Composite Thermal Damage Measurement with Handheld FTIR

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Composite Thermal Damage Measurement with Handheld FTIR

- Motivation and Key Issues
  - Damage detection in composites requires different techniques than metals
  - Incipient thermal damage occurs below traditional NDE detection limits

FAA Sponsored Project Information

- Principal Investigators & Researchers
  - Brian Flinn (PI)
  - Ashley Tracey (PhD student, UW-MSE)
  - Tucker Howie (PhD student, UW-MSE
- FAA Technical Monitor
  - David Galella (year 3)
  - Paul Swindell (year 1 & 2)
- Industry Participation
  - The Boeing Company (Paul Shelley, Paul /Lbl8001 Tw 0

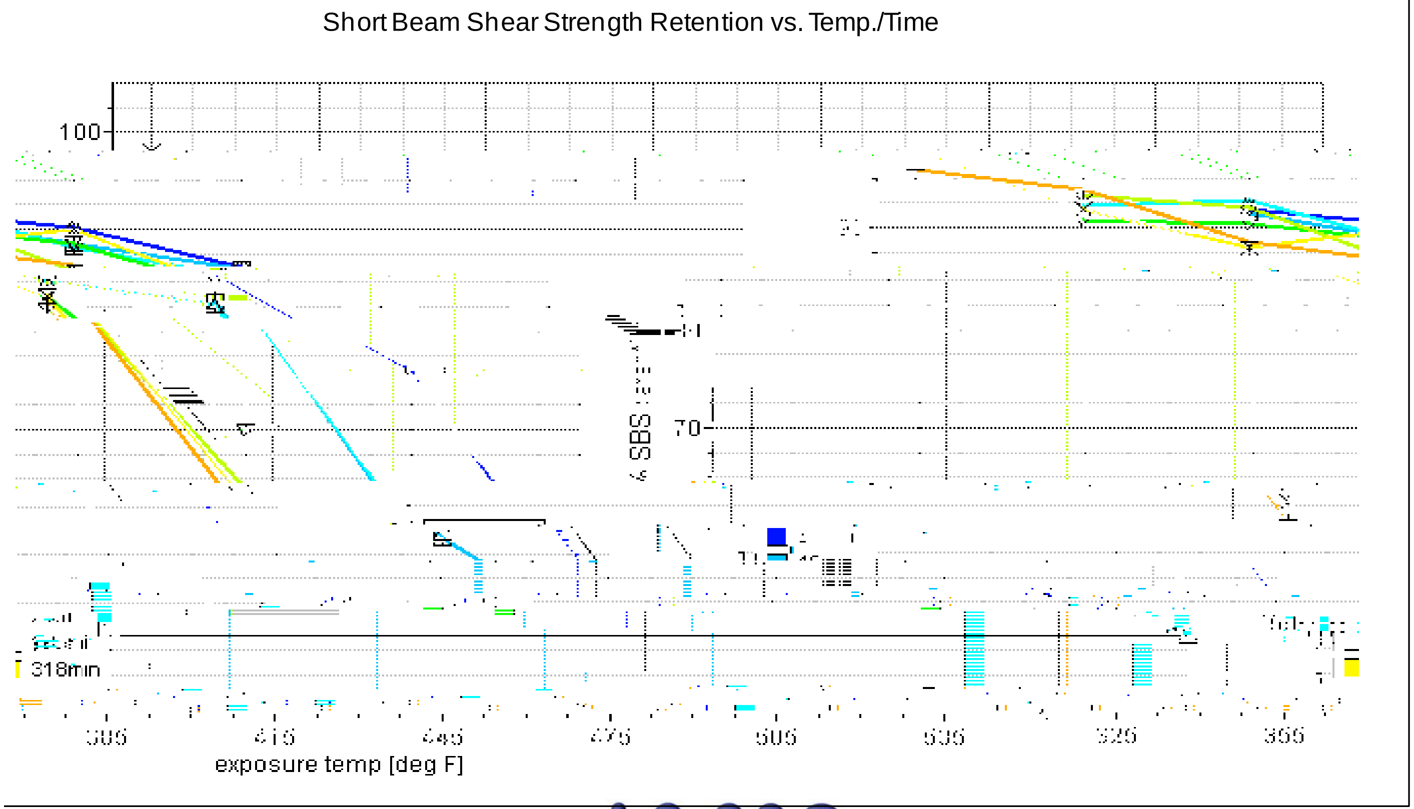
Background

Continuation of existing project (year 3 of 3)

