Integrated Sensors for Water Quality

SPORIAN® MICROSYSTEMS, INC

Small Business Innovation Research (SBIR)

Motivation and Objectives

Motivation: There is a present/growing emphasis on reducing or maintaining the water-use footprint in the energy sector (water-energy nexus)

- Effective water management requires reliable, real-time, measurement of water quality/composition.
- Monitoring should occur both within treatment systems & bodies of water associated with power generation facilities.
- Existing water quality sensor technologies are expensive, large, and difficult to install/deploy.

Sensor System Needed for Effective Water Resource Monitoring

- Low-cost, rapidly-deployable, wireless, self-powered, real-time, in-situ measurements.
- Simultaneously monitor multiple factors ⟶ reduced overall cost.
- Rugged hardware/packaging for field environments.
- **Water quality measurements of highest interest:**
  - Temperature
  - Turbidity
  - pH
  - Total dissolved solids (TDS),
  - Scale-forming minerals (ions) & salts,
  - Recovery Act (RCRA)-monitored heavy metals (RCRA 8s).

Long Term Objectives:

- Leverage Sporian's existing water monitoring systems/technologies and add RCRA heavy metals detection capability to meet all application needs.

Phase I Objectives:

- Experimentally evaluate MIP/IIP formulations to detect heavy metal ions in water.

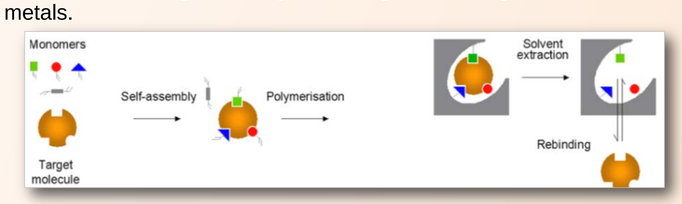
Future/Phase II Objectives:

- Work with industry stakeholders to develop and field test full prototype water quality monitoring systems that meet the application needs.

MIP/IIPs as Sensing Materials

Molecularly imprinted polymer (MIPs)/Ion Imprinted Polymers (IIPs)

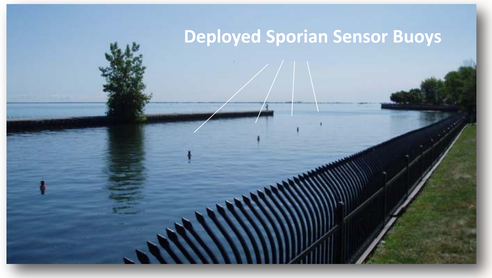
- Highly crosslinking polymers with recognition properties based on the self-assembled formation of a complex between an analyte (template) and a functional monomer during synthesis and crosslinking.
- Complexes preserved after crosslinking, leaving **binding selective** molecular cavities physically and chemically complimentary to the target.
- Polymer => **tailored to desired properties: durability, permeability, optical characteristics, inexpensive, etc.**
- Commercially sold for highly specific chemical separation/filtration.
- Reported for a range of heavy metal targets including all of the RCRA 8 metals.



Approach/Technology Basis

Leverage Sporian's previous experience and technology developed toward water quality monitoring sensor systems

- Sporian currently develops and sells water quality and distributed water quality monitoring sensors, to both government and private industry.
- Stemmed from US Army funded development of rugged, inexpensive, wireless, sensor systems for distributed/remote monitoring of water resources throughout supply chain (surface water, ground water, treatment systems, etc.).



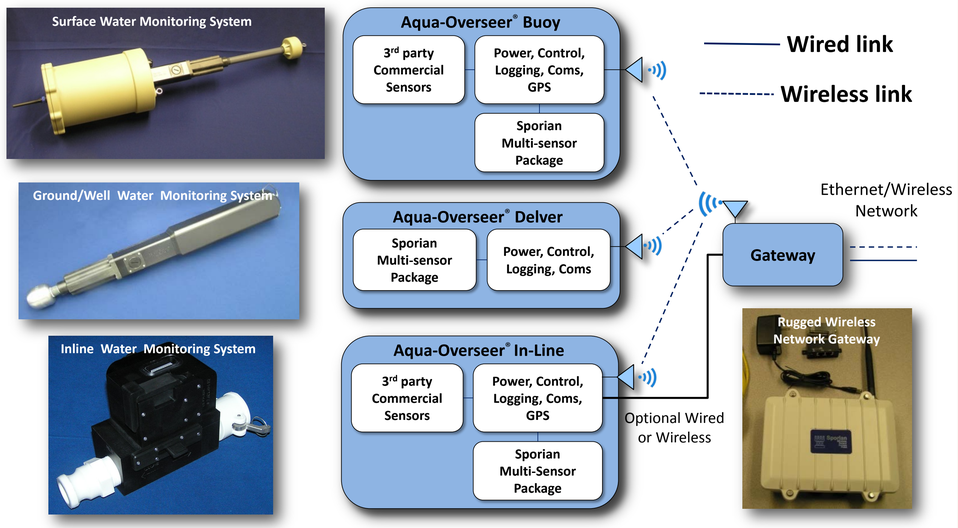
Existing Sporian Water Resource Monitoring Systems

