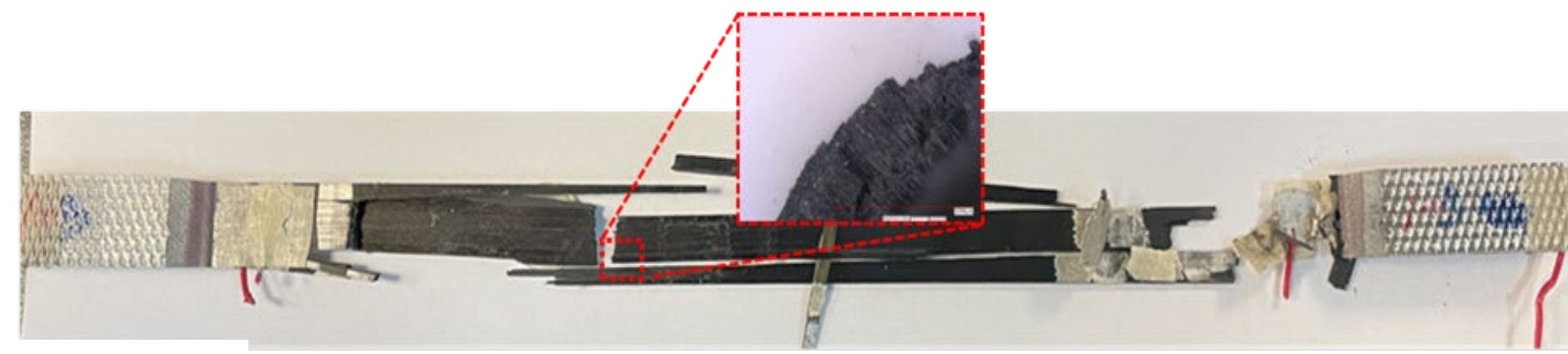


# Different Acoustic Signals in Tensile Testing of Continuous and Discontinuous Carbon Fiber Composites

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## Introduction

- Continuous and discontinuous carbon fiber composites in tension have different failure mechanisms



Disc.

- Discontinuous fiber composites
  - Fiber Pullout
  - Matrix Cracking
  - Fiber Breakage
  - Void Formation