- Years 1 and 2 (A2 Technologies, Boeing and U of DE)
  - Characterization of homogeneous thermal damage
    - Ultrasound
    - Short beam shear (SBS)
    - Microscopy
    - Handheld FTIR (ExoScan)
  - Calibration curve for FTIR detection of thermal damage (SBS data)
  - Mapped surface of localized thermal damage
- Year 3 (UW and Boeing)
  - 3-D characterization of localized thermal damage
  - Include contact angle and fluorescence spectroscopy
  - FTIR guided repair of thermal damage
  - Test repair

Thermal Damage vs. Detection Method

- SBS, ultrasound, and microscopic analysis of composites with thermal damage
  - Properties degrade before detection possible need method to detect incipient thermal damage (ITD)



Experimental Overview

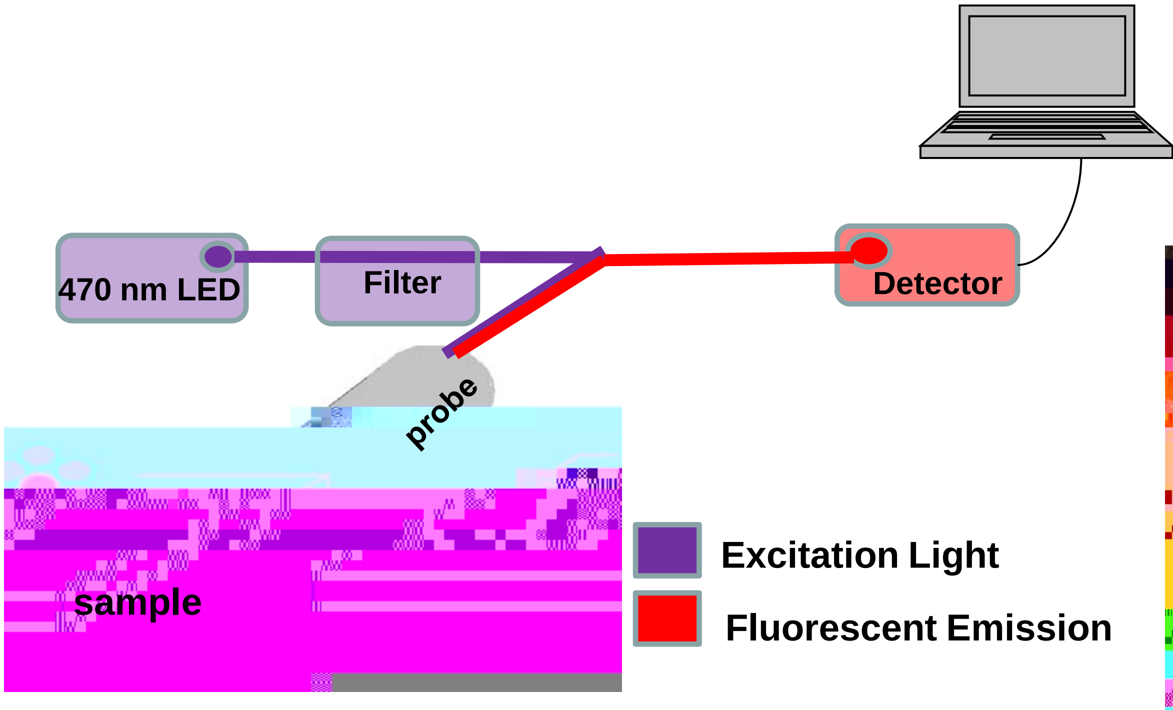
Investigate ITD of composites with various inspection techniques

