UPISC UNIVERSITY OF PITTSBURGH INFRASTRUCTURE SENSING COLLABORATION WORKSHOP

NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

Overview of Fiber Optic Sensors R&D: Interrogation Systems and their Applications

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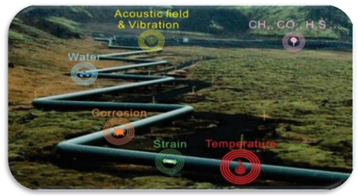
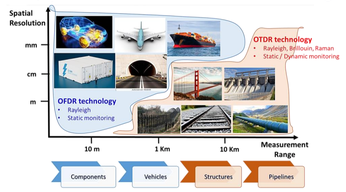


1. Fiber Optic (FO) Sensors for Infrastructure Monitoring

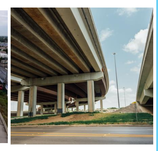
- **Optical fiber sensor are:**
  - Lightweight / embeddable in composite material
  - Explosion- and electrical-proof
  - Can work up to 1000 °C temperature
  - Point, **quasi-distributed** and **distributed** sensing



- **Distributed Fiber Sensors:**
  - **Fiber optic** cable act as a transducer
  - **Real-time detection** of diverse events and objects
  - **Identify and Classify** the events and objects; ML/AI
  - **Ability to simultaneously monitor**: Acoustic, Vibration, Temperature and Strain

Natural Gas, Oil, & H_2 Transport, Storage & Plants

Civil (Road, Bridges, Water)

