

CRC -P Smart Linings
for Pipe and Infrastructure
Project

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Session 4:
Wastewater Code of Practice,
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CRC-P: Sub-Project 3

Smart Sensing and Application *Wastewater Pipe Coatings*

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Review of Current Embedded Sensing Technologies for Monitoring Wastewater Pipe Coatings

Embedded Sensing

- Acid permeation is widely regarded by water utilities and researchers as the most important parameter that needs to be monitored in the long-term to evaluate sewer pipe coatings.
- No non-destructive sensing technologies available in the literature that can directly measure the levels of acid permeation inside sewer pipe coatings.
- The measurement of pH levels at different depths is used as a proxy parameter to estimate the penetration of acids inside the coatings.

Review of Current Embedded Sensing Technologies for Monitoring Wastewater Pipe Coatings

Embedded Sensing : Existing Technologies

- Researchers from the University of London (UoL) in collaboration with Sydney Water Corporation have developed an optical fibre based sensor system for monitoring humidity conditions in concrete sewer pipes for indirectly estimating corrosion.
- The UoL research team has recently developed coumarin based pH sensitive fluorescent probes. Their fluorescent behaviours were evaluated with aqueous solutions of different pH levels. The developed material can be used with optical fibres to measure pH in alkaline media. However, it is challenging to build a sensor that is robust enough to withstand the acidic conditions of concrete sewer pipe coatings.
- Macquarie University in collaboration with the Sydney Water Corporation is developing embedded fibre-optic sensing technology to measure the relative humidity and temperature conditions inside the concrete sewer host pipe for estimating corrosion.
- All the existing sensor's suitability to measure pH at different levels is yet to be proven in sewer conditions.

Review of Current Embedded Sensing Technologies for Monitoring Wastewater Pipe Coatings

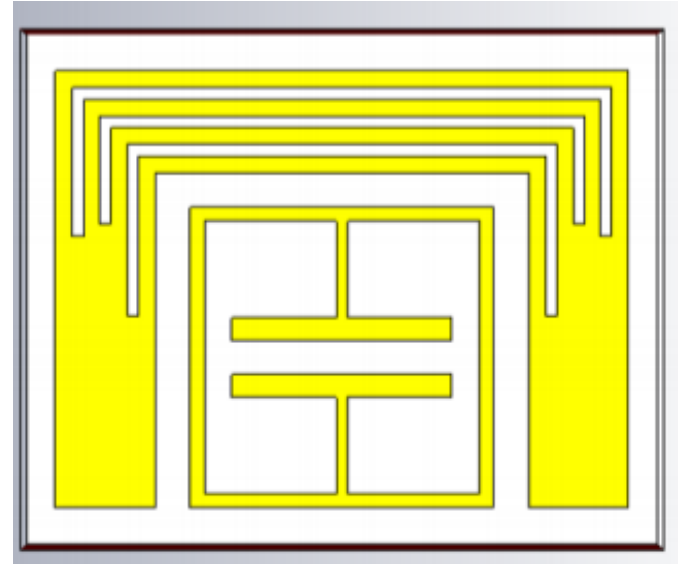
Embedded Sensing : Forward Thinking

- For monitoring pH conditions in concrete sewer pipe coatings, UTS conducted a review of the sensing capabilities and shortlisted a few types.
- Smart material based RFID sensors embedded in coatings combined with robotic observers seems very promising.
- We did sensor preliminary simulations to understand their characteristics specifically focusing on data transfer. This is a blue sky research, which is currently supported through the UTS blue sky research grant.

