



## Dielectric Sensor for Stress and Strain Detection

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**The Wisconsin Alumni Research Foundation (WARF) is seeking commercial partners interested in developing a solid-state sensor that detects deformations using the dielectric response, resulting in cost reductions and additional applications.**

### Overview

Load bearing structures experience stresses and/or strains that deform the material from which they are made. Regardless of a building component's size, exposure to or tolerance for stress and strain, it often is helpful to monitor the stress and strain a material experiences. This information allows the manufacturing process, components and design to be optimized.

One type of sensor determines stress and strain by measuring the expansion or contraction of the object under stress. A capacitor with two parallel plates separated by a small distance is attached to the object. When the object is distorted by stress, the plate that is directly attached to it moves slightly, changing the capacitance of the circuit. Although this change in capacitance gives an indication of the stress the object is experiencing, the capacitance also changes slightly based on the dielectric property of the material. Dielectrics describe how an electrical field acts within a material, and have an effect that is overlooked by capacitive sensors. Additionally, capacitive sensors are vulnerable to overload, do not measure shear force well, are not sensitive enough for some applications and cannot measure deformations occurring at different planes.

### The Invention

UW-Madison researchers have developed capacitive strain sensors that measure stress and strain based only on dielectric properties. The two parallel plates are affixed to a substrate so that variance in capacitance occurs only due to change in dielectric properties rather than mechanical displacement. The dielectric change is then translated into an indication of stress and strain.

The sensors consist of interlocked electrodes that can be deposited on a rigid or flexible substrate. They can be implemented as single sensing elements or arranged in rosettes of up to eight capacitors to measure dielectric properties along multiple axes at once. The planar geometry of the electrodes makes the sensors compatible with standard complementary metal-oxide semiconductors (CMOS) fabrication processes, so their characteristics may be tailored easily to particular applications. Signal conditioning circuits also may be incorporated on the same substrate to reduce the need for additional external components and simplify the construction process.

Because rosettes are capable of detecting the dielectric response without direct physical contact, they are suspended slightly away from the measured object to eliminate mechanical contact that could disrupt the measurement. The sensors may be interfaced to the material through a thin layer of mineral oil, which reduces mechanical constraints by lubricating the surface. In addition, the oil eliminates moisture effects and minimizes sensitivity loss.

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- Monitoring the manufacturing process of materials in liquid or solid state, including tempered glass, polymers or plastic parts
- Monitoring the health of load bearing structures.



## Key Benefits

- Measures stress and strain of solid or liquid dielectric materials
- Reduces costs by eliminating the need for embedding, attaching or interfacing external devices
- Requires no mechanical contact with the monitored part
- Can be mounted using self-adhesive stickers
- Sensors do not dissipate heat.
- Uses little energy
- Sensors are not susceptible to deformation.
- Can be used in place of destructive testing
- Detects stress and strain on different axes when using multiple sensors
- Provides a simple manufacturing solution for multi-component sensing
- Can be manufactured in large volumes or customized for different applications
- Sensors can be manufactured using a method that is compatible with CMOS.

## Stage of Development

Testing with the sensor has shown a repeatable, proportional relationship between deformation dynamics and dielectric response.

## Additional Information

### Related Technologies

- [See WARF reference number P02044US for another strain sensor based on electrostriction.](#)

### Publications

- Lee H.Y. and Shkel Y.M. 2007. Dielectric Response of Solids for Contactless Detection of Stresses and Strains. Sensors Actuators A: Phys. 137, 287-295.

### Tech Fields

- [Analytical Instrumentation, Methods & Materials : Sensors](#)
- [Engineering : General engineering technologies](#)

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