MagSens-PV

Magnetoelastic Smart Sensors for Smart PV Modules and Components

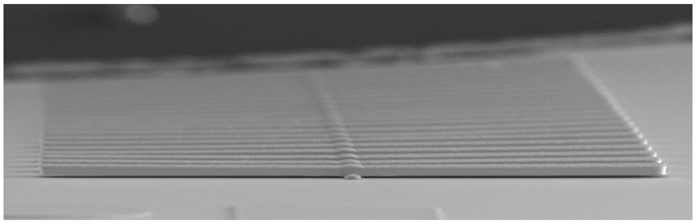
Integrating smart sensors into grid systems will enable more complex modeling and adaptation to unknown problems for preventing future catastrophic failures.

Passive Microsensor for Autonomous Sensing

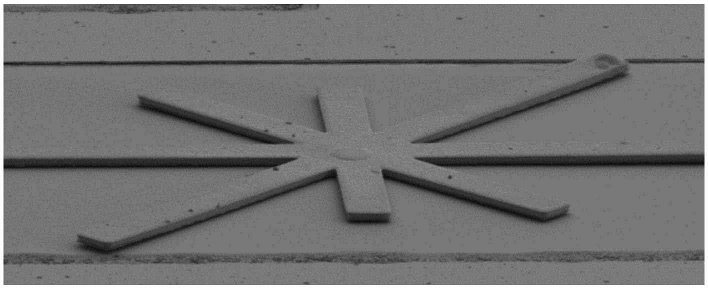
Grid health and reliability forms the backbone of our Nation's infrastructure. Real time monitoring and fast failure location and identification is critical for electrical grid sustainability. We propose the development of a cheap, fast (μs), fully integrated, passive micro-sensor capable of detecting changes in currents at μA levels in electric grids, which can enable the early detection of failures in the electric grid.

Accurate Fault Detection

Current grid monitoring systems rely on Phasor Measurement Units (PMUs) which are prohibitively expensive for deployment in the electric grid. To revolutionize the future of grid monitoring and fault detection, we propose a novel passive microsensor for autonomous sensing. These wireless magnetoelastic resonant smart sensors (MagSens) are capable of detecting small changes in magnetic fields emanating from current carrying conductors (CCCs) to detect μA levels of leakage in μs time scales through highly accurate frequency detection. The adoption of a sensitive and reliable fault detection system will ensure improved safety and integrity in complex grid, power generation, energy storage, and power electronics systems. Additionally, MagSens can provide failure location identification through unique coding for location pinpointing and state of health monitoring of a CCC.



CoFe 5 MHz 10 Resonator Array.

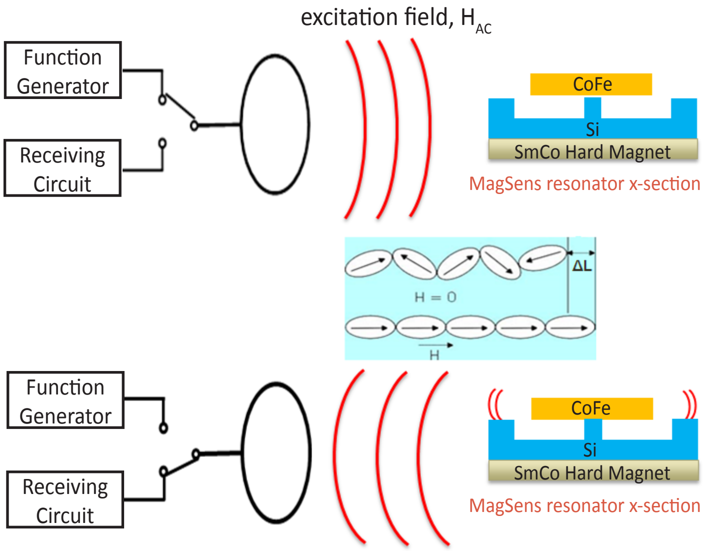


CoFe Starburst Resonator. Resonator frequencies span 1 MHz to 4 MHz.

CoFe Alloy Films Produce Sensitive Monitoring Capabilities

This technology employs first-of-its-kind patterned ECD cobalt iron (CoFe) alloy films that demonstrate giant magnetostriction (i.e., a large change in material shape induced by an applied magnetic field) to produce sensitive monitoring capabilities at micro-to-meso size scales. This material displays world class saturation magnetostriction that far surpasses other commercially available magnetostrictive films such as Metglas (lambda_sat = 27 ppm) used in similar sensors.

These smart sensors convey frequency information remotely by near field magnetic induction. An AC magnetic signal emitted via a loop antenna coil is used to interrogate thin rectangular resonators of magnetostrictive CoFe. This induces longitudinal mode vibrations that, in turn, emit their own secondary oscillating magnetic field generated from the resonator mechanical ring down. The same antenna detects the induced resonant response from the MagSensor by switching from a transmitting to a receiving circuit. When exposed to a tertiary magnetic field from a current carrying wire, the sensitive resonant frequency of the smart sensor shifts in response to this field.



The AC magnetic field from the loop antenna causes the CoFe resonator to vibrate along the length direction due to Joule magnetostriction.

Due to mechanical inertia, the resonator continues to vibrate emitting it's own AC magnetic signal that is picked up by the same antenna.

Technology Advancement

Development funding for the following activities willl be needed to advance the technology for insertion into the commercial sphere.

- Developing a SmCo thin film electrodeposition process to create an integrated biasing magnet will help improve signal-to-noise performance and lower integration costs.
- Materials characterization studies to include XRD, SEM/TEM, and magnetometry will be used to characterize and optimize the SmCo film performance as well as provice feedback and direction in the development effort.
- Some design, modeling, and process integration spins will be needed to hone the manufacturing process. This involves sensor layout/photomask creation, sensor processing and analytical and FE modeling of MagSensor performance to guide this effort. Sensor characterization will involve magnetic bias induced frequency shifts as well as measurements to determine read range and shielding effects.
- Stability studies must be performed to determine the effects of environmental parameters such as temperature, humidity, earth's magnetic field, etc. in order to determine the kind of packaging and calibration needed for a commercial product.
- Finally, a MagSensor demonstration in a photovoltaic module using a prototype sensor will serve as proof of performance.

Applications

- Tags for Nuclear Waste/UF6 Cylinders
- Component Identification Inside Transportation Vehicles
- Tagging Medical Radioactive Material
- Damage Monitoring of Composite Aircraft Structures
- Pressure, Temperature and pH Monitoring of
- Isolated Elements
- Ground Fault Prevention in Photovoltaic Systems
- Angular Position Detection

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