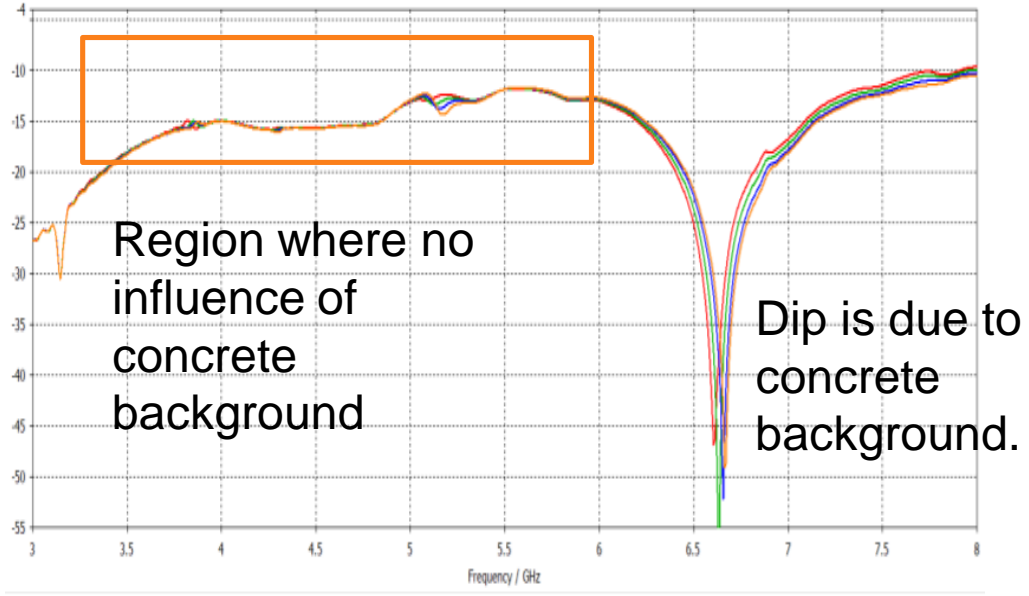
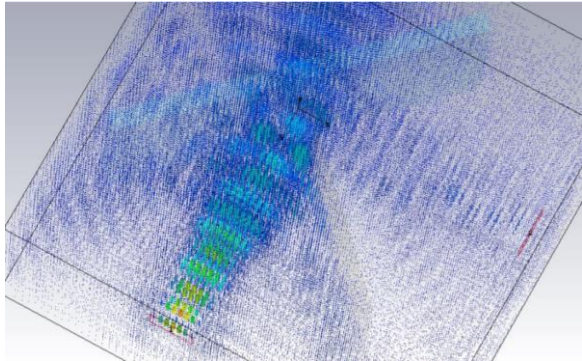
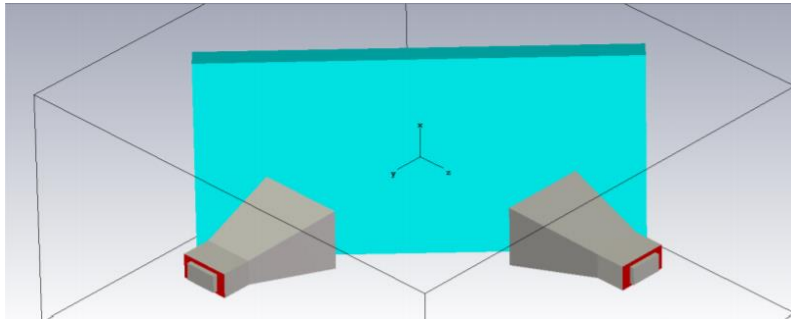
Review of Current Embedded Sensing Technologies for Monitoring Wastewater Pipe Coatings

Embedded Sensing : RFID Simulation

- We are simulating an implantable RFID sensor for monitoring sub-surface concrete conditions.
- This is a passive type of sensor.
- When the radio frequency signals strike the sensor, it gets activated and reflects a portion of the signal back.
- The reflected signals can be interpreted for monitoring.