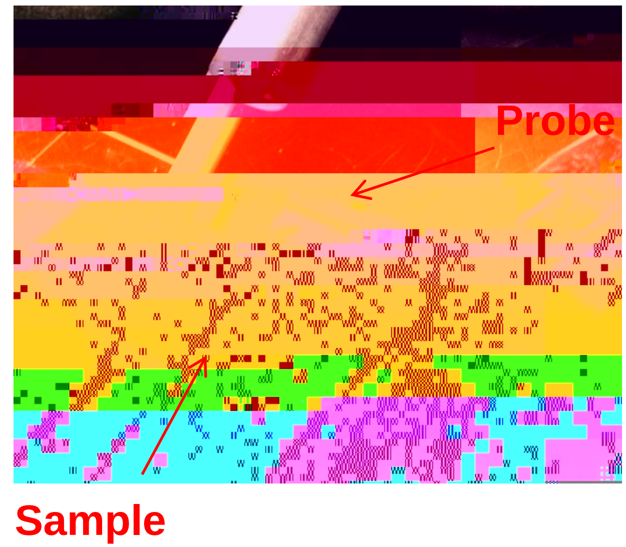
- Characterize composite samples and panels with controlled thermal damage using various methods:
  - Contact angle (CA)
  - Fluorescence
  - FTIR
- Can results be related to SBS values and detect thermal damage?

Materials and Process

- Toray 3900/T800 composites with various levels of thermal damage
  - Provided from Year 1 & 2 research
  - SBS samples thermally exposed in air
  - Panels with localized thermal damage in vacuum
- Characterize toolside (resin rich) and sanded (resin poor) surfaces
  - Sand surfaces with random orbital sander using 120 grit 3M Al_2O_3 sanding pads
- Measurement techniques: CA, fluorescence, FTIR

Materials and Process – Fluorescence



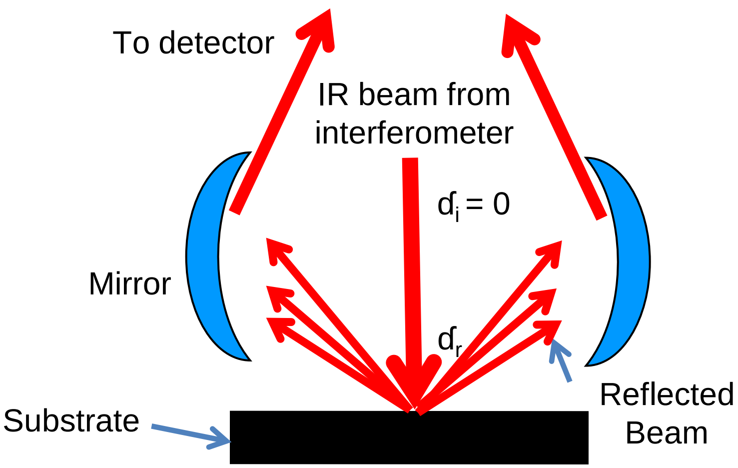


- Sample absorbs excitation light and emits light at longer wavelength than the absorbed light (fluorescence).
- Measure changes in intensity and wavelength at max intensity (λ_{MAX}) of fluorescence emission

