Printed Wireless Sensor for Heavy Metal Detection

Product:
Printed Wireless Inductive-Capacitive (LC) Sensor for Heavy Metal Detection

Development Stage:
Proof of Concept and Early Prototype

Primary Inventor:
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Heavy metal contamination, such as from past and present industrial waste, presents a severe, ongoing threat to the well-being of nearly all living organisms. Heavy metals are toxic, and their toxicity is concentration dependent. In addition, they are not biodegradable. Exposure to toxic levels of heavy metals is known to cause disease when present anywhere in the ecosystem, especially in the food chain, ultimately causing neurological and psychological disorders in humans.

In response to the dangers caused by heavy metal contamination, various detection and monitoring techniques have been developed for the environmental and food processing industries. These include colorimetric analysis, impedance spectroscopy, Raman spectroscopy, and titration, all of which have been widely used over the years. However, these techniques require complicated instrumentation and typically entail significant manufacturing and operational costs. Thus, there is a need for a simpler and lower cost option.

Technology Description

Researchers at WMU have developed a low cost, printed wireless sensor for heavy metal detection. The WMU technology comprises an inductive-capacitive (LC) circuit that is highly sensitive to the presence of heavy metal ions, such as lead (Pb^{2+}) and Mercury (Hg^{2+}). The wireless sensor is fabricated on a flexible thermoplastic polymer substrate, polyethylene terephthalate (PET, Figure 1). The components of the detector system include a printed coplanar inductor, a printed capacitor with interdigitated electrodes (IDEs), a sensing coil, and a network analyzer.

The sensor can be fabricated by screen printing silver (Ag) ink onto a flexible PET substrate to form a metallization layer. Palladium, gold, or silver nanoparticles (Pd/Au/Ag NPs) are drop cast onto the IDEs to form an enhanced sensing layer. Changes to the LC sensor are remotely monitored through the detection coil (a planar inductor) with a network analyzer or equivalent instrumentation. The resonant frequency of the LC sensor changes when heavy metal ions interact with the sensing layer, enabling identification of heavy metals, such as mercury (Hg^{2+}) and lead (Pb^{2+}), and measurement of their concentrations (Figs. 2 & 3).

The ability to detect very low concentrations of a variety of heavy metal ions makes this sensor extremely useful for many applications (e.g., food, water, environmental safety). As compared with active sensors which require amplifiers, batteries, antennas and radio frequency (RF) circuits, this

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passively activated wireless sensor is very inexpensive. Furthermore, it can be easily configured into a portable system for field measurements.

Potential Benefits

- Wirelessly transmits specific signature of toxic metal and concentration level
- Simple to use with low production and operation costs
- Can detect very low concentrations of a variety of heavy metal ions making it extremely useful for food, water, environmental safety monitoring
- Can be easily configured into a portable system for making field measurements

