**2015 NETL Crosscutting**
**Research Review Meeting**
Sheraton Station Square Hotel
Pittsburgh, PA

# EMBEDDED ACTIVE FIBER OPTIC SENSING NETWORK FOR STRUCTURAL HEALTH MONITORING IN HARSH ENVIRONMENTS

DE-FE0007405

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# MOTIVATION AND OBJECTIVES

# Motivation

- Health condition monitoring of key materials and structures can ensure safety and minimize system shutdowns.

- Challenges from a new set of extreme physical and chemical conditions:
  - Ultrahigh temperature
  - High pressure
  - Severe chemical corrosion

# Impacts

- Currently available methods:
  - X-ray defect detection
  - Ultrasonic tomography
  - Remote techniques using piezoelectric transducers
- Advantage of new fiber optics based technology:
  - Can be attached or embedded
  - Multi-parameters monitoring with single sensor
  - High temperature
  - Remote, no on-site power required
  - Potential of multiplexing

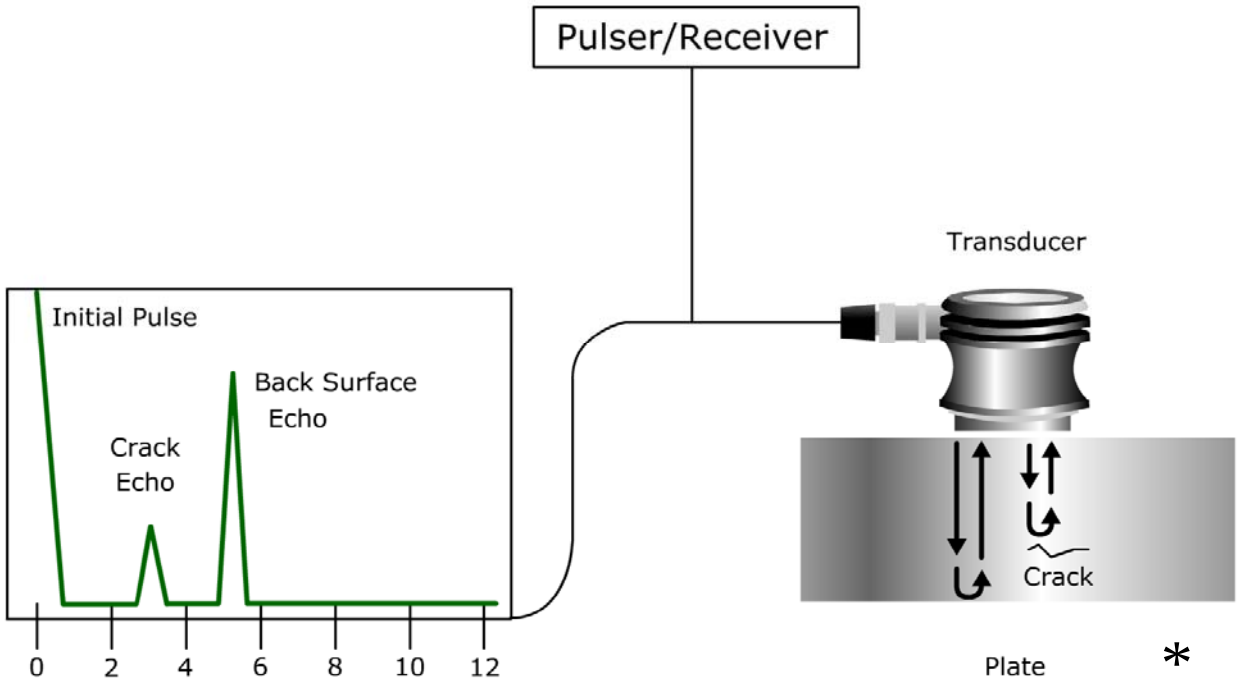
# Project Overview & Objectives

- Three-year project beginning 4/1/2013.
- Objectives:
  - Develop a fiber-based multi-parameter (temperature, strain, corrosion, and defects) health monitoring sensor
  - Develop the attachment or embedment technology of the sensor to steel
  - Demonstrate the feasibility of FO-NDE sensor multiplexing

