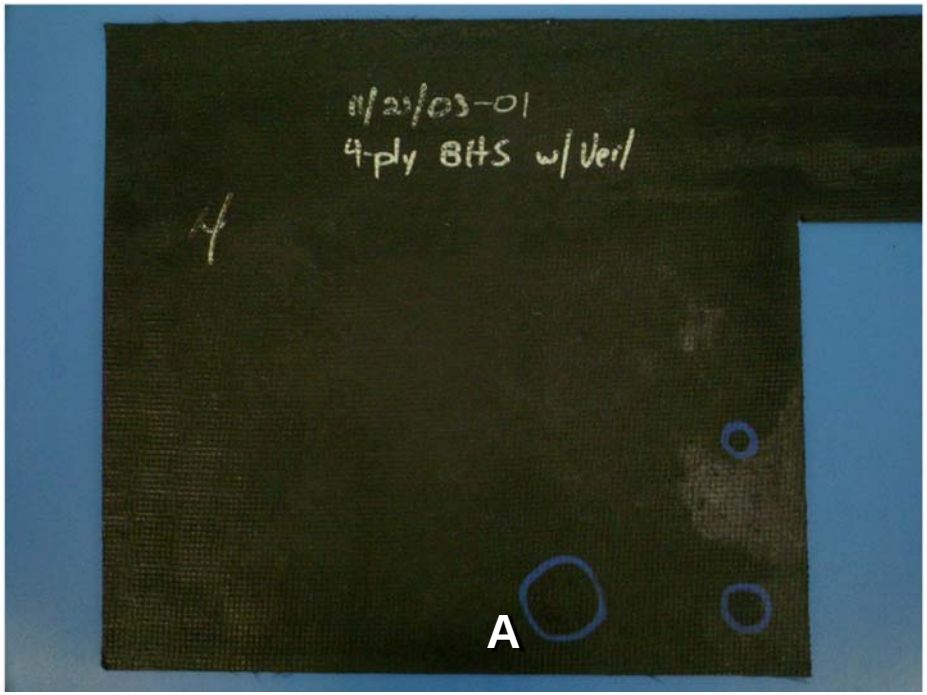


Details of Defect

- Defects in 1.90 mm Thick Cut Sample

Thickness of the Sample: 1.90 mm

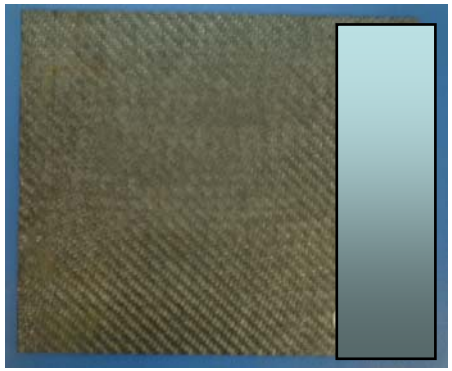
A. Deep: 0.25 mm, diameter: 20 mm



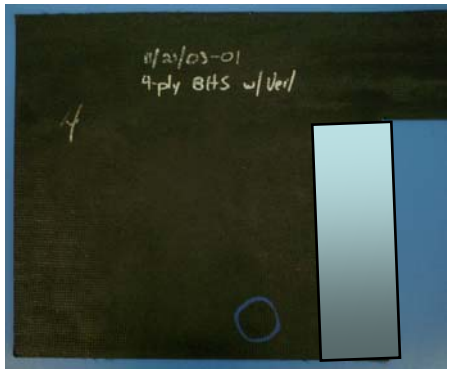
Details of Scanning

- All the samples were scanned by
  - Ultrasonic Immersion scanning in through transmission mode using 5 MHz probe
  - Ultrasonic Immersion scanning using pitch catch mode using 5 MHz probe
  - N-BUS scanning using 1 MHz probe

