IIT MADRAS
Indian Institute of Technology Madras

Technology Transfer Office
TTO – IPM Cell

Industrial Consultancy & Sponsored Research (IC&SR)

Selectively Exposed Embedded Acoustic Waveguide Sensors For Guided Wave Based Online Monitoring of Rheology Changes and Damage/Defect Thereof

IITM TECHNOLOGY AVAILABLE FOR LICENSING

PROBLEM STATEMENT

- **Composites are widely used in Civil, Aerospace**, and Mechanical Industries due to their strength relying on bonding layers.
- **Inspection of composites** is challenging due to multiple layers, anisotropic nature, time, and complex structure features. **Non-Destructive Technologies (NDTs)** like Ultrasonic Guided Waves are widely used for inspection, as they can inspect large areas quickly and effectively detect defects.
- However, **current NOE techniques** for structural health monitoring use **omni-directional wave transduction** via surface bonded transducers, which generate cylindrical waves that **decay away from the source, limiting the applicability of ultrasonic guided waves** due to attenuation over distance.

TECHNOLOGY CATEGORY/ MARKET

Technology: Acoustic Waveguide Sensors For Guided Wave Based Online Monitoring of Rheology Changes and Damage/Defect
Category: Non-Destructive Testing Methods & Equipment (NDT/NDE)
Industry: Material Inspection Industry
Application: Composite testing
Market: The global market size was **USD 14.28 billion in 2022** and is projected to grow from **USD 15.78 billion in 2023 to USD 33.73 billion by 2030,** exhibiting a **CAGR of 11.5%** during the forecast period.

INTELLECTUAL PROPERTY

IITM IDF Ref. 1435 ,Patent No: IN 373496

TRL (Technology Readiness Level)

TRL-3, Experimental proof of concept;

Research Lab

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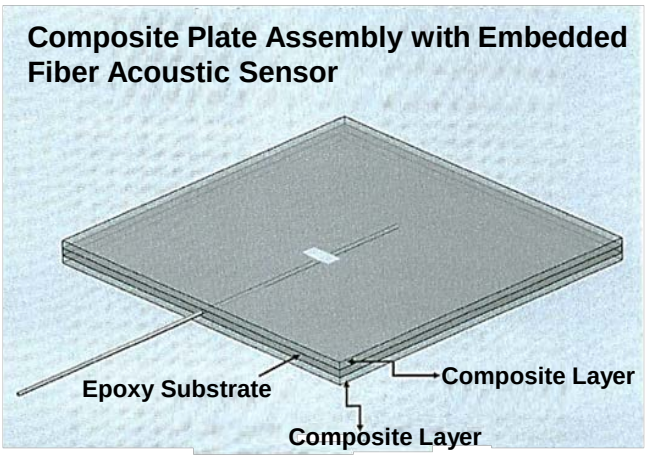
TECHNOLOGY

1. A **system for guided wave** based online monitoring of rheology changes, damages and defects in a structure using selectively exposed embedded acoustic waveguide sensors, comprising of:
2. **one waveguide sensor** embedded into the inter-laminar region of a composite structure, one end of the embedded waveguide is protruded out from the structure,
3. a **coating surrounding the waveguide** coating prevents leakage of waves into the surrounding structure and ensures one dimensional plane wave generation and energy distribution inside the structure through much longer distance;
4. **one sleeve opening on the waveguide** sleeve receives reflections of wave energy from various places inside the structure;
5. **one probe attached to a pulser receiver**, converts the electrical energy from the pulser receiver to mechanical vibrations using a **piezoelectric crystal,** which is transmitted into the waveguide in the form of **ultrasonic waves**.