# BACKGROUND AND FUNDAMENTAL TECHNOLOGY

# Ultrasonic Non-Destructive Evaluation (NDE)

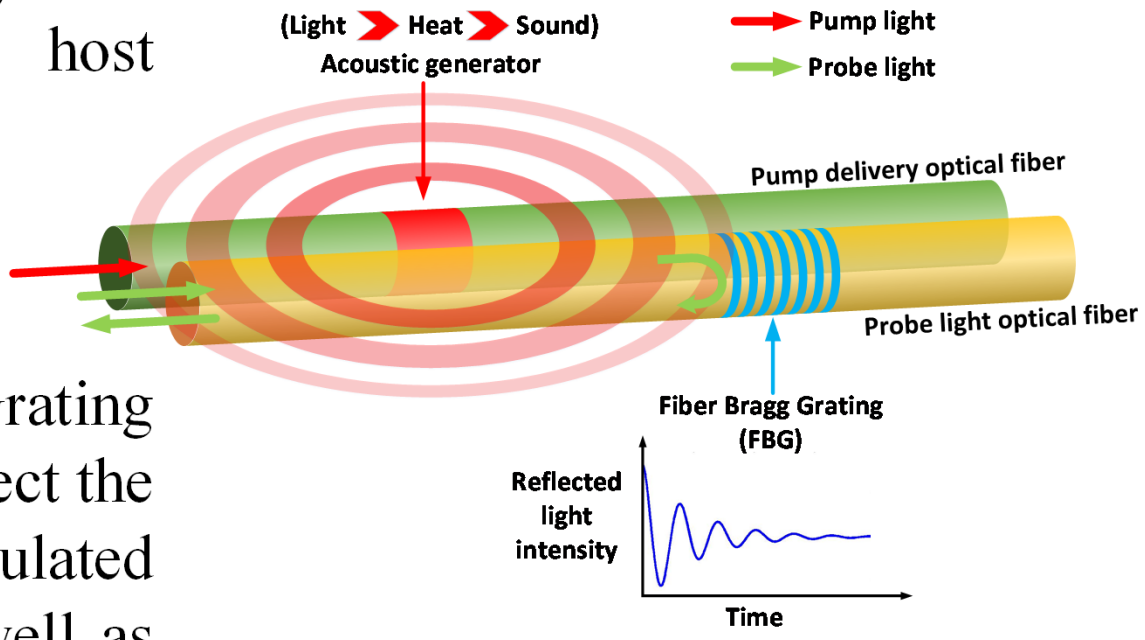
- Widely used and versatile technique of material defect detection.




* Figure from www.ndt-ed.org

# Active Fiber-Optic Non-Destructive Evaluation (FO-NDE)

- An acoustic wave is generated optically to propagate in the host material.
- A Fiber Bragg Grating (FBG) is used to detect the acoustic signal modulated by the material as well as other parameters.



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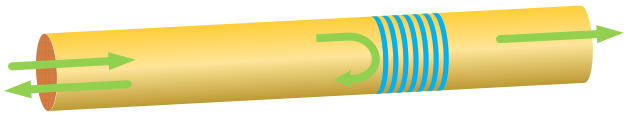
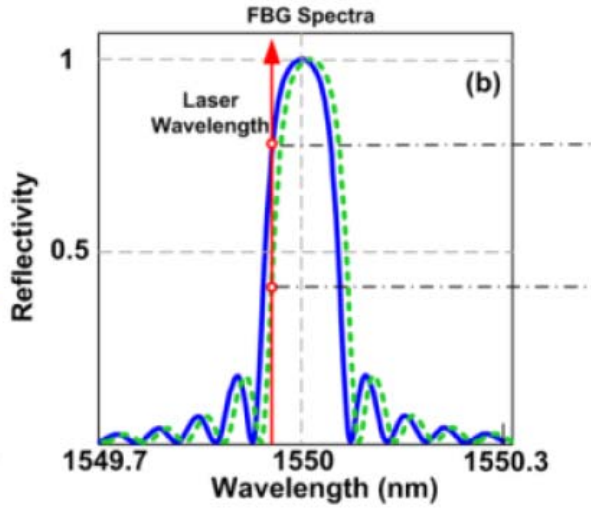
# FBG Working Principle



Fiber Bragg Grating
(FBG)