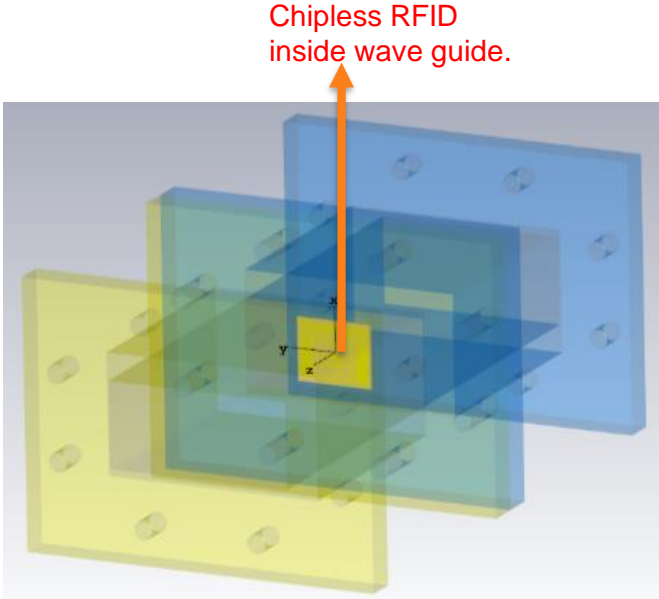
RFID Embedded Sensor Simulation



Note: Embedded sensor development and simulation studies were funded through UTS Research Grants.

RFID Embedded Sensor Simulation

Increasing the size of RFID sensor to study the resonant frequency changes



Size	Resonant Frequencies			
	ELC (GHz)	S1 (GHz)	S2 (GHz)	S3 (GHz)
1.05	6.599	8.029	9.151	9.822
1.10	6.324	7.655	8.359	9.173
1.15	6.071	7.325	7.996	8.810
1.20	5.763	7.017	7.677	8.447
1.25	5.554	6.742	7.369	8.117
1.30	5.378	6.478	7.094	7.798
1.35	5.249	6.460	7.048	7.523
1.40	5.015	6.016	6.599	7.248
1.45	4.861	5.818	6.379	7.006
1.50	4.707	5.620	6.170	6.775
1.55	4.567	5.444	5.972	6.555
1.60	4.443	5.268	5.785	6.346
1.65	4.322	5.103	5.609	6.159
1.70	4.201	4.921	5.455	5.983
1.75	4.080	4.839	5.301	5.818
1.80	3.948	4.696	5.158	5.653

Size 1.40 is chosen for embedding inside concrete

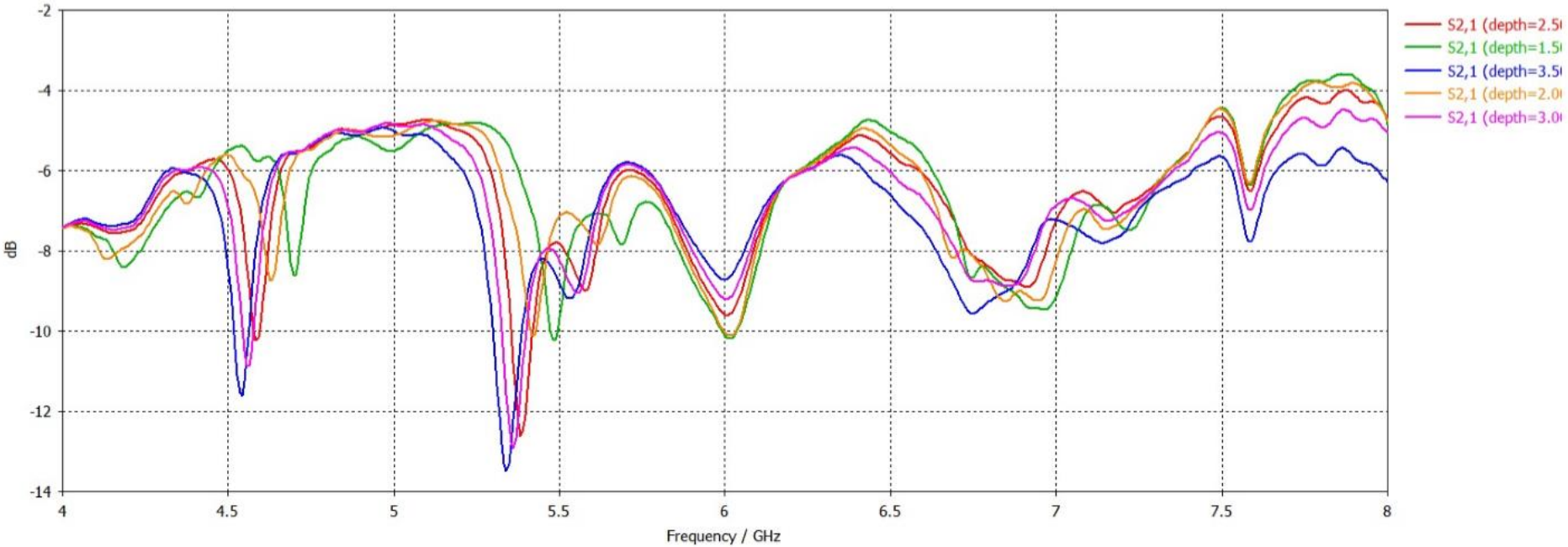
Note: Some parts of the embedded sensor development and studies were funded through an UTS Research Grants.