1 mm thick plate



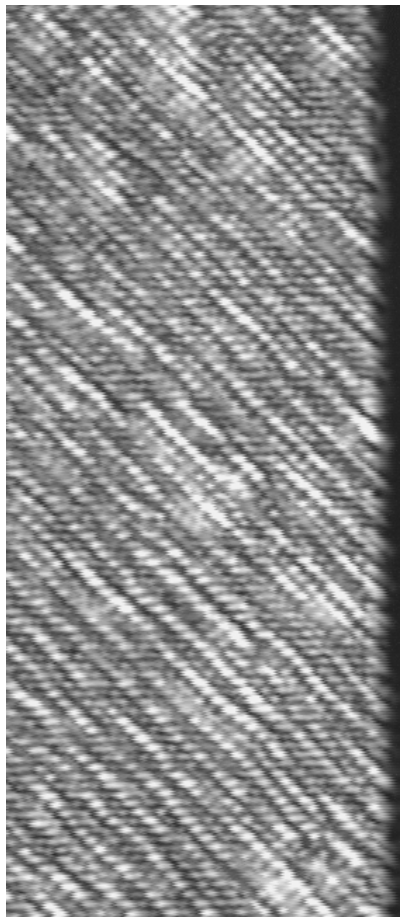
3 mm thick plate



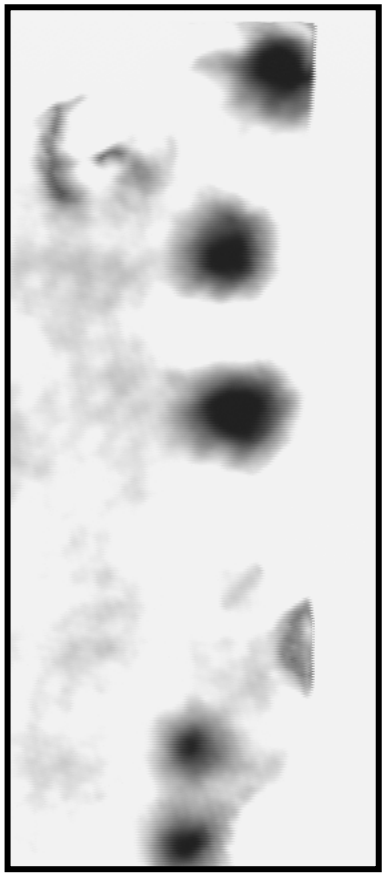
2 mm thick cut plate

- Due to restrictions in current C-Scan setup, the samples were scanned for 70 mm width at the right side as marked in the pictures above
- Scanning for N-BUS was also done over the same area for comparison purposes