Materials and Process – FTIR

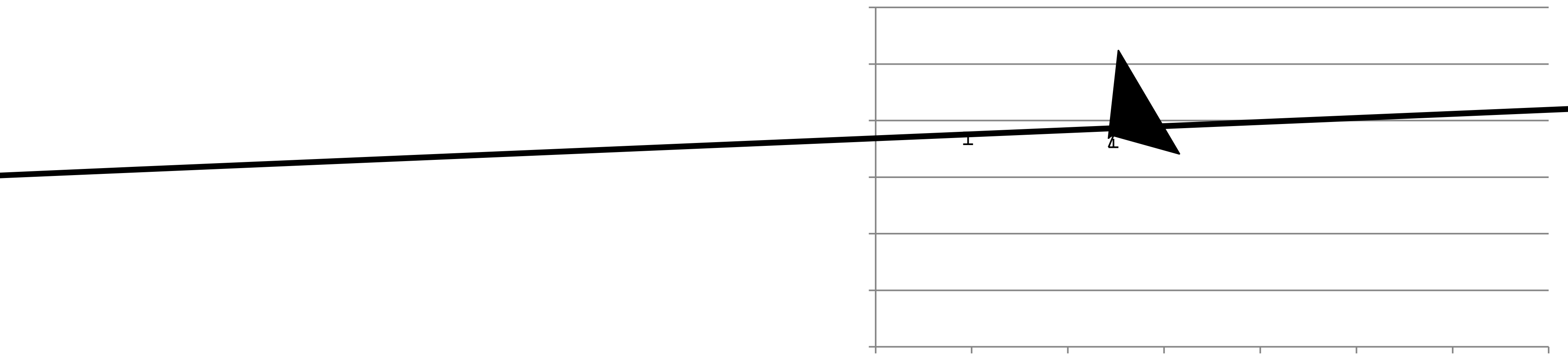
- Mid-IR data region: 4000 cm^{-1} to 650 cm^{-1}
- Diffuse reflectance sampling interface
- Data collection: 120 coadded scans with 8 cm^{-1} resolution for background and specimen

ExoScan FTIR



An infrared beam path for diffuse reflectance

Year 3 Results: CA Measurements on SBS Samples



increasing thermal damage

increasing thermal damage

- CA on sanded surface lower than toolside surface
- No significant correlation between SBS values and CA measurement – 415, 445, 475, 505 °F

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Year 3 Results: FTIR Verification

- FTIR measurements on resin rich surface of SBS consistent with previous results
  - Oxidation peaks increase with damage

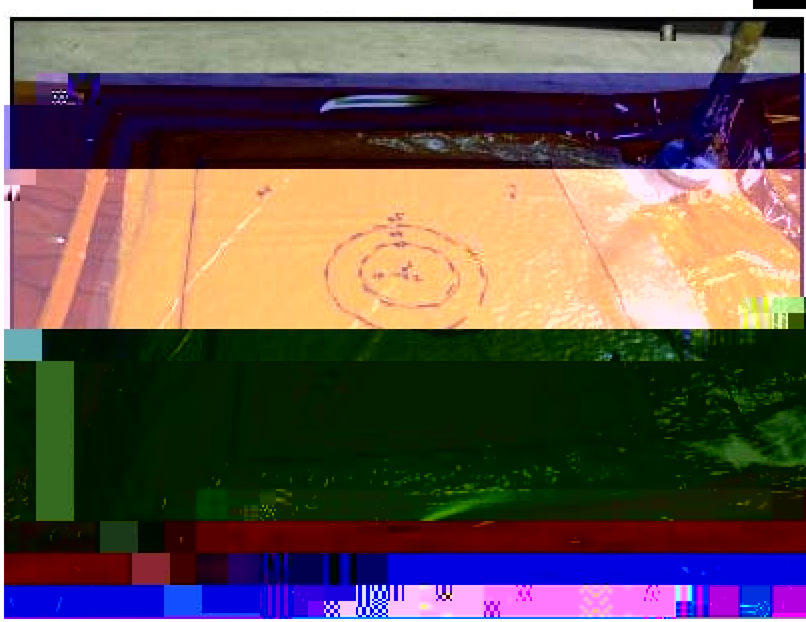
Year 2 Results: FTIR on Sanded Surfaces

Year 3 Results: FTIR Orientation

- Signal varies based on sample orientation
  - –

Year 1 & 2 Results: Localized Damage

- Hot spots created
- 3 temperatures
  - 440, 465, 490 °F
- 2 panels each



Year 1 & 2 Results: Map of Localized Damage

- FTIR Map of Surface Damage
  - Blue is low damage
  - Brown is high damage

Year 3 Results: Panel Mapping

Future Work

- Apply multivariate analysis
- Surface map thermal damage (all panels)
- 1st set of panels- mechanical testing (SBS, Tg)
- 2nd set of panels – scarf repair guided by FTIR
  - Map damage ply by ply during scarfing FTIR
  -

Looking Forward

- Benefit to Aviation
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End of Presentation.

Thank you.