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PhD thesis title

Implantable and Ingestible Devices: New Opportunities for Electronics and Human Body Interaction

Short Abstract

The area of Biomedical Engineering dealing with the interaction between electronic technologies and human body is increasingly gaining relevance and has long since revolