Ultrasonic Characterization of Explosively-Bonded Concentric Tubes

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Presentation Outline

- Background
- Purpose
- Machining
- Microscopy
- Ultrasound techniques
- Conclusions
- Future work

Background

- Concentric tubes used in military applications
- Wear resistance liner (donor tube)
- Tubes bonded explosively
- Many factors in process, affect bond quality
- Ends of composite tube are scrapped
- Bond quality difficult to ascertain

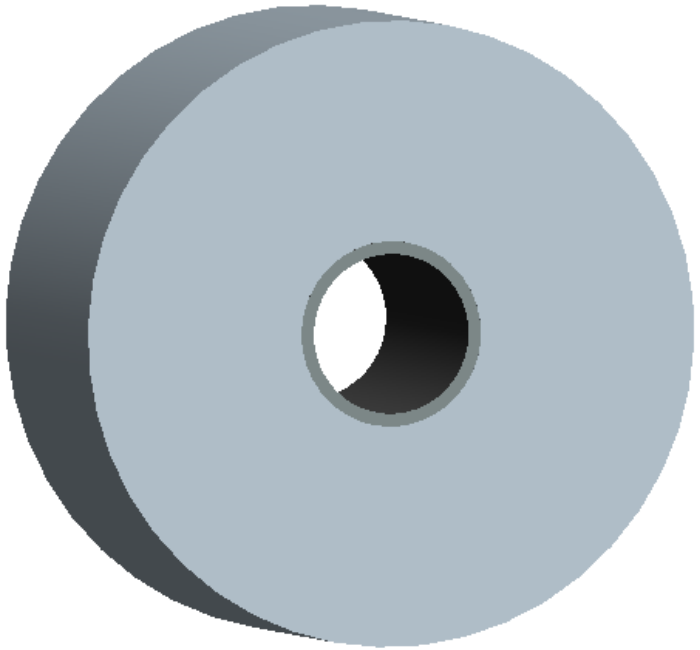
Aim

- Find inspection method for material interface
- Non-Destructive Test (NDT) is preferred
- Assess overall bond quality
- Serve as QC or life monitoring tool
- Correlate NDT and destructive methods

EB Specimen

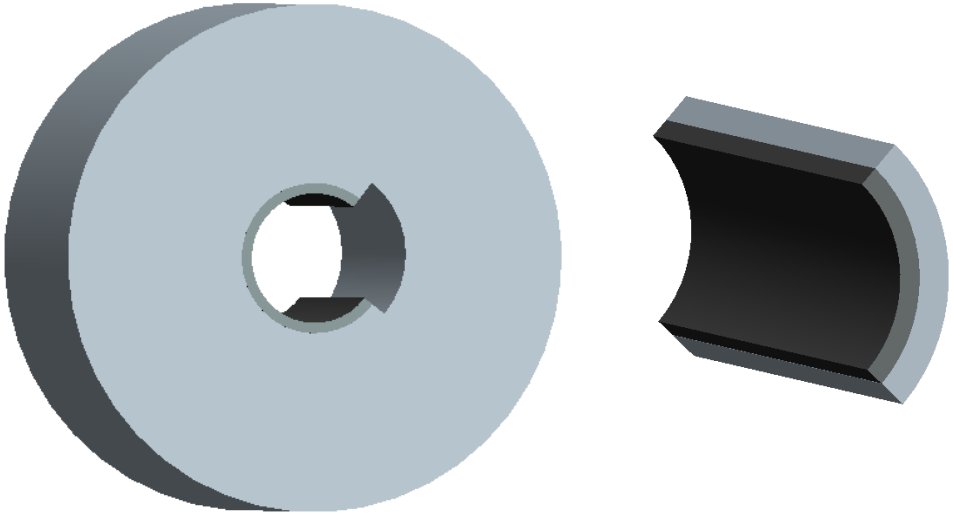
- Steel major tube
- Alloy donor tube
- ~ 3” length
- ~ 4” OD, 1” ID

- 1 “poor” - PEBS
- 1 “good” - GEBS



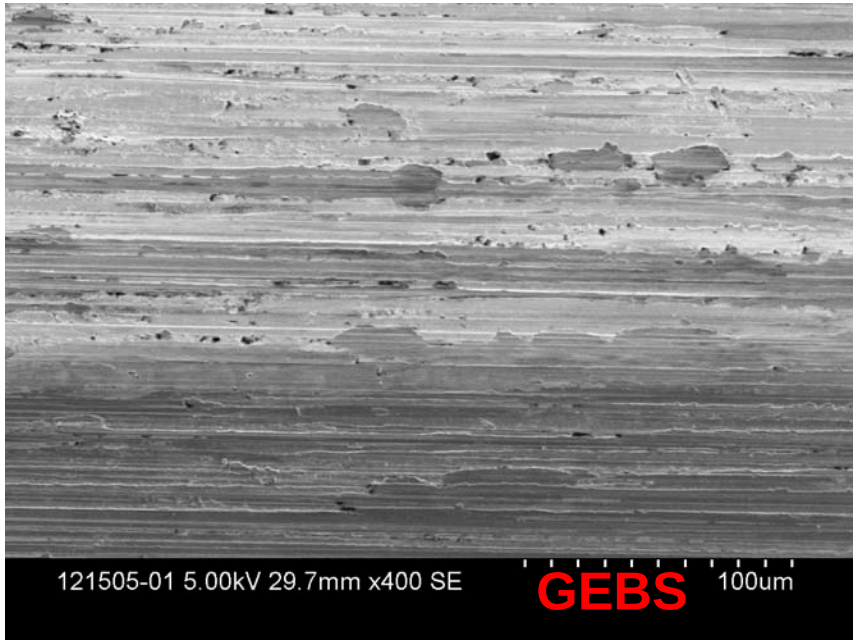
Machining

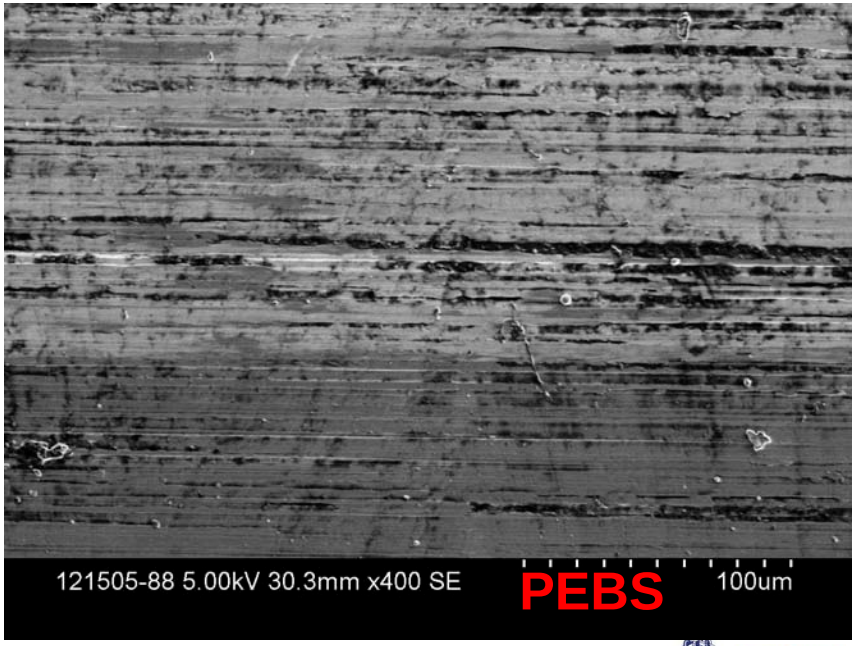
- EDM samples
  - Destructive tests
  - Microscopy
  - Hardness tests
  - Alloy analysis



Microscopy

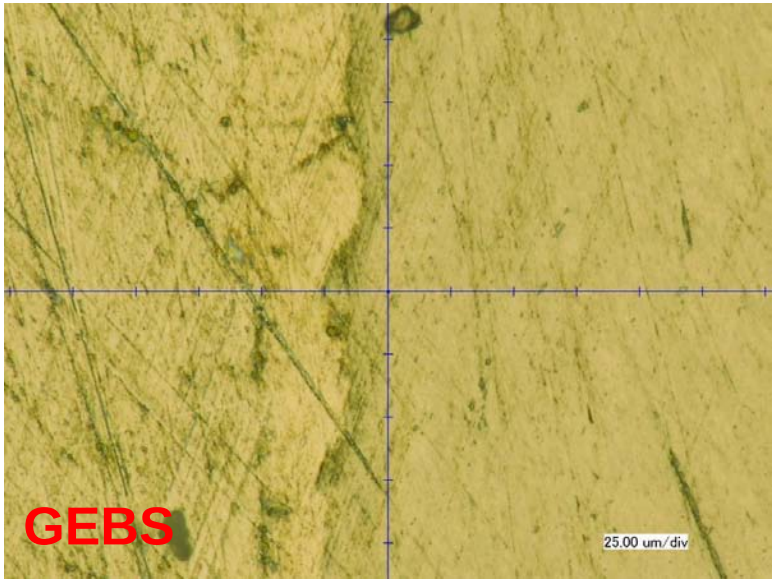
- SEM
  - Destructive, time consuming, small sampling area
  - Looking for “wavy interface” and “material mixing”

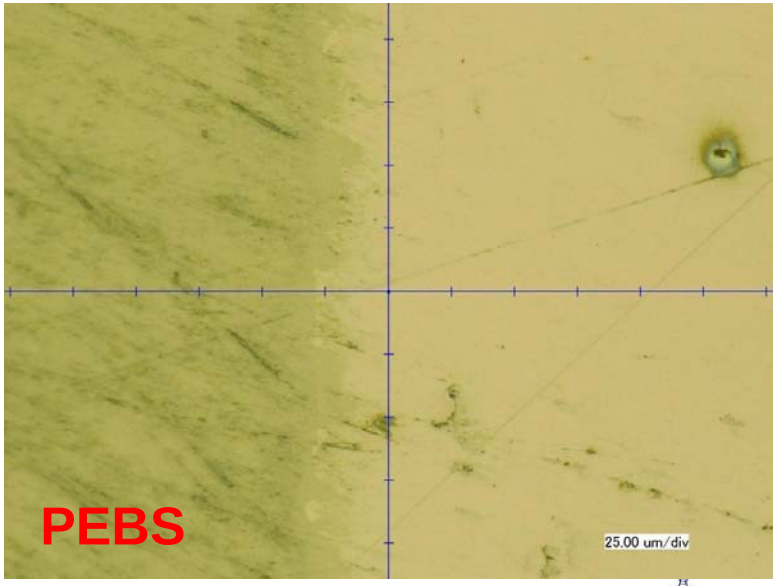




Microscopy

- Digital Microscope
  - Quick, little preparation, color

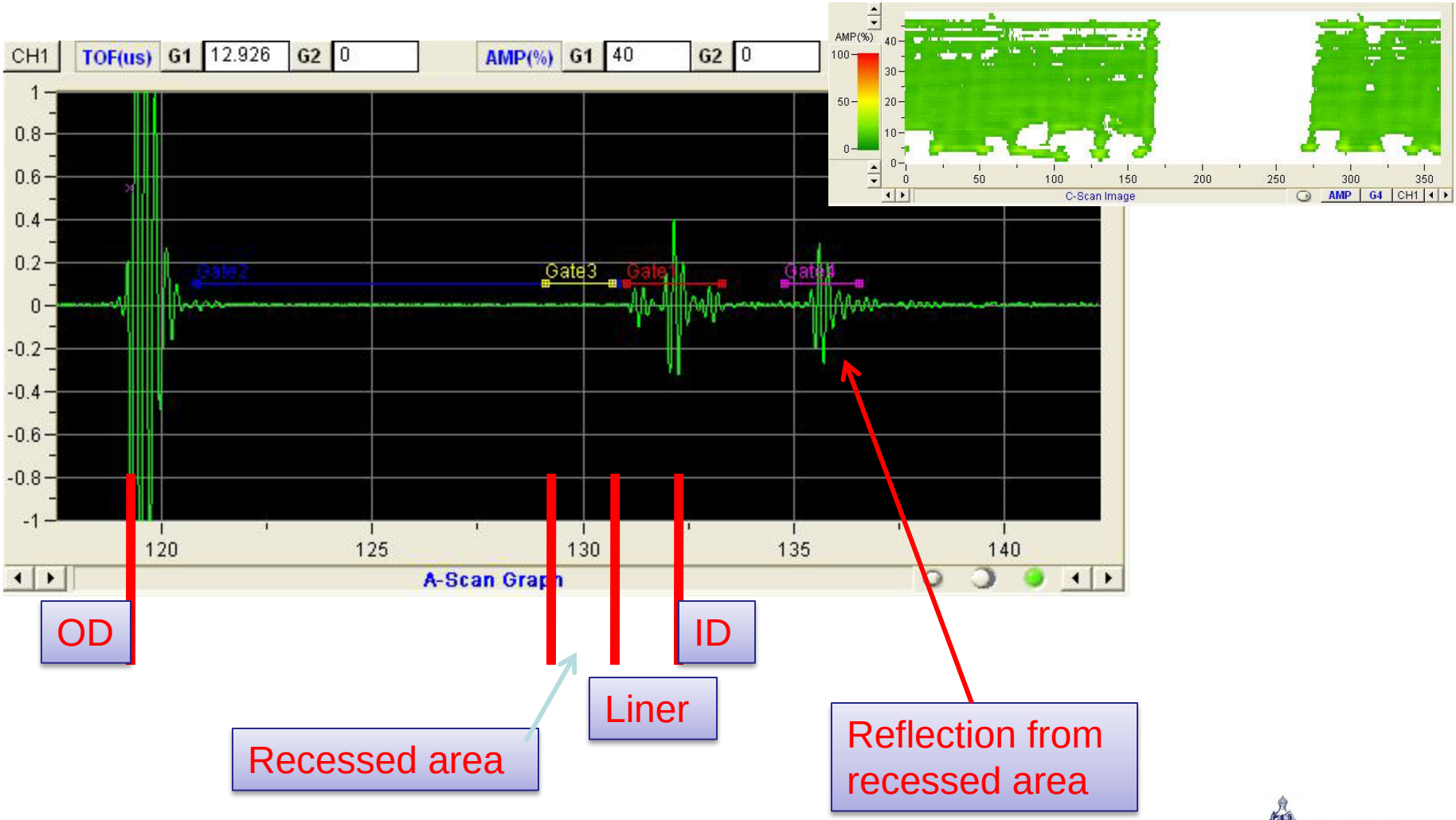




Ultrasonic Methods

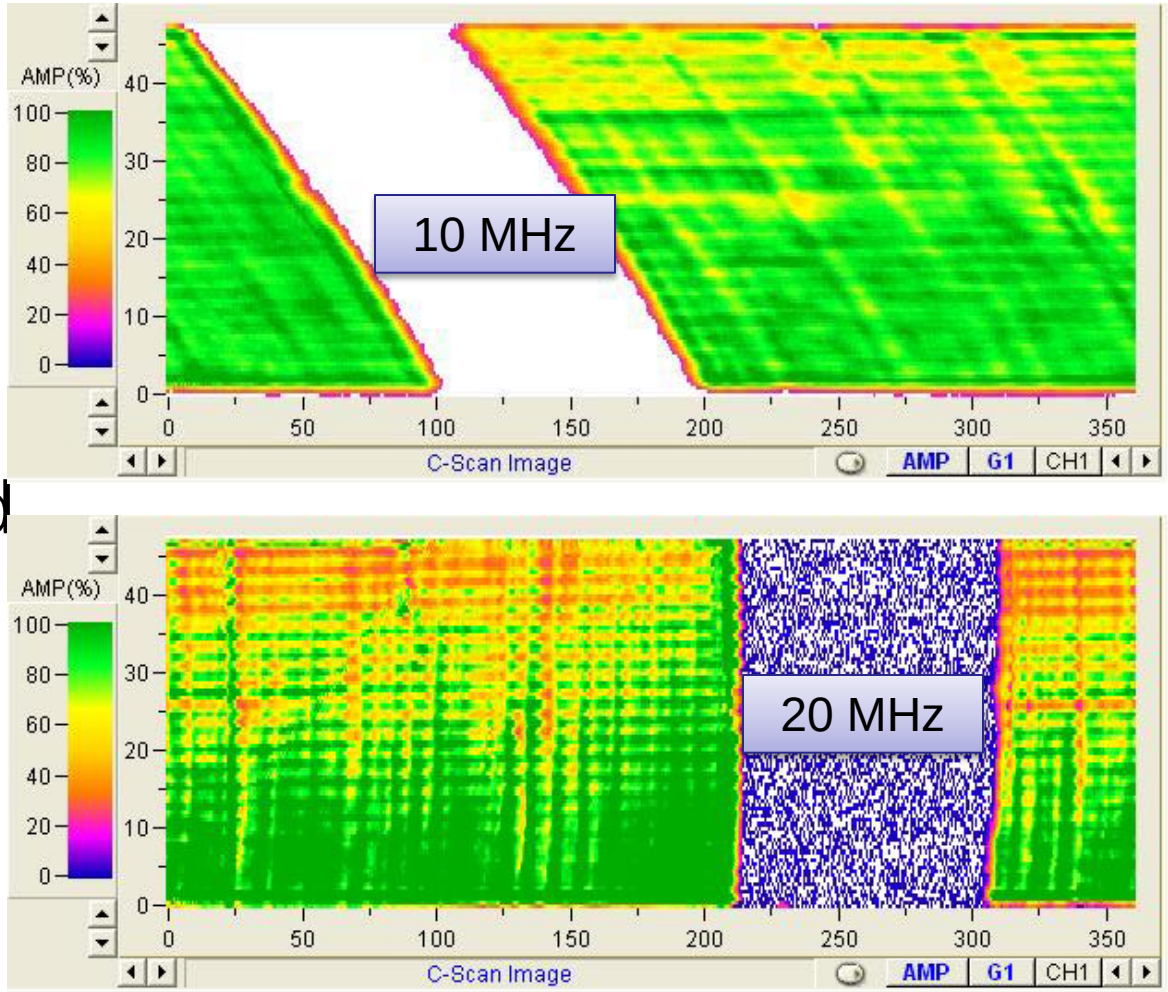
- Physical Acoustics
  - Immersion Scanner
- Resolution 0.0001”
- Max 20 in/sec
- 2,000 lbs max load
- 3-10” diameter tubes
- Up to 5’ length

Bond Focusing



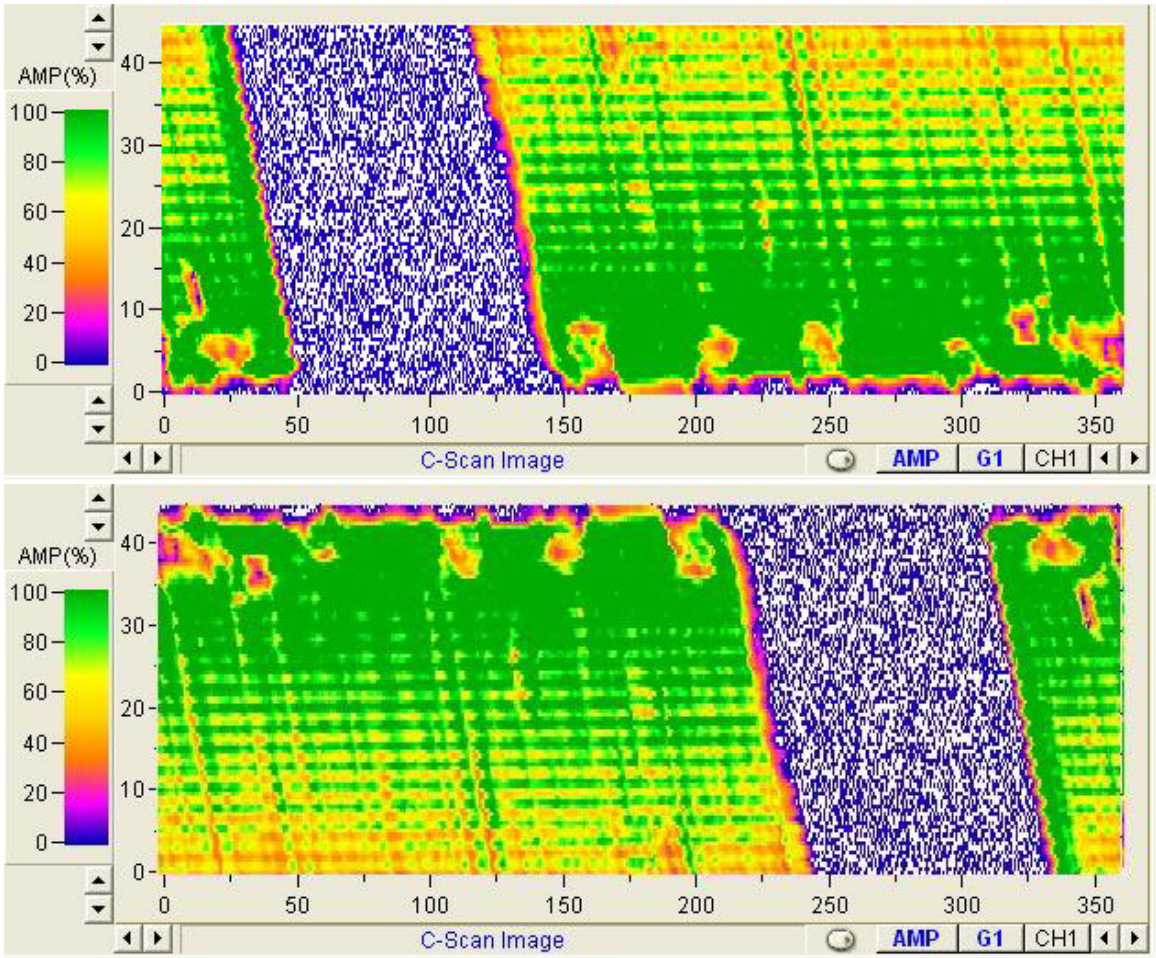
Frequency Optimization

- High frequency
  - Inc. resolution
  - Same settings
- 20 MHz selected
  - On hand
- Gap = Removed
- Slant = Tuning



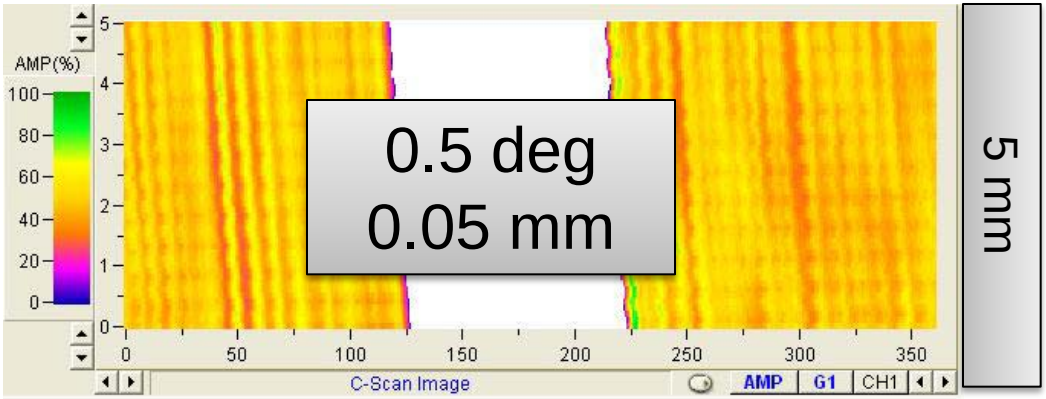
Gradient

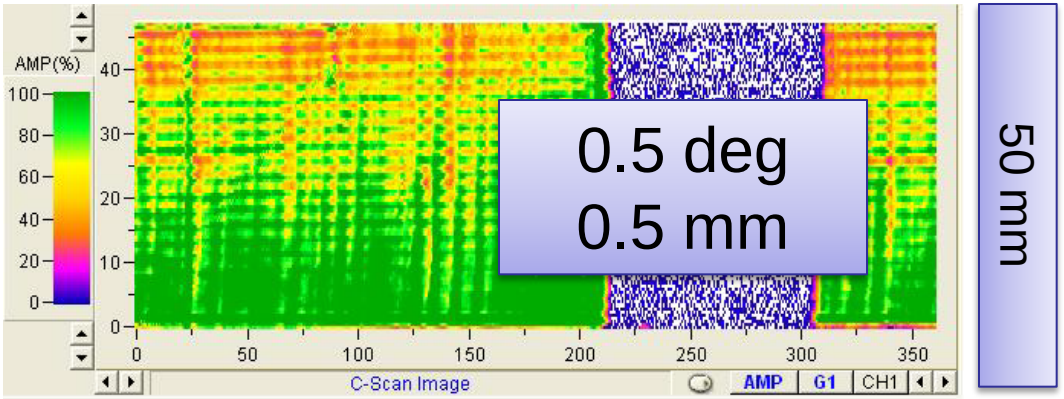
- Caused by ?
  - Δ bond
  - Scan method
- Reversed part
  - Same scan
  - Same trend
- Δ bond is cause
- Less obvious GEBS



Stripes

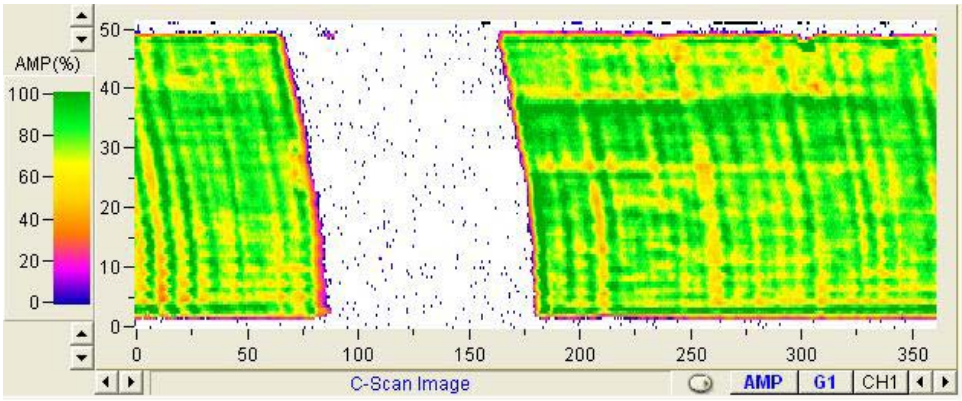
- Caused by ?
  - Wavy axial bond
  - Scan method
- Changed step size
  - Same results
- Scan method