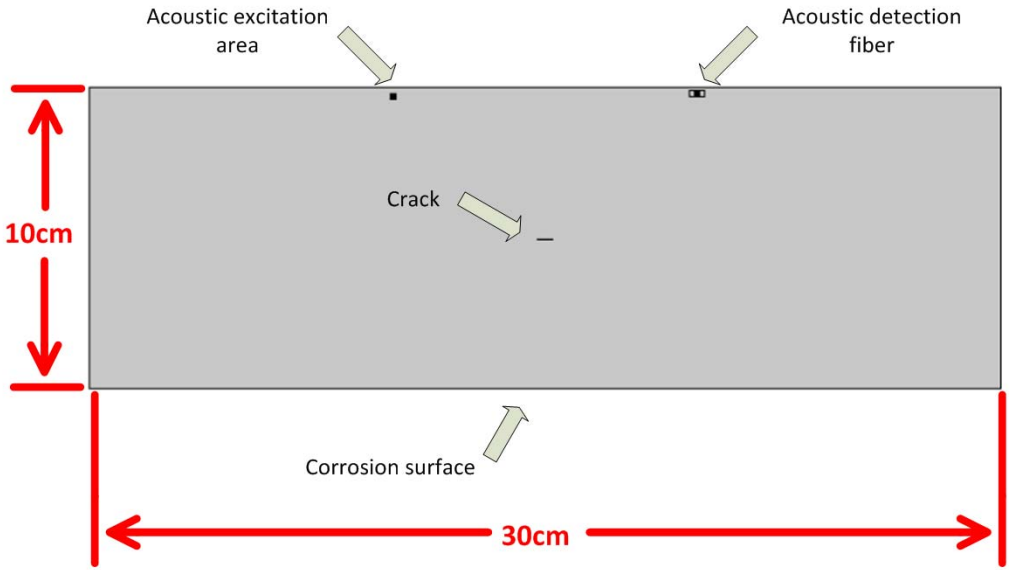



1. Detection of static strain & temperature
2. Detection of dynamic strain = acoustic vibration

# PROJECT PROGRESS

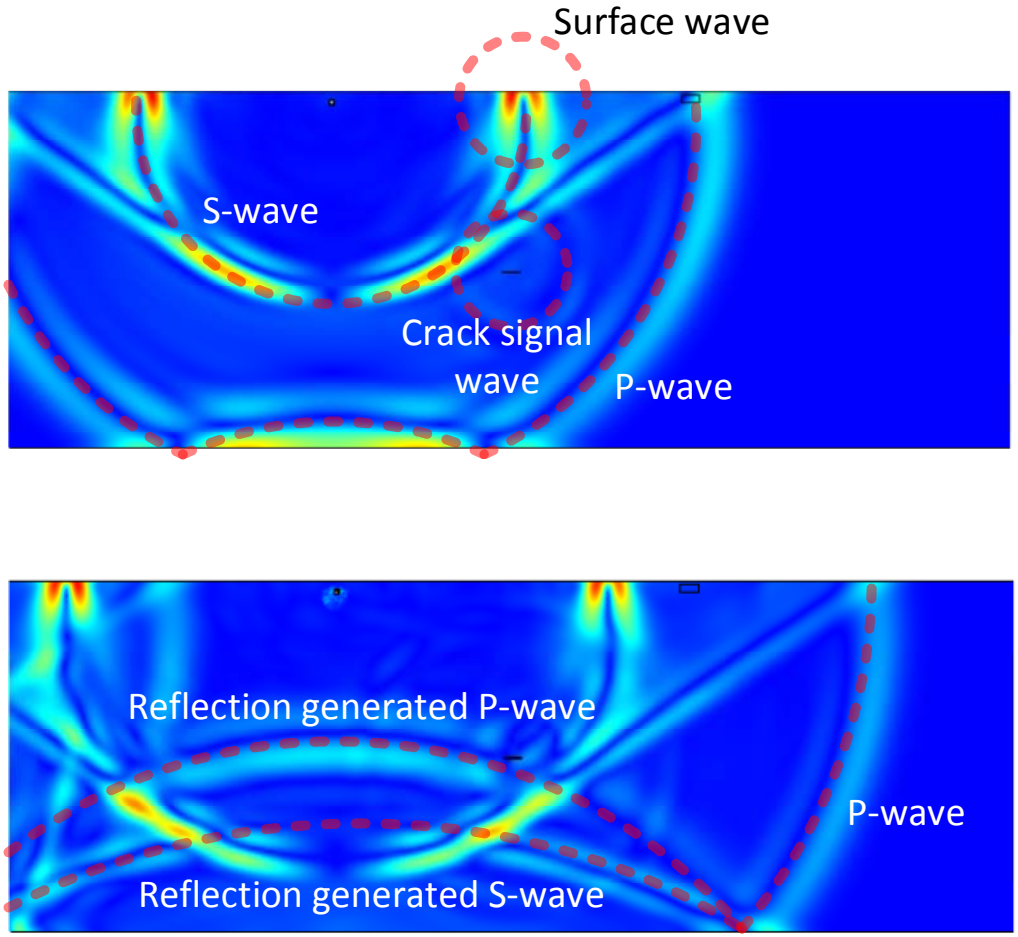
# Computational Modeling

- A 2D computational model was built to simulate acoustic propagation in a bulk material.
- Cracks and corrosions were placed on the block to simulate acoustic responses of the system.