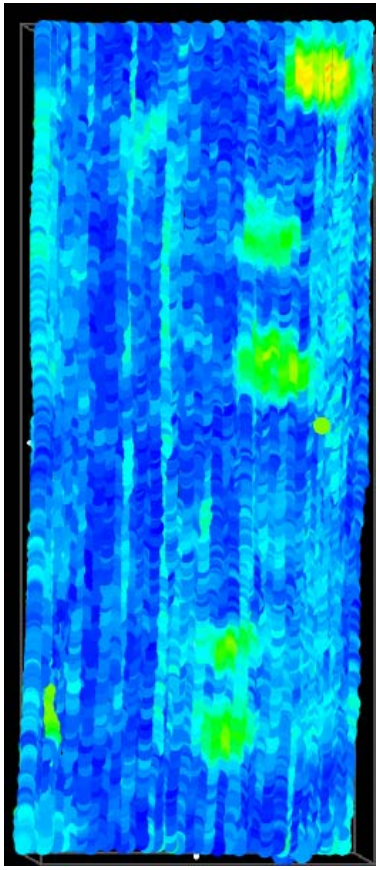
1.35 mm thick sample



C Scan Image Pitch – catch at 0.25 mm pitch

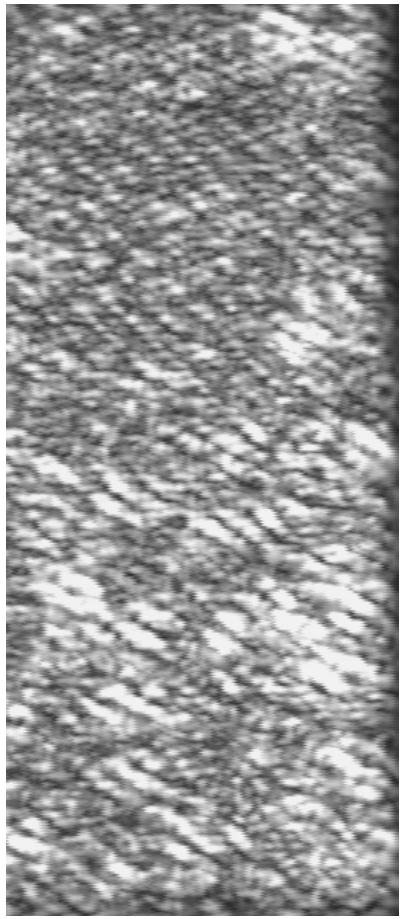


C Scan Image Through Transmission at 0.25 mm pitch

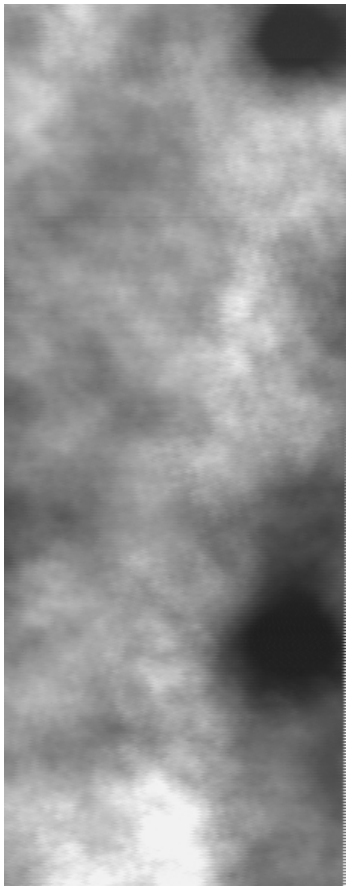


N-BUS Scan Image at 2 mm pitch

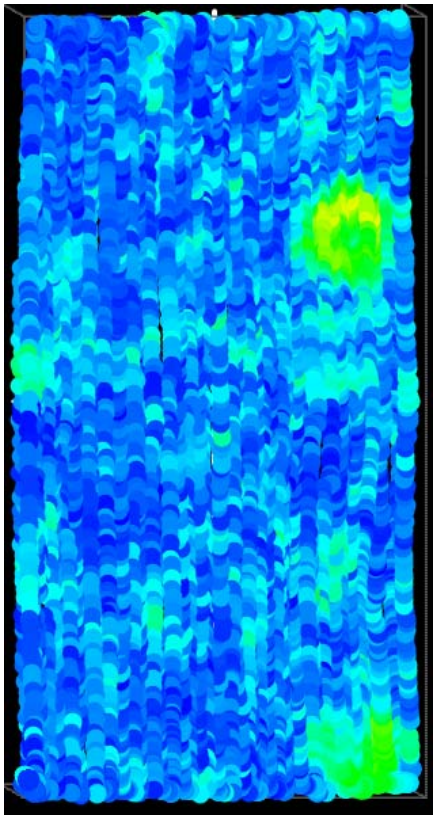
2.79 mm Thick Sample



C Scan Image Pitch – catch at 0.25 mm pitch



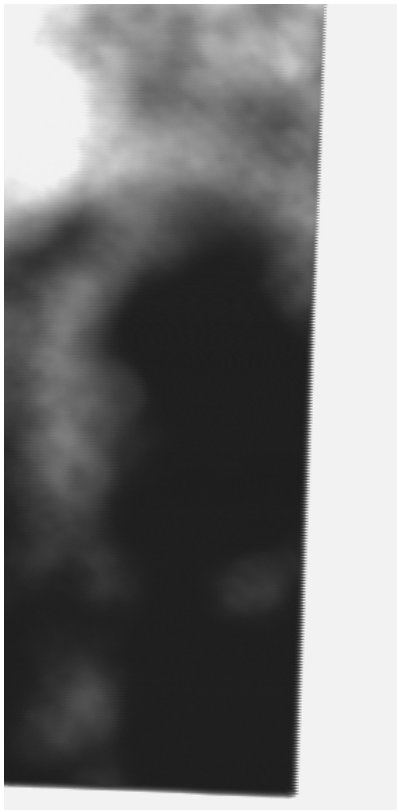
C Scan Image Through Transmission at 0.25 mm pitch



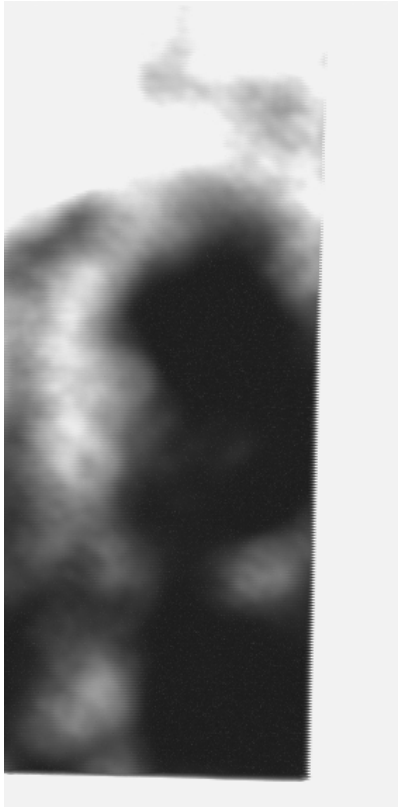
N-BUS Scan Image at 2 mm pitch

(defects on the opposite side)