Composite Plate Assembly with Embedded Fiber Acoustic Sensor



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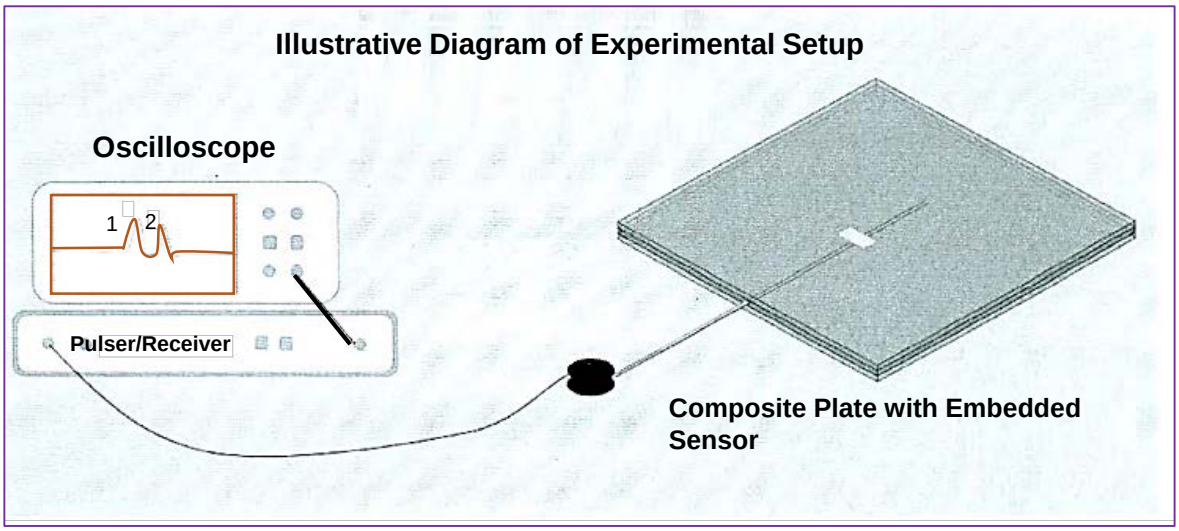