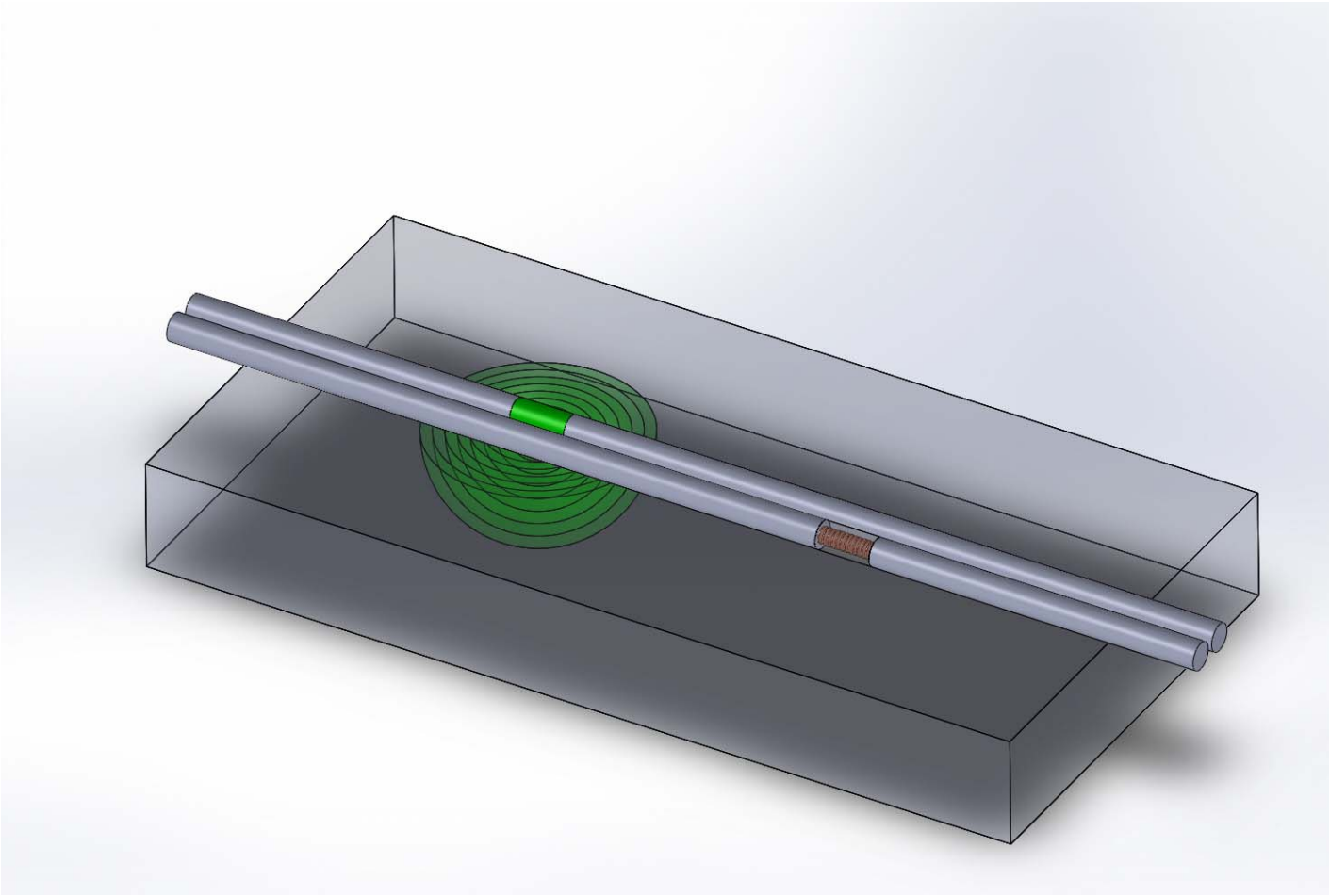


# Acoustic Wave Simulation

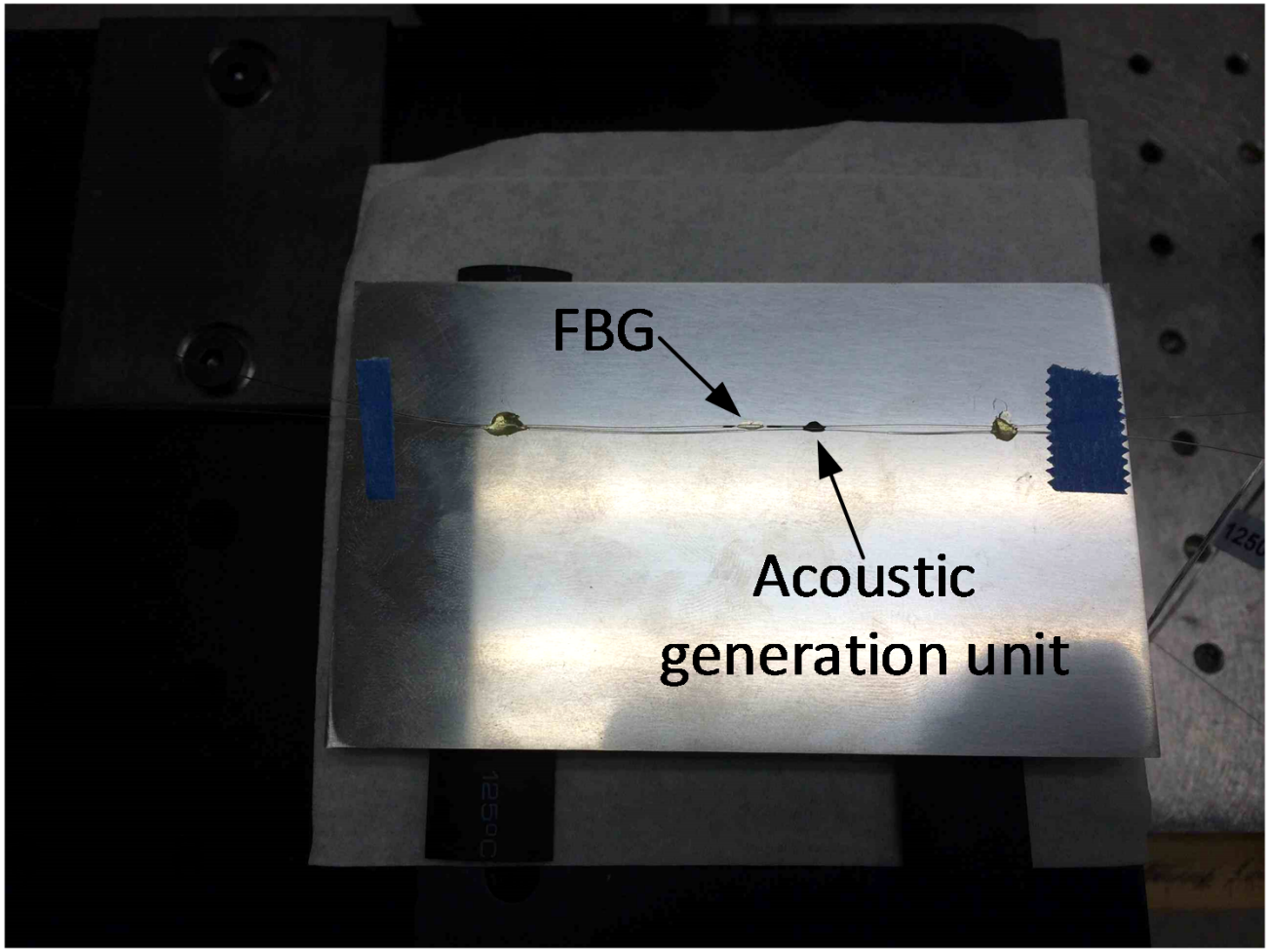
- Elastic wave propagation model
- Simulated
  - P-wave
  - S-wave
  - Surface wave
  - Reflection
- Demonstrated acoustic propagation in a specimen with crack and corrosion