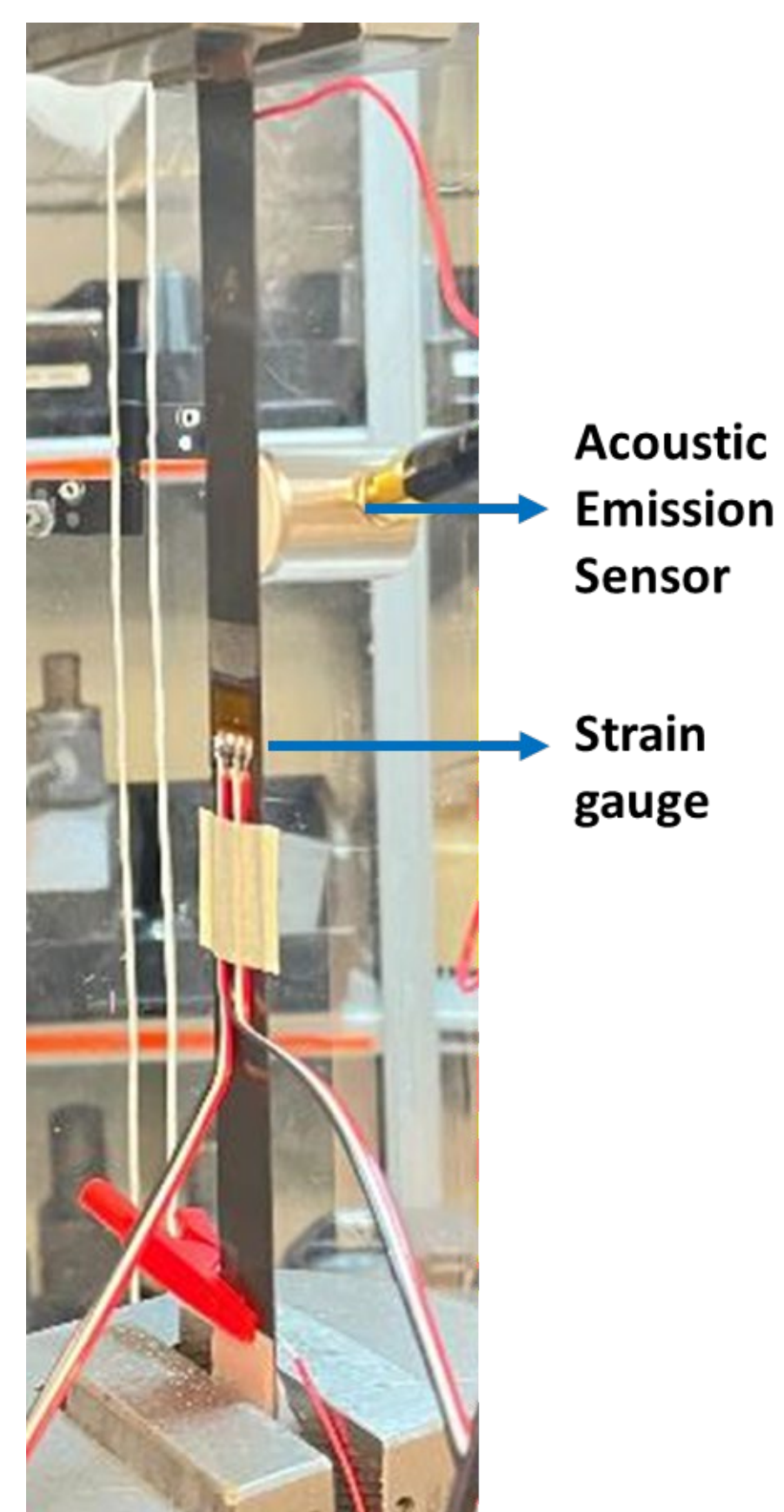


Cont.

- Continuous fiber composite
  - Fiber Breakage
  - Delamination
  - Fiber matrix debonding
  - Matrix Cracking

- Acoustic emission (AE) signals generated during testing can provide more information about failure mechanism

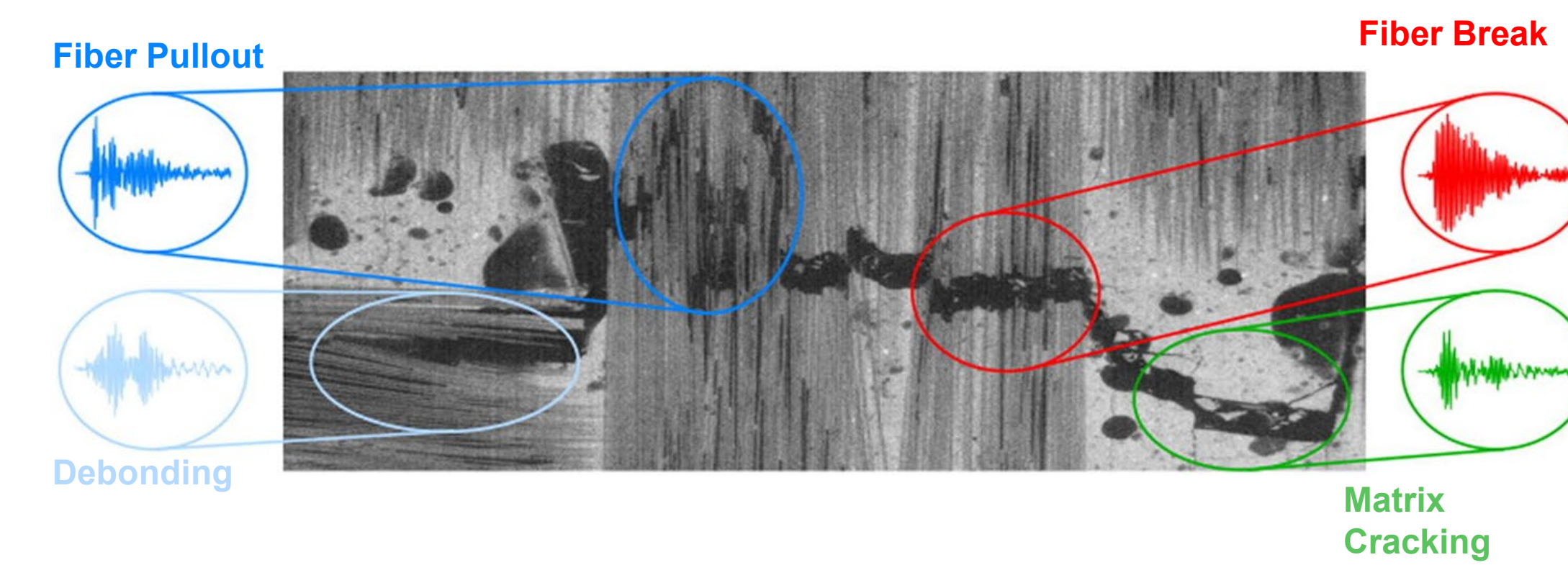
## Tensile Test Setup



- AE sensor was attached about 1-2 inches away from the strain gauge
- Samples were loaded at the rate of 0.05 inch/min until failure
- Load and strain data is recorded along with acoustic signals
- AE data was recorded and analyzed using AEwin