Available Formats: Wireless buoys, inline process monitors, handhelds, downhole/well monitors.

Available Sensor Types: Temperature, dissolved oxygen, pH, conductivity, salinity, turbidity, biological pathogens, TDS. **Free chlorine and ion concentration under development**.

Key Features

- Function as part of sensor network
- Wireless communication (IEEE 802.15.4, ~1000 m range)
- GPS
- Data logging
- Expansion ports for additional sensors (analog and digital interfaces)
- "Smart" electronics for data processing
- Low power consumption/battery operation & energy harvesting



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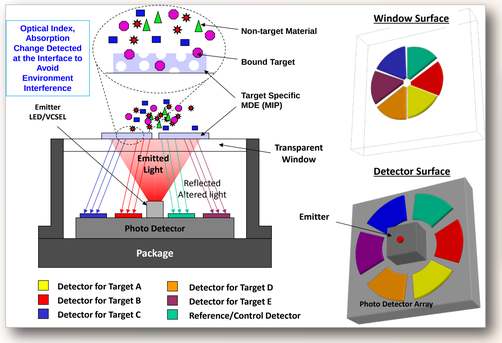
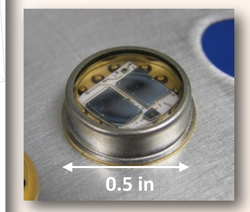
Compact Optical Sensor Architecture

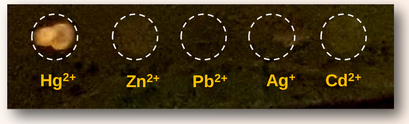
- **Heavy metal sensors are based on custom tailored MIP/IIP and Sporian's patented optical sensor architecture used in existing water quality monitoring systems**



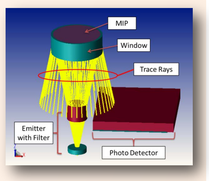


Key Results from Phase I

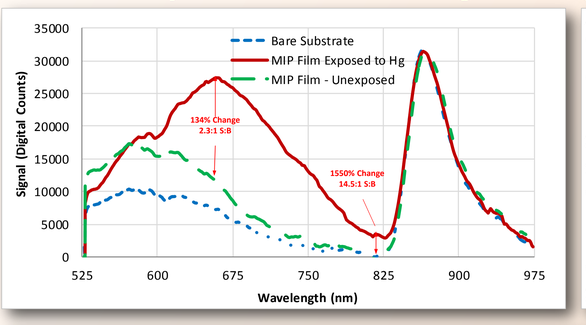
- **Successfully developed IIP/MIP for Hg(II) in water**
  - Selective against other ions.
  - Developed films that can exhibit either an index, fluorescence, or absorbance change in response to target, but **fluorescence chemistry gave best performance**.
  - Produced sensing films for integration with hardware

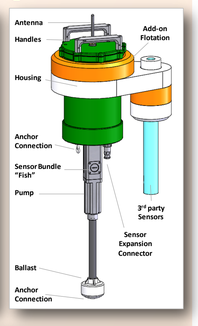


- **Combined films with optical detection hardware/electronics**
  - Current hardware sensing range ~500 ng/mL to 0.5 g/mL.
  - Lower end detection limits can be further decreased by reducing the dynamic range and increasing measurement time.
    - Lower limit is hardware noise floor. Increasing from 20 ms to 500 ms ~96 % noise reduction



- **Developed a revised preliminary sensor element design and identified system/architecture changes moving forward**





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