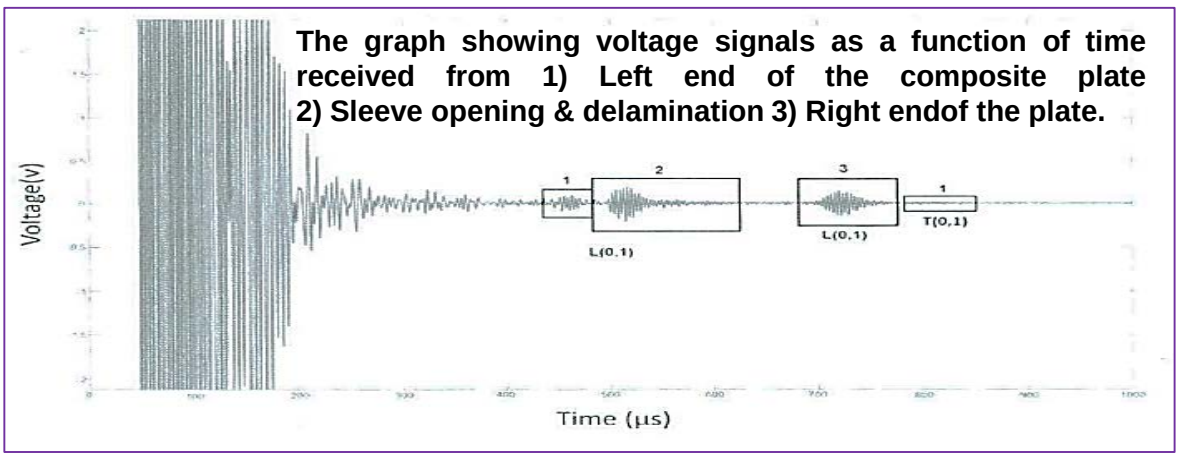

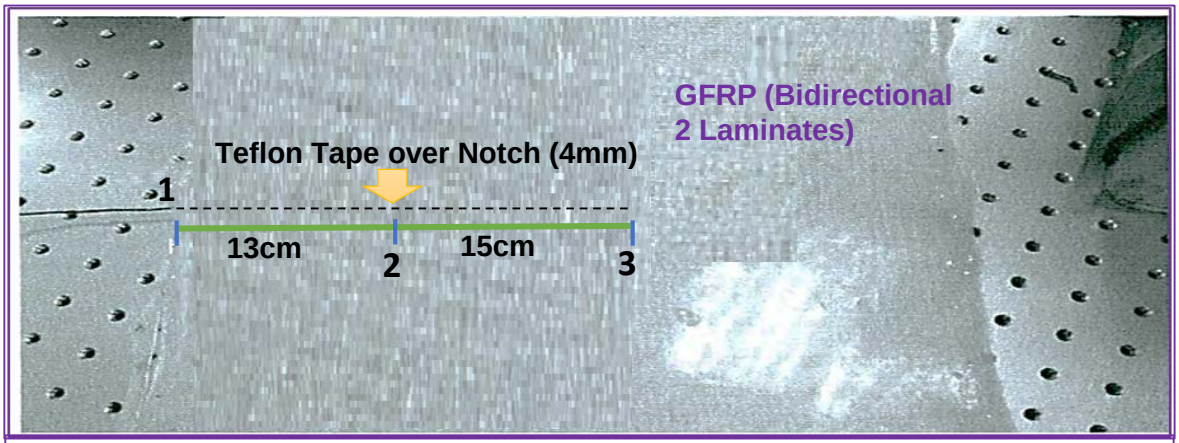

Image showing the Corresponding Positions from the signals receivedin the composite plate

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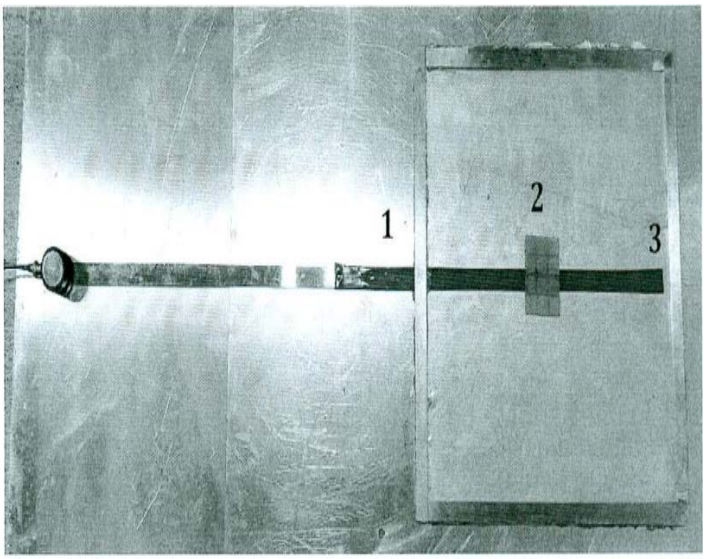
Image showing the corresponding positions of composite plate from which the reflections received



Method

- Guided Wave-Based Online Monitoring of Structure Rheology
- Generates guided ultrasonic wave modes using an ultrasonic transducer.
- Transmits these modes along the waveguide, interacting with the structure.
- Recorded reflected wave signals using an ultrasonic transducer and instrumentation.
- Detects crack/delamination in the structure by calculating wave energy leakage and reflection.
- Determines the location of crack/delamination by calculating the time of flight of reflected wave signals.

Key Features / Value Proposition

Composite Structure Delamination/Crack Detection
- Provides reference signal.
- Ensures integrity of composite structures.

Wave Energy Calculation
- Determines delamination/crack location.
- Calculates time of flight.

Waveguide & Sleeve Opening
- No airgap between waveguide and sleeve.
- Removes coating for sleeve opening.

Waveguide Shapes and Sensor Types
- Circular, cylindrical, tubular, elliptical, square, rectangular.
- Longitudinal, Torsional, Flexural.
- Anti-Symmetric, Symmetric, Shear Horizontal.

Waveguide Coating Overview
- Polymers, paper, or heat shrink polyolefin.
- Pulser receiver connected to digital oscilloscope.

Wave Signal Reception Process
- Receives one wave signal without delamination/crack.
- Receives two wave signals with second reflection from structure.
- Reflects second signal to waveguide sensor and receiver probe.

Wave Mode Generation in Piezoelectric Crystals
- Dependence on relative crystal position.
- Guided waves generated via piezoelectricity, electromagnetic transduction, or Thermal Mechanisms.

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