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XXXVII Cycle

Materials and processing for power electronics packaging and green technologies

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Research context and motivation

- Nowadays, contamination of heavy metals (HMs) in waters, caused by the anthropogenic release, is a global issue. In fact, in the field of green technology, devices that are able to detect the concentration of these elements are essential. They are required not only for measurements on common drinking water, where the low limit of concentration are set by law, but also for metal detection in industrial processes, such as electroplating, where the concentrations are higher.
- In this research effort, emerging Micro Electro Mechanical System (MEMS) technologies, such as lab-on-a-chip, are used to address market demands by combining chemical processes with electrical interfaces and to generate manufacturable devices.
- One of the project's aim is to develop a system that can be installed *in situ* for online autonomous and real-time monitoring of HMs detection, as well as other physical and chemical parameters. At the same time, another purpose is to investigate innovative materials for the packaging of these new devices that can satisfy manufacturing and installation requirements.

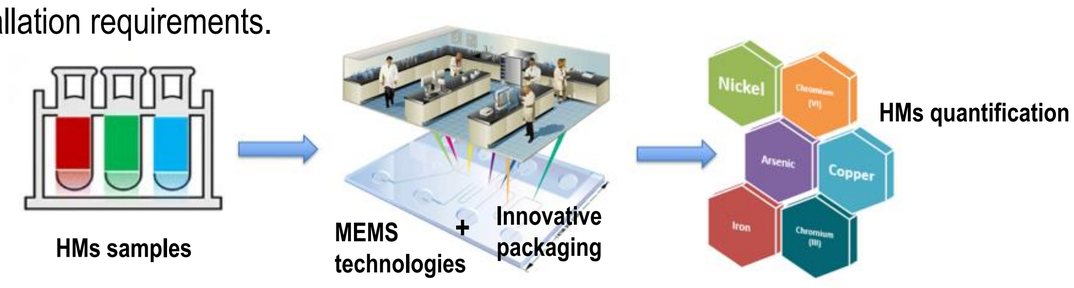

Figure 1: Schematic representation which describe the detection of HMs

Addressed research questions/problems

- To achieve the ultimate aim of a multifunctional system, a mix of interdisciplinary abilities in chemistry, materials science and engineering will be required. The goal is to create an instrument that can provide several outputs at the same time by combining various approaches and instruments.
- Opening new horizons as micro/nano portable manufacturing tools with high technological impact, within an original and functional packaging, can be a key element in a wide range of fields. The final device can be employed by different industries that require close control of the parameters described above to obtain an excellent final product, such as the automotive industry. On the other hand, the wastewater that can come from these sectors, must be closely controlled because could have negative effects on the environment and ultimately a deadly impact on human health.
- In this field of study, the choice of a packaging material that permits the specified instrument to fulfill its duties becomes critical.

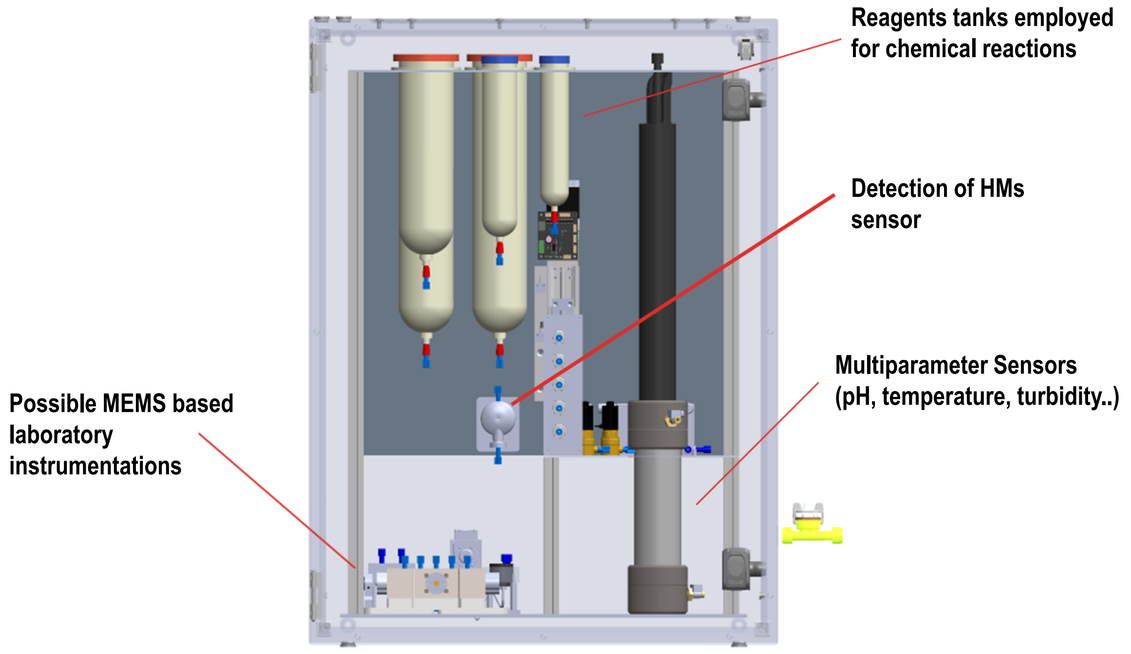

Figure 2: Rendering of the final measuring device with related components to be implemented.

