**Embedded Sensor Technology Suite for Wellbore Integrity Monitoring**

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**Project Overview**

- A suite of technologies for wellbore integrity monitoring.
- Chemical sensing of high priority parameters (pH, corrosion onset, etc.)

**Distributed Optical Fiber Based Chemical Sensors**

- **Chemical/pH Sensing Layers (NETL)**
  - Sensing Principle: Evanescent Wave Sensors
  - Distributed Sensing

- **Organic pH Sensitive Coating Fabrication/Deployment (IOS)**
  - Sensor Cladding: pH indicator copolymerized with pHEMA cladding material

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**Passive, Wireless Surface Acoustic Wave (SAW) Sensors (NETL & CMU)**

- SAWs for Liquid Phase Application
  - SAW Attenuation ($\Delta a$) and Velocity ($\Delta v$): $\Delta a = 4a(e, e, c, T, P)$, $\Delta v = \Delta v_0 + \Delta v_0 (e, e)$

**Passive, Wireless Silicon Integrated Circuit Sensors (UCLA)**

- Sensing Principle and System Setup
  - CT scans of cement samples with sensors embedded
  - Embedded fibers in high temperature metals, including curved parts.

**Embedding of Sensors in Cement and Casing Materials (NETL & U Pitt)**

- Embedded Fiber Sensors for Defect Detection using Artificial Intelligence
- Mechanical testing of cement with sensors embedded

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**Simulation and Experimental Results**

- Measure $\Delta v$ in terms of time delay.

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**Component Analysis**

- Method 2: Principle Component Analysis
- Method 1: Multi-modal Neural Network