RFID Embedded Sensor Simulation

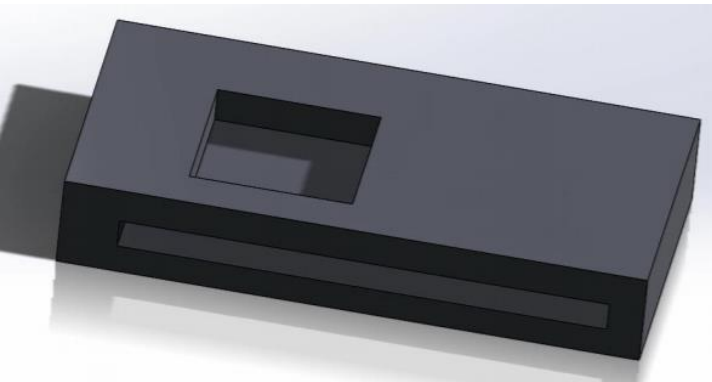
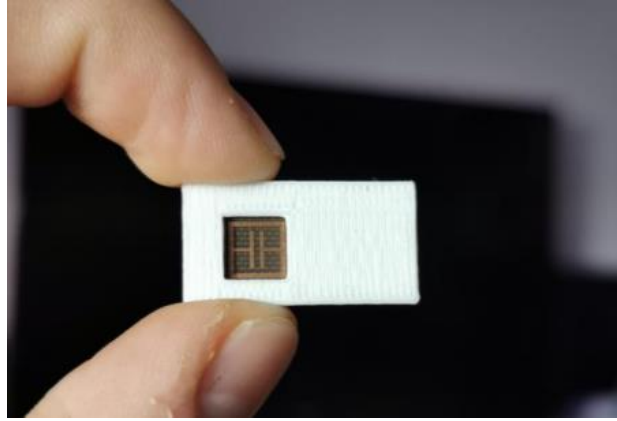
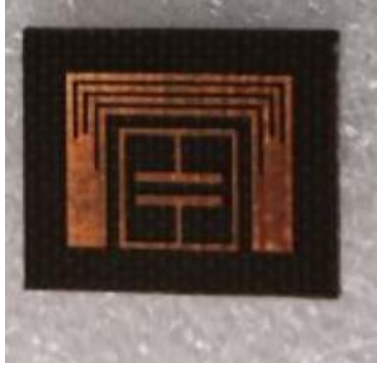
Matrix of sensors placed at different depths

Simulation studies indicate up to 3.5mm depth RFID sensor can be placed for sensor monitoring.

Practical experiments needed to arrive conclusions



RFID Embedded Sensor Preliminary Laboratory Investigations



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1. Parameters of interest for short-term and long-term performance monitoring of wastewater and water pipe linings
2. Ultrasonic Technology for Evaluating Thickness of Cement Based Coatings for Wastewater Assets
3. Measuring Acid Permeation for Long-term Performance Monitoring of CAC and Geo-polymer Coatings
4. Review of Current Embedded Sensing Technologies for Monitoring Water and Wastewater Pipe Linings and Infrastructure

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