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HABILITATION THESIS

A B S T R A C T

Sensors, functional printed materials and IoT platforms for environmental monitoring and biomedical applications

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The presented research program describes a coherent evolution from the initial topic of the doctoral thesis – distributed measurements and expert systems – towards a complete "material – sensor – platform – decision" architecture, applied in health, environment and energy. The unifying element is the intelligent use of measurements (electrochemical, optical, dielectric, environmental) in complex, connected systems, in which fuzzy/neuro-fuzzy models and modern instrumentation (physical and virtual) support the decision.

A first major pillar is the development of hybrid nanomaterials and printed electrochemical sensors (based on graphene, ceramic nanotubes, conducting polymers, metallic nanoparticles), which have demonstrated increased sensitivity compared to classical electrodes, low detection limits and good stability over time, especially for anions and species relevant for environmental and biological fluid monitoring. The second pillar concerns IoT/PoC measurement platforms and distributed instrumentation, which allow the transition from isolated experiments to connected sensor networks, with real-time data acquisition, processing and transmission.

A third pillar is represented by biomedical models and healthcare applications (liver hyperthermia, burn model, assisted reproduction devices), which demonstrate the design and validation capability of instrumentation under in vivo conditions and pave the way for the integration of flexible sensors and IoT connectivity in clinical applications. These directions are complemented by work in the area of environmental sustainability and energy (fuzzy/neuro-fuzzy models, building-level energy management, environmental sensor networks) and interdisciplinary studies on materials and photodegradation, which provide design rules for applications in sensors, biomedicine and environmental protection.

Beyond the scientific results, the thesis highlights the establishment of a research-innovation ecosystem around the themes of sensors - IoT/PoC - sustainability, based on the collaboration between TUIASI, SC Intelectro and clinical/industrial partners. This ecosystem is fueled by research projects, modernized infrastructure, training of master's and doctoral students, as well as technology transfer initiatives. The impact is seen at the scientific level (Q1/Q2 publications, international profile), technological (functional prototypes, TRL increase) and societal (applications oriented towards public health, environmental quality and energy efficiency).

The thesis also recognizes the current limitations - the need for extensive field validation, standardization and regulatory alignment, ensuring material stability and addressing data security and governance issues - and transforms them into starting points for the next stage. The career development plan (chapter 3) proposes a 3–5-year roadmap, focused on the consolidation of printed biosensors, integration into PoC platforms, validation and transfer, and education and ecosystem development.