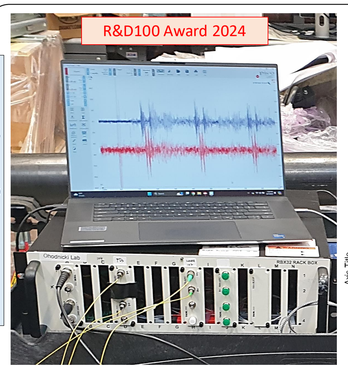


Electricity Grid Transport & Transformer

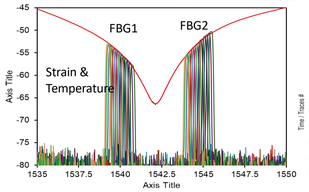
Conventional & Renewable Generation

2. Optical Interrogation Methods

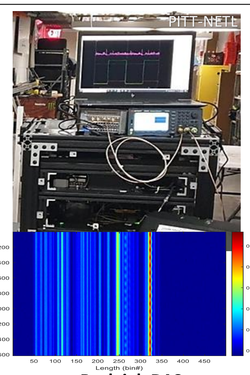
Custom-designed Systems



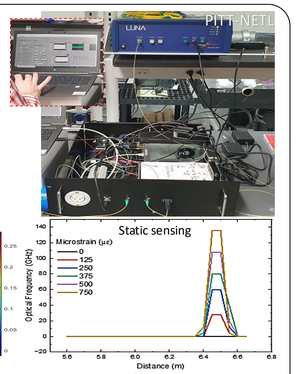
Ultrasonic Acoustic Interrogator



FBG interrogator

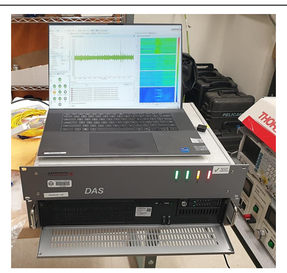


Rayleigh DAS

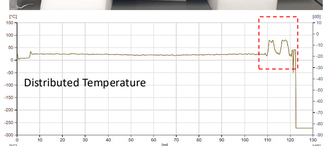


Rayleigh OFDR

Commercial Systems



Rayleigh DAS

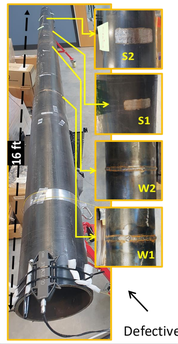


Raman DTS

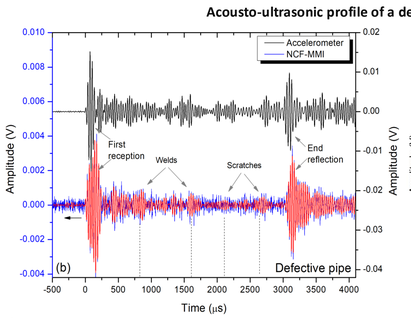
FBG Interrogator

3. FO Sensors' Applications

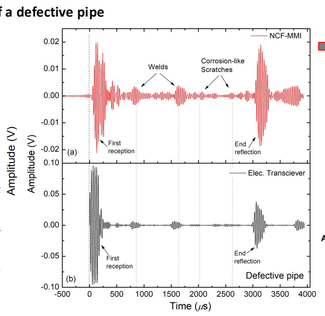
Pipeline monitoring



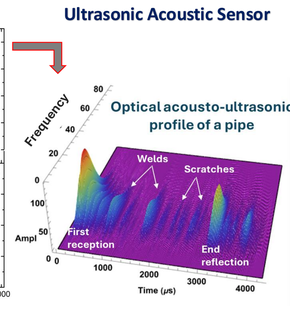
Defective pipe



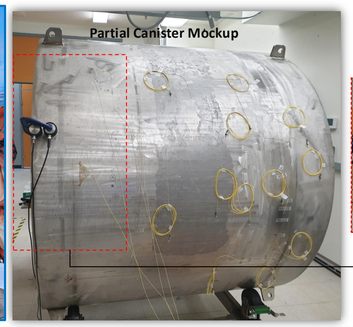
Excitation source: Dual-PZT patches

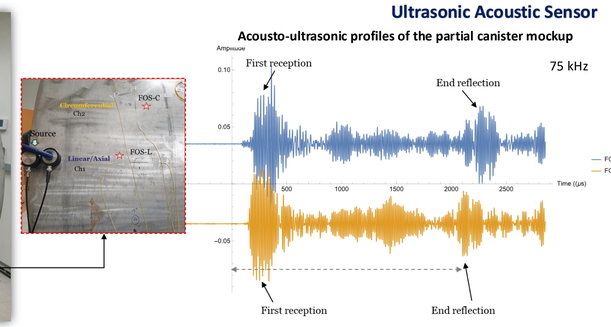


Excitation source: Magneto-strictive (MS) Collar



Nuclear Canister monitoring

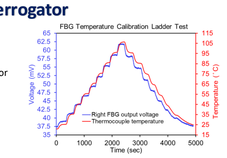


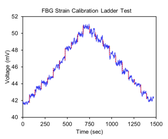


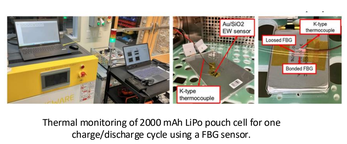
Li-ion Battery monitoring

Custom FBG interrogator

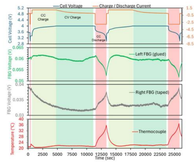
Calibrations of two FBGs for simultaneous strain—temperature sensing applications





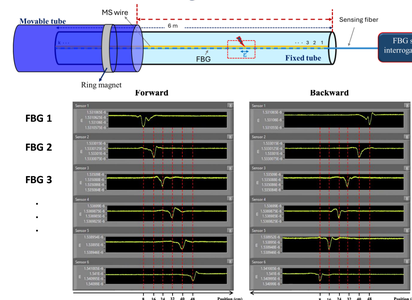


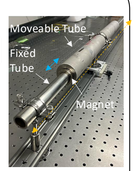
Thermal monitoring of 2000 mAh LiPo pouch cell for one charge/discharge cycle using a FBG sensor.



Spatial position monitoring

Commercial FBG interrogator





Response of a specific FBG# to a linearly-moveable magnetic field.

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NEUP Nuclear Energy University Program — U.S. Department of Energy

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5. K. Naeem, Changwon Lee et al., "Multiparameter Distributed Fiber Sensor Based on Optical Frequency-Domain Reflectometry and Bandwidth-Division Multiplexing", IEEE Sensors J., vol. 21 (22), pp. 25703-25709, Nov. 2021