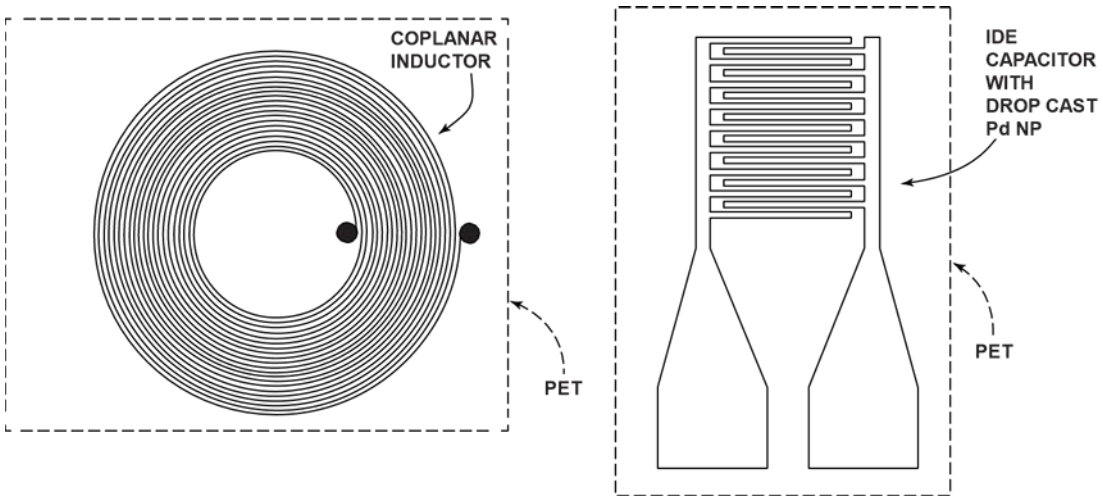

Figure 1. Schematic of Printed Wireless LC Sensor Components

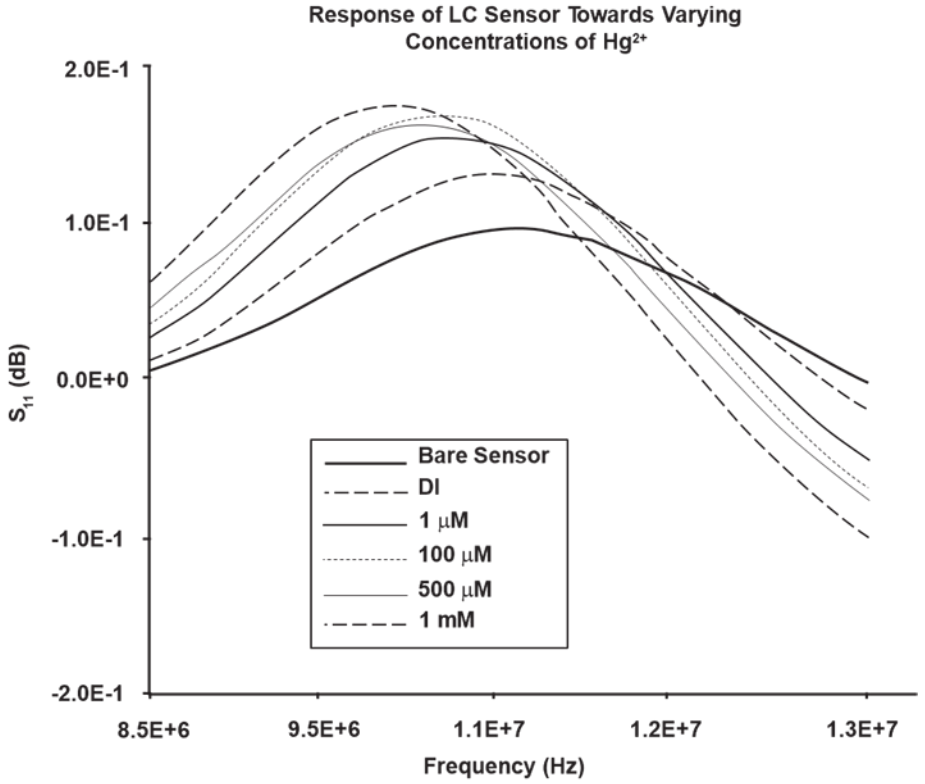

Figure 2. Sensor Response for Varied Levels of Mercury

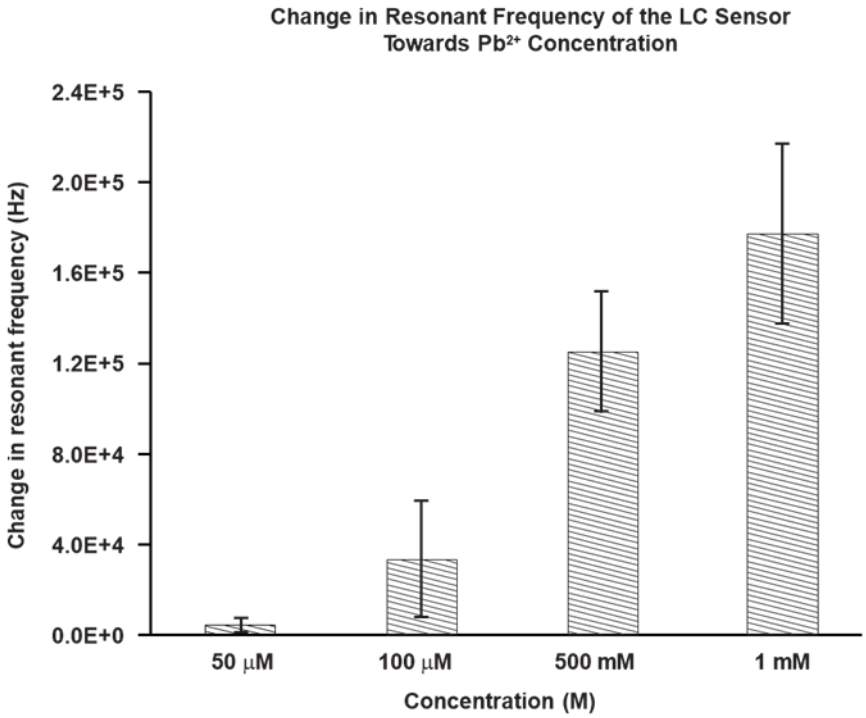

Figure 3. Sensor Response for Varied Levels of Lead