Autonomous Radiofrequency Corrosion Sensors for Reinforced Concrete Infrastructure Monitoring

https://labsticc.fr/fr

Supervisor: Stéphane Rioual (rioual@univ-brest.fr)

This project aims at optimizing the monitoring of port infrastructures by implementing predictive maintenance based on the development of sensors. Various non-destructive techniques such as impedance measurement, electrochemical potentials, radar or ultrasound methods exist to collect information on the mechanical properties of structures and on the corrosion of reinforcements. However, most of the time, their are limited in space, their cost is high and they often lead to complex interpretations. An alternative is to provide numerous sensors embedded in concrete structures under monitoring. In this case, the use of wireless sensors, totally autonomous in energy, and at low cost is essential. Recently, at Lab-STICC, we have shown the possibility of producing such sensors integrated in concrete for monitoring steel corrosion. The sensor is then interrogated from the outside by a reader and is intended to provide data to artificial intelligence, BIM structures, or digital twins. Despite the interest of the method, technological barriers have to be solved for an application of this type of sensor to port infrastructures. This is the aim of the present project.

The sensors developed in this project are inspired by RFID (RadioFrequency IDentification) technology, for which a tag is interrogated remotely by a radio frequency reader. **They are based on the electromagnetic coupling between an antenna, or a RF function and a corrosion-sensitive thin film**. They were carried out as part of a European project dedicated to the monitoring of atmospheric corrosion (https://www.sensmat.eu/). However, the method is limited in the case of application to port infrastructure. Indeed, unlike atmospheric corrosion, for which the loss of metal occurs uniformly on the surface, corrosion of steels can occur by the formation of pitting. This phenomenon is all the more dangerous as it is very difficult to detect pitting during inspections of structures. A major challenge of the project is therefore to propose a sensor to distinguish the two types of corrosion in concrete. For this, we will rely on variations of electromagnetic properties (resistive, capacitive, inductive) associated with these two processes. This will require during the thesis to use the tools specific to the characterization of materials in the field of microwaves (electromagnetic simulations, network analyzers, ..) and possibly to have knowledge in the field of corrosion. This multidisciplinary project is part of a partnership context, particularly with the Brittany Region and the University of Stuttgart.

Keywords: sensors, radiofrequencies waves, materials, corrosion

References :

Decoupling free chloride and water ingress by a dielectric resonant sensor, K. Bouzaffour, B. Lescop, F. Gallée, P. Talbot, S. Rioual, Construction and Building Materials, 372, 130806 (2023).

Development of an embedded UHF-RFID corrosion sensor for monitoring corrosion of steel in concrete, K. Bo0uzaffour, B. Lescop, F. Gallée, P. Talbot, and S. Rioual, *IEEE Sensors Journal 21 12306-12312 (2021).*

Development of a RFID sensitive tag dedicated to the monitoring of the environmental corrosiveness for indoor applications, I.El Masri, B. Lescop, P. Talbot, G.N. Vien, J. Becker, D. Thierry, S. Rioual, *Sensors and Actuators: B. Chemical 322 128602 (2020).*

Development of wireless and passive corrosion sensors for material degradation monitoring in coastal zones and immersed environment, R. Khalifeh, M. Yasri, B. Lescop, F. Gallée, E. Diler, D. Thierry, S. Rioual, *IEEE J. Ocean. Eng.* 99, 776-782 *(2016)*