Published and submitted works

- Periolatto, M. , Mossotti, G., et al., "*Routine Monitoring of Trace Arsenic in Water by Lab-on-a-chip Technology: a Preliminary Study*", Chemical Engineering Transactions, vol. 91, 2022, pp. 379-384.
- Mossotti, G. , et al., "*Spectrophotometric Detection of Copper in Water by Lab-on-a-chip Technology: Application to Electroplating*", Chemical Engineering Transactions (Accepted for publication)
- Mossotti, G., et al., "*Spectrophotometric Detection of Nickel in Water by Lab-on-a-chip Technology: Application to Electroplating*", Chemical Engineering Transactions (Accepted for publication)

Novel contributions

- The research project is focused on:

1) Metal-specific chelating agents that detect HMs presence following chemical reactions.
2) Optimization of the existing method regarding compatibility between packaging interface and reagents.
3) Multiparameter determination of different elements in liquid samples, by specific sensors.

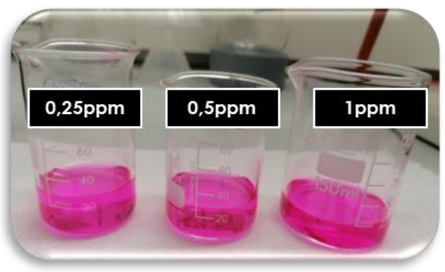

Figure 3: Liquid samples containing traces of Arsenic, detected in presence of Rhodamine-B as a chelating agent

Adopted methodologies

- Techniques involved in characterization of HMs and development MEMS technologies:
  1) UV-Vis spectroscopy
  2) Chronopotentiometry

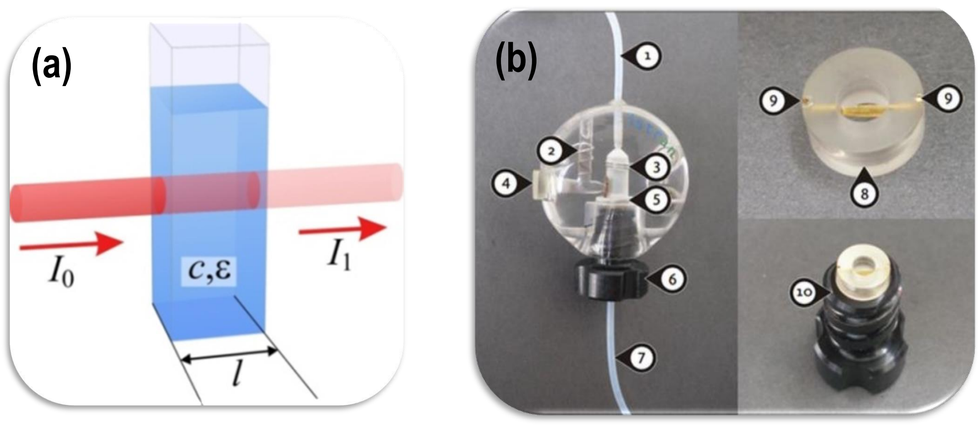

Figure 4: (a) Wide range of HMs concentration in water may be accurately determined via spectrophotometric analysis, with high selectivity and sensitivity, with respect to more sophisticated and expensive procedures (e.g., ICP-MS). (b) Chronopotentiometry measuring cell based on an electrochemical-controlled current detection method, suitable for low concentrations and continuous analysis.

Future work

- Implementation for detection of as many heavy metals as possible, on water samples, in a wide range of pollutant concentrations, from g/L to ppb.
- Investigating and implementing novel packaging materials for specific reagents and interfaces.
- Increasingly sophisticated measurements of components inside aqueous samples by advanced MEMS technology (e.g., gas-chromatograph in Fig. 5) to be incorporated and integrated into the final product, for the detection of various types of hydrocarbons.

Figure 5: Example of portable GC for hydrocarbon detection

List of attended classes

- 01UKGKI – Synthesis methods to tailor the surface and the structure properties of advanced materials (24/05/2022, 5 CFU)
- 01PJMRV – Computer ethics (27/04/2022, 4 CFU)
- 01VJAPE – Advanced Technologies and Applications (9/09/2022, 6 CFU)
- 01QORRV – Writing scientific paper in English (16/06/2022, 3 CFU)

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