## Acoustic Signals in Composite Failure

- Each AE hit produces its own unique waveform
- These waveforms are very helpful as they can
  - Distinguish between failure modes (as shown in the graphic above)
  - Locate crack initiation
  - Provide real-time information about the health/degradation of a material



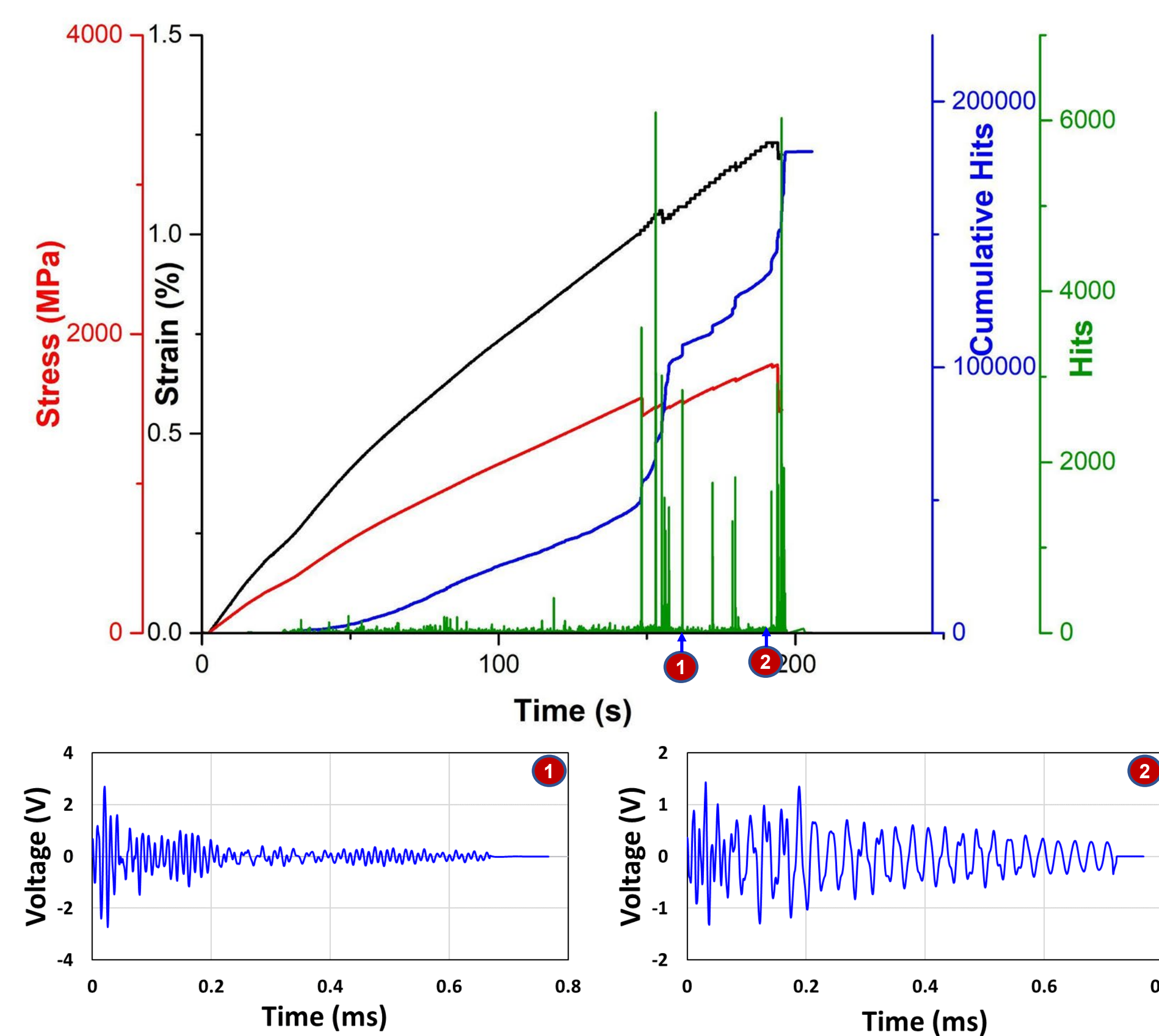
## Acoustic Emission Analysis

- Feature Analysis**
  - Uses parameters to determine damage
  - Common parameters include amplitude, duration, and rise time
- Frequency Analysis**
  - Uses frequency properties to determine damage type
  - Techniques include fast Fourier transform, wavelet transform, and power spectral density
- Modal Analysis**
  - Identifying and characterizing the different wave modes generated by the failure events