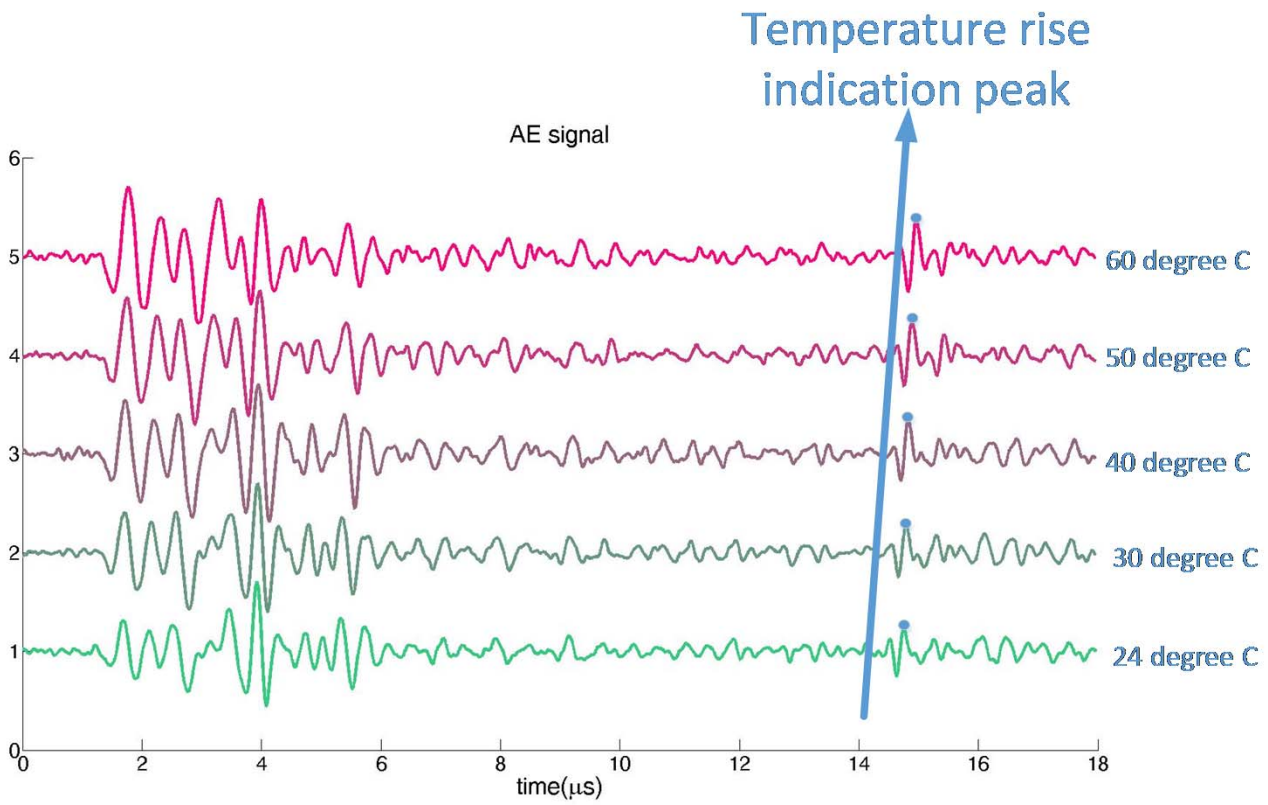
# Sensor Element Design



# FO-NDE Element Testing Unit



# Temperature Monitoring



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