TECHNOLOGY MATURATION OF WIRELESS HARSH-ENVIRONMENT SENSORS FOR IMPROVED CONDITION-BASED MONITORING OF COAL-FIRED POWER GENERATION

M. Pereira da Cunha1,2, R. J. Laa1,2, G. Harkay2, A. Maskay1,2
1University of Maine, Orono, Maine, U.S.A.
2Environetix Technologies Corporation, Orono, Maine, U.S.A.

Surface Acoustic Wave (SAW) Technology

- Class of Micromechanical Systems (MEMS)
- Electronic platform: electrical signal translated into microphone acoustics using a piezoelectric substrate
- Delay line and resonators: typical SAW structures used for sensor applications
- Interdigitated transducers (IDTs) used for wave generation; reflector electrodes used for acoustic wave energy trapping

GOALS

- Usage of Harsh-Environment (HE) High-Temperature (HT) Wireless Surface Acoustic Wave (SAW) Sensor Technology to:
  - Reliable maintenance through CBM of critical coal-based power plant equipment
  - Cost-effective efficiency of power plant operations
  - Power Plant Safety

OBJECTIVES

- HE/HT Wireless Surface Acoustic Wave (SAW) Temperature Sensors ➔ CBM in Coal Power Plants
- Improvement in the packaging of SAW temperature sensors & antennas
- Advancement in piezoelectric films and strain sensors
- Wireless communication protocols & signal processing refinements
- Technology validation and transition to coal-based power plants

SAW Sensors in Harsh Environments

- SAW technology can be used to measure a variety of sensor parameters: temperature, pressure, torque, strain, gas
- Small sensor footprint
- Robust and stable over long-term
- Varying detection mechanisms: loading, absorption, stress, changes in film thickness or material properties
- Existence of substrates for high temperature applications, such as the langasite (LGS)
  - LGS: 1470°C Melting point

SAW Sensors in Harsh Environments

- Wireless, battery-free, robust, passive operational capability leading to reduced installation & maintenance cost

Project Structure & Implementation

- Project Tasks:
  - TASK 1 - Project Management & Planning
  - TASK 2 - Technology Transition & Adaptation: High Temperature Wireless SAW Sensor Technology in Harsh Coal-Fired Power Plant Environments
  - TASK 3 - Implementation and Testing of Mature Prototype Wireless Sensor System within Power Plants
  - TASK 4 - Protective Coatings and Piezoelectric Thin Films for Improved Sensor Packaging & Performance
  - TASK 5 - Development of Prototype SAW-based Harsh Sensor

Collaboration with Penobscot Energy Recovery Company (PERC) Power Plant in Orrington, ME

- PERC ➔ Municipal Solid Waste (MSW) Power Plant
- Goal: Implement a Wireless Temperature Monitoring System(s) at the MSW power plant

Wireless HE/HT Sensor Array tested in Economizer

- Power plant conditions:
  - Temps ➔ 900°C (1650°F)
  - Highly erosive/corrosive exhaust gases

Wireless HE/HT Sensor Array tested in Boiler

- 1/4" Schedule 40 Hastelloy thermocouple tube after ~6 mo

Conclusions

- Project initiated within the past 2 months.
- Presented Project Background: Motivation, Goals, & Objectives
- Provided SAW Technological Overview and HE/HT SAW Sensor Background
- UMaine/Environetix are under current discussions with coal power plant collaborators to be selected as test bed for technology demonstration and advancement
- Described Project Structure & Implementation
- Tasks & Milestones
- Current Activity Status

SAW Sensors in Harsh Environments

- Wireless SAW sensor tests in power plant harsh environment carried out over 2 years

Example of wireless temperature monitoring over 5 weeks

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