Parameter	Matrix Cracking	Fiber Breakage	Delamination
Amplitude	Low to Moderate	High	Moderate to High
Energy	Moderate	High	Moderate to High
Rise Time	Long	Short	Variable
Duration	Long	Short	Variable
Counts	Moderate to High	High	High

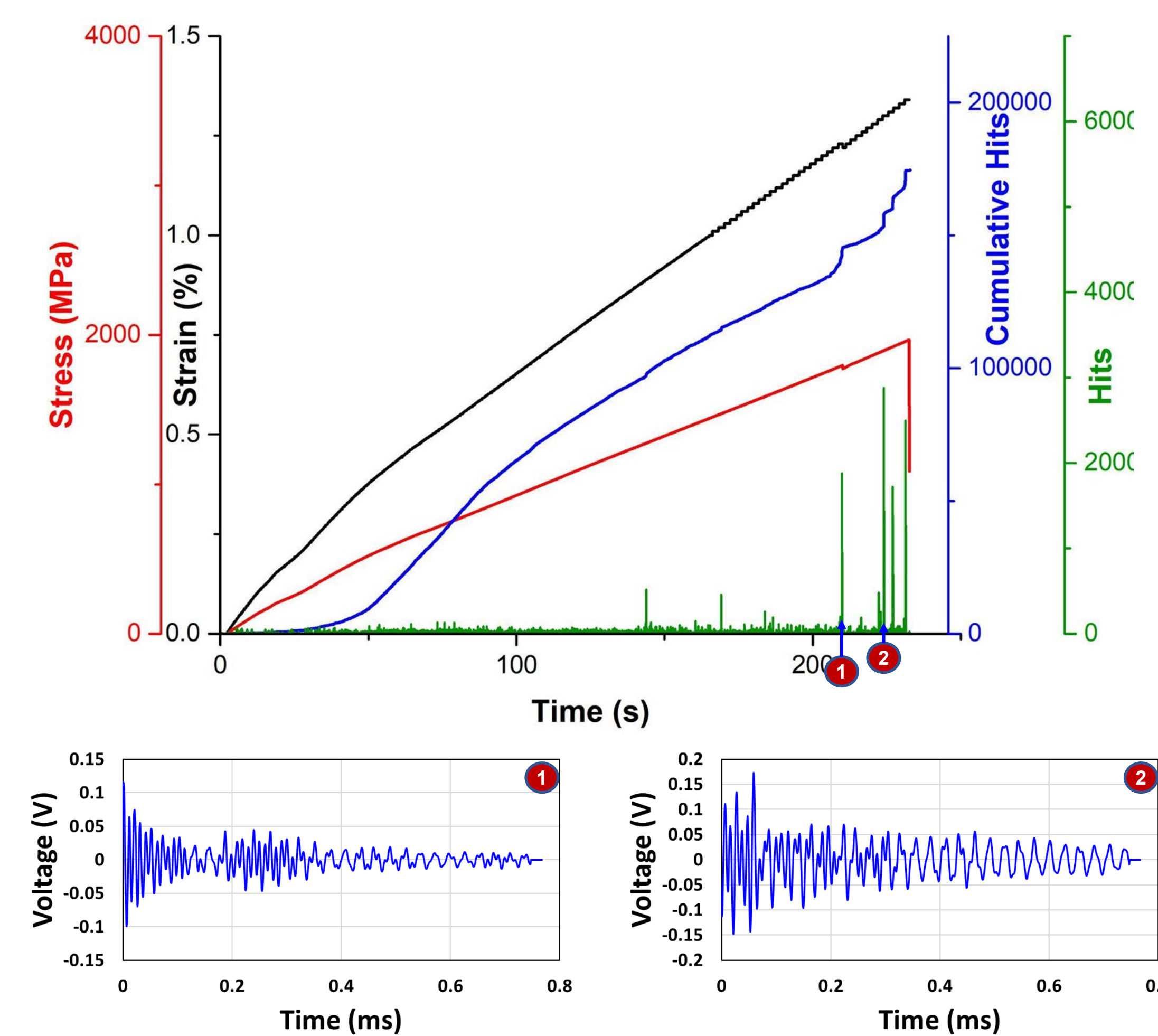
## AE in Carbon Fiber Composites

### Continuous Carbon Fiber Composite

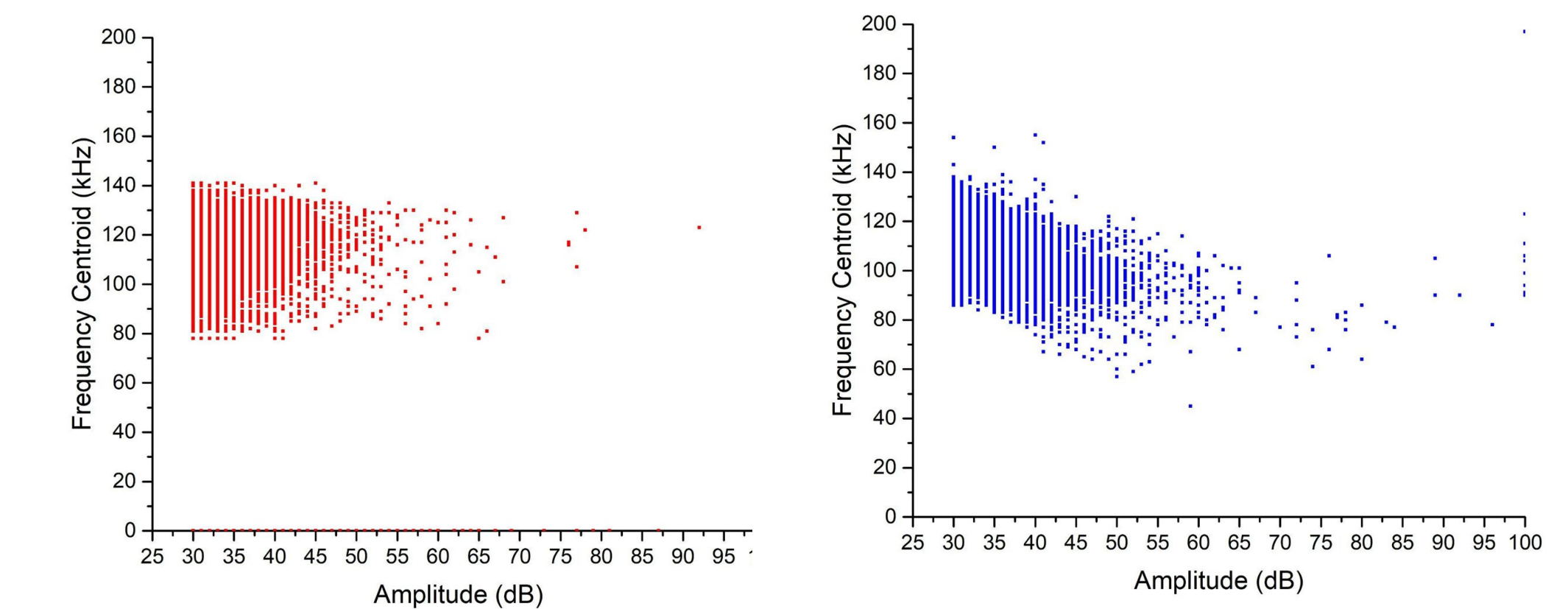


- Hits are clustered around the areas of load drop
- The first waveform resembles a fiber break
- The second waveform resembles a large delamination

### Aligned Discontinuous Fiber Composite



- Hits are fairly consistent with small clusters at high damage areas
- The first waveform resembles matrix cracking
- The second waveform resembles fiber pullout



Aligned Discontinuous Fiber

Continuous Fiber

- Continuous carbon fiber composites have more high amplitude hits caused by fiber fracture
- The frequency centroid is more central in aligned short fiber composites

## Conclusions

- For discontinuous fiber composites, acoustic hits are first observed from the start of the tensile test
- Continuous fiber composites have a high number of hits near the load drop
- High amplitude waveforms are observed in continuous fiber composite, possibly because of fiber fracture
- The lower amplitude and longer duration seen in aligned discontinuous carbon fiber composites

## Future Work

- Categorization of the waveforms at significant damage events for damage type
- Collecting AE data with multiple acoustic sensors to find out the damage location and type
- Generation of matrix failure waveform to isolate fiber fracture events in continuous fiber composite