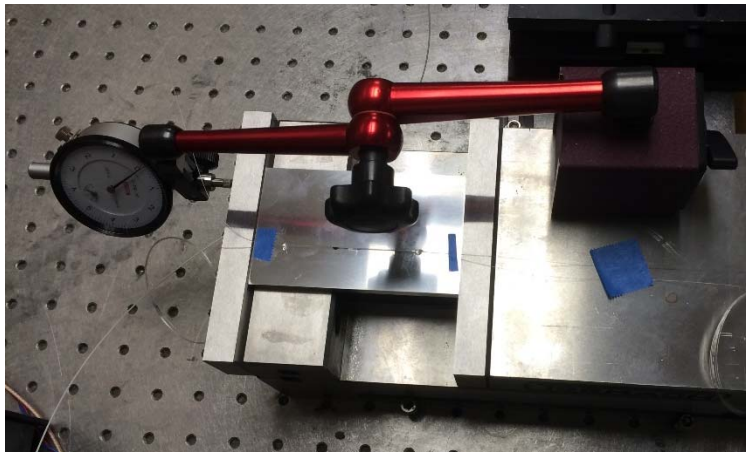
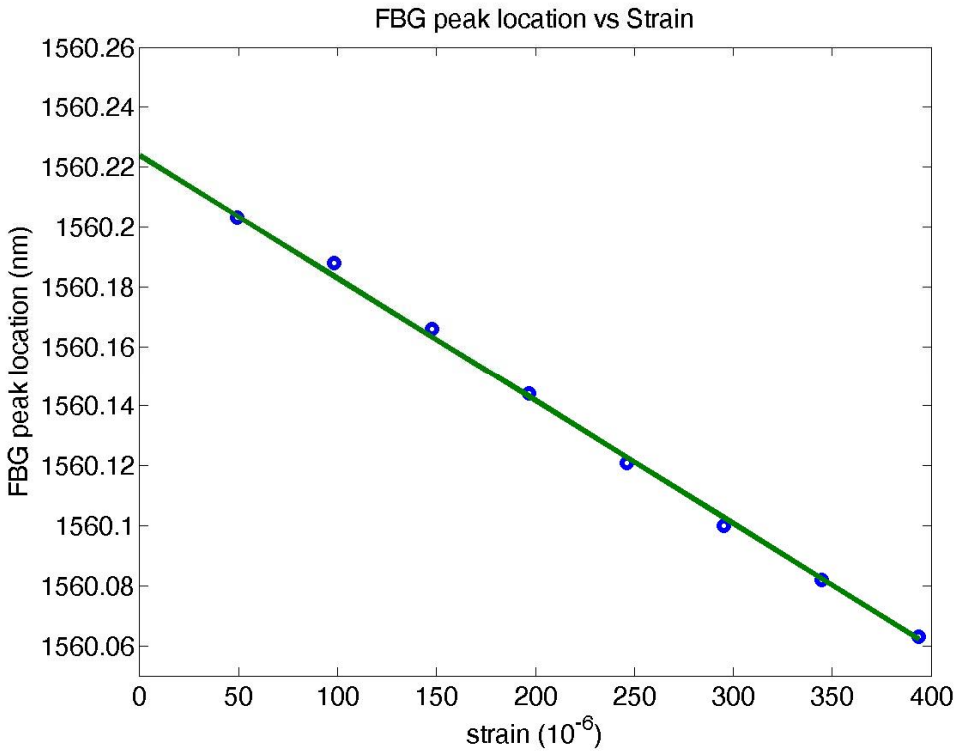
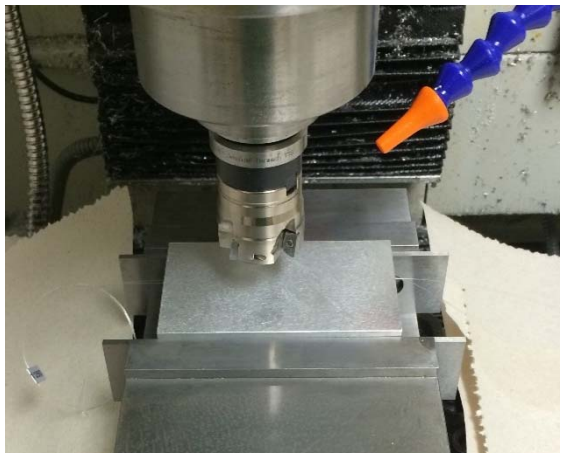
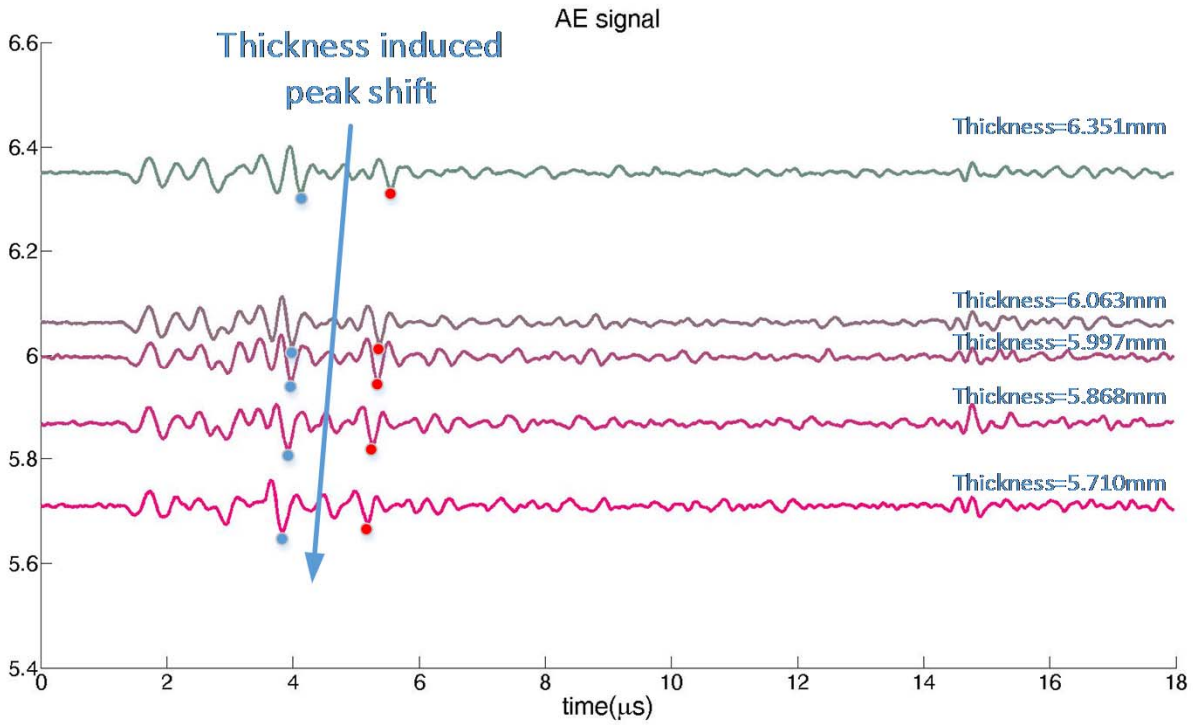
# Strain Monitoring