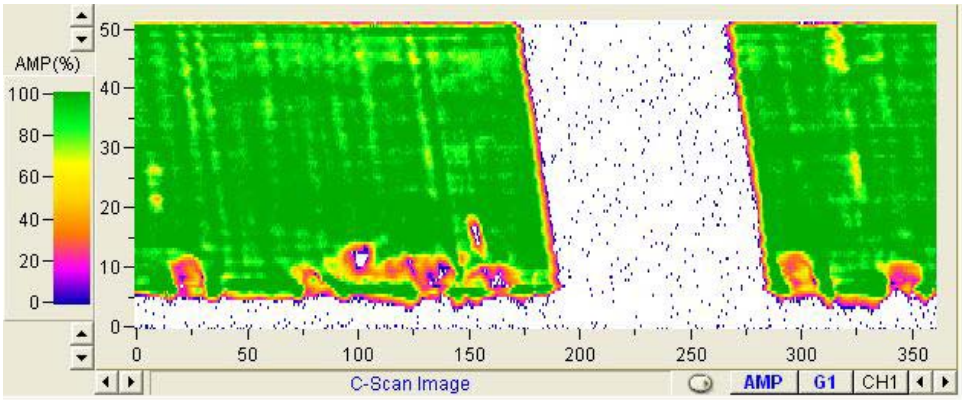




Good vs. Poor

- GEBS
  - Lower reflection amp.
- PEBS
  - Higher reflection amp.
- Good bond provides easier transmission of acoustic energy





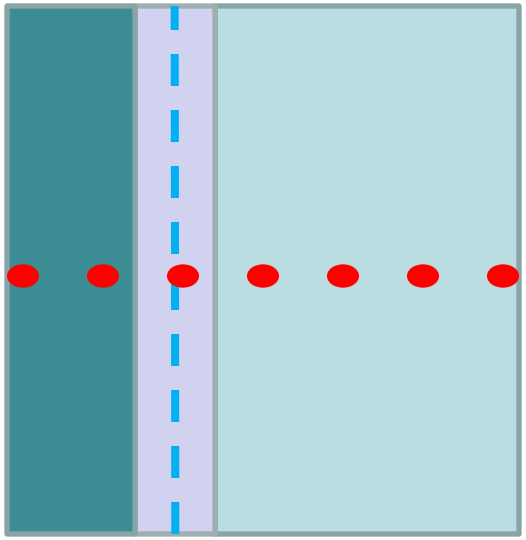
Conclusions

- Semi-Quantitative
  - Need reference tube as standard

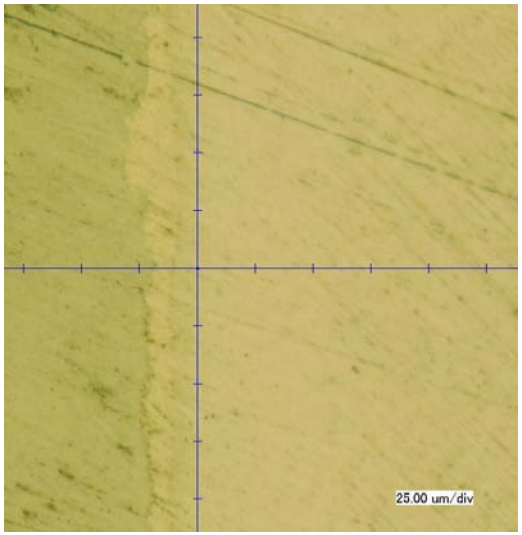
- Poor vs. Good — Distinguishable
- Observed Gradient — Due to bond
- Frequency Effects — Higher (20MHz) is Better
- Stripes — Due to scan method

Future Work

- Reference specimen



- Hardness vs. alloy composition
  - Micro hardness tester
  - Alloy analyzer



- Correlate to NDT-UT & destructive results

Questions?

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