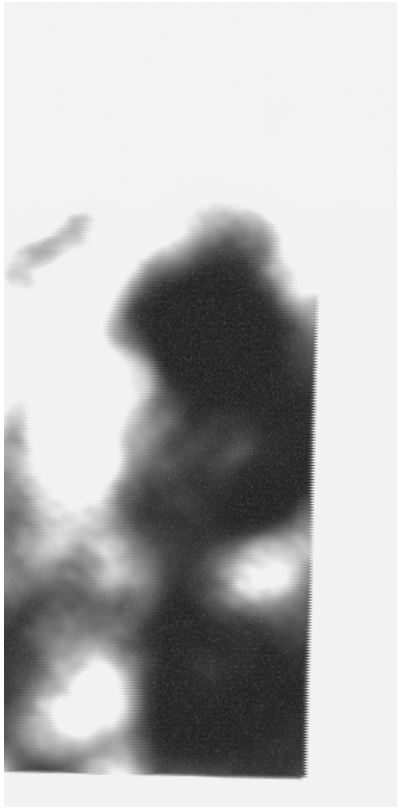
1.9 mm Thick Cut Sample



C Scan Image Through Transmission at 0.25 mm pitch, 18 dB Gain

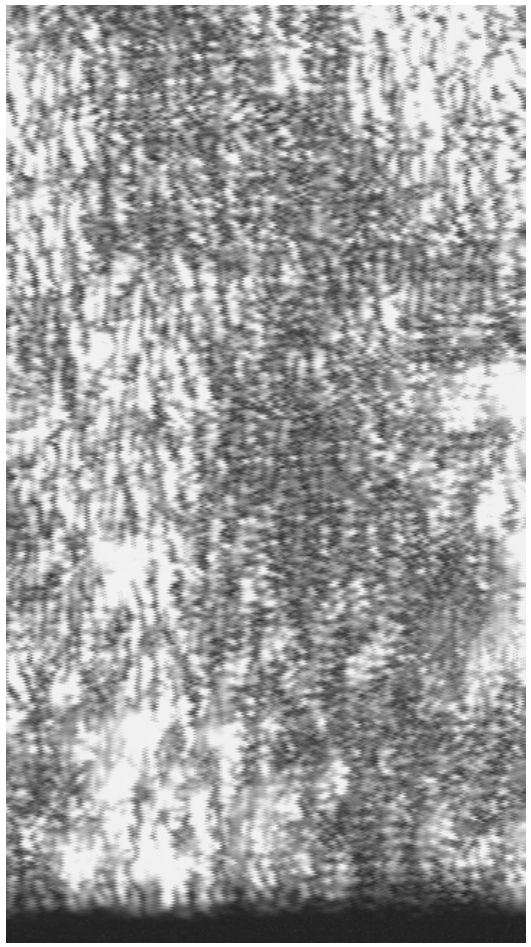


C Scan Image Through Transmission at 0.25 mm pitch, 30 dB Gain

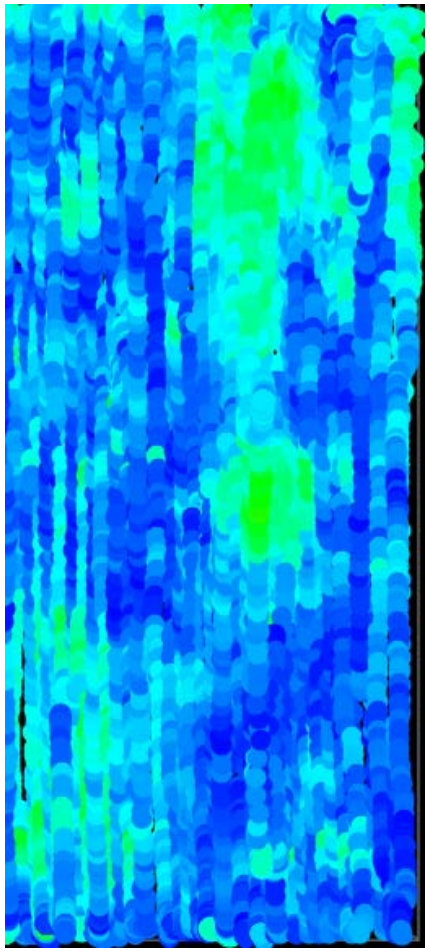


C Scan Image Through Transmission at 0.25 mm pitch, 36 dB Gain

1.90 mm Thick Cut Sample



C Scan Image Pitch – catch at 0.25 mm pitch



N-BUS Scan Image at 2 mm pitch (scanned from opposite side)

Conclusions

- All the defects are picked up by Ultrasonic Immersion Through Transmission Technique
- Ultrasonic Immersion Pulse Echo Technique does not pick up most of the defects
- N-BUS technique along with FreeScan detects all the defects
- NBUS is the most suitable technique for deployment in following applications:
  - **In-service inspection of large components that cannot be taken into immersion tank**
  - **Inspection of components where access from both sides is not available.**