# Corrosion Test





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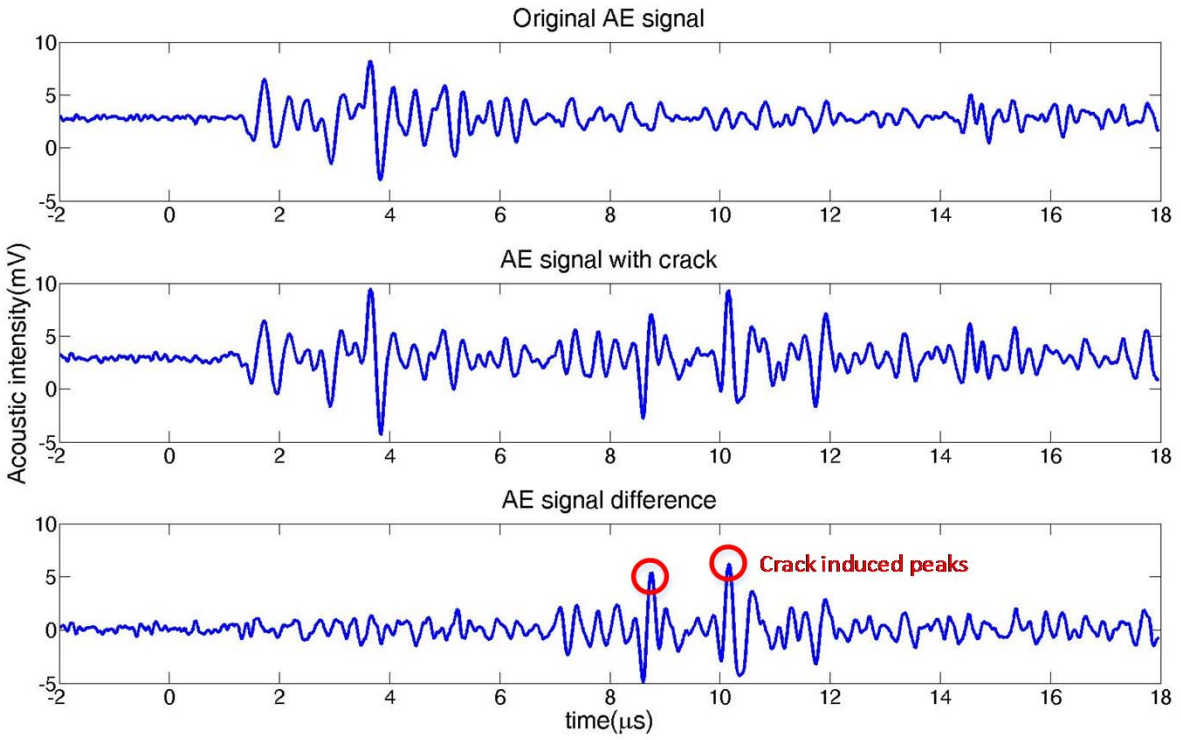
# Crack Test



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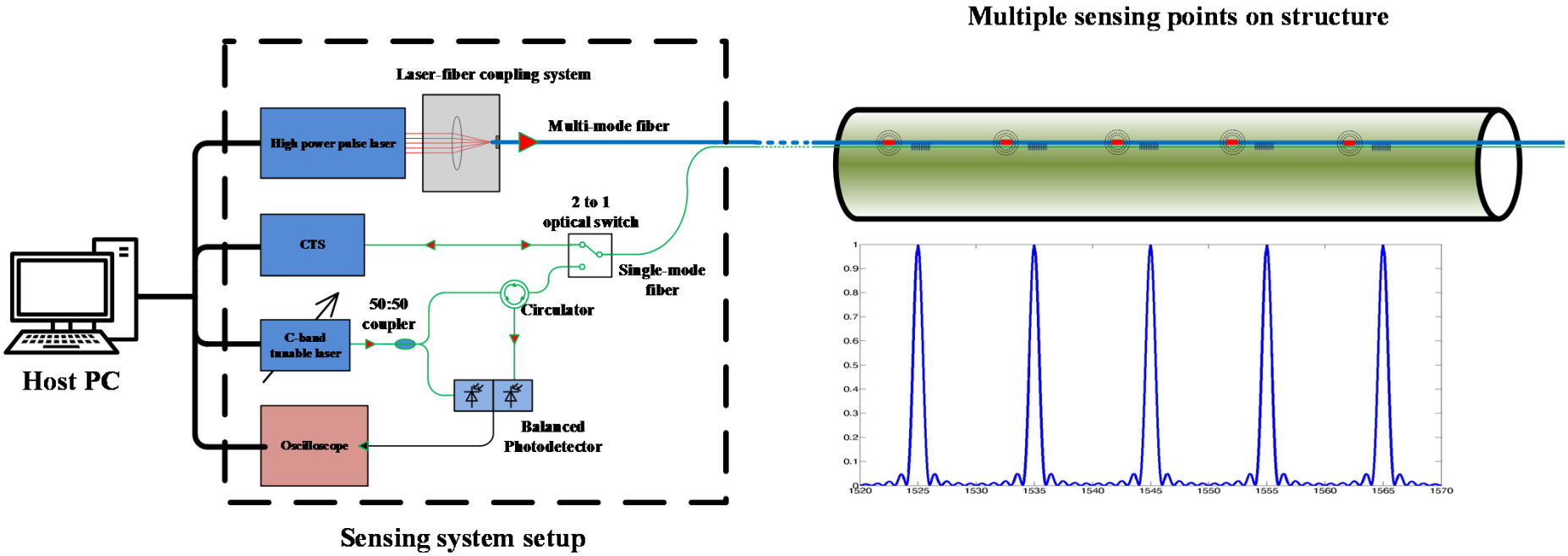
# Multi-point Sensing System Design

- Wavelength Division Multiplexing (WDM) technique for signal demodulation in a multiplexed system



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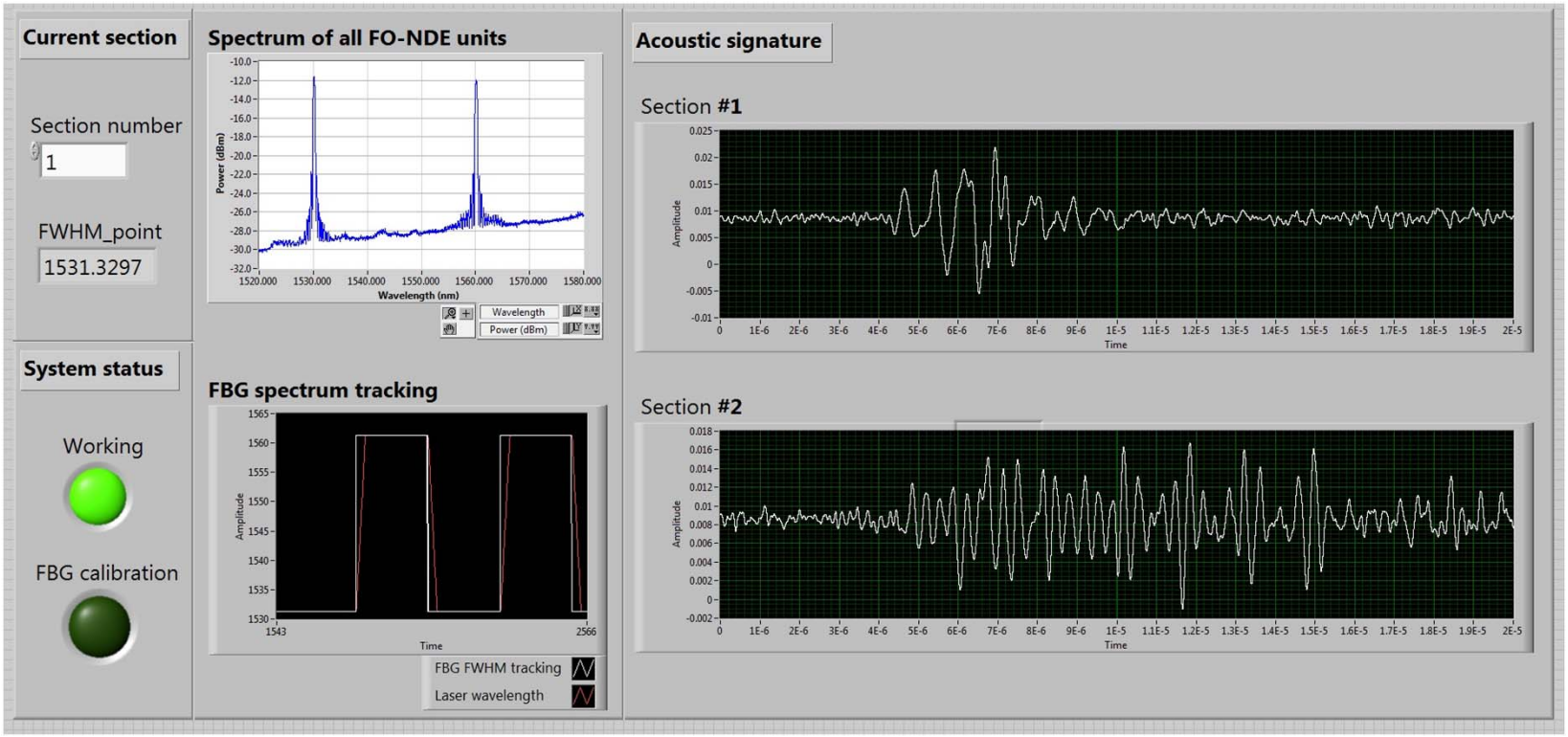
# FO-NDE Network Testing Sample

# System Controlling Software



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# Next Steps

- Demonstrate multi-point and multi-parameter sensing.
- Test system stability in high temperature environment.
- Improve system performance.

# SUMMARY

# Task Status

1. Project Management & Planning
2. Acoustic Generation, Propagation and Detection Modeling
3. Sensor Element Design
4. Demonstrate FO-NDE Element
5. Design, Implement and Demonstrate FO-NDE Sensor Network
6. Test Sensor in the Simulated Environment
7. Prepare Final Report

# Acknowledgement

The research presented in this presentation is supported by DOE grand fund DE-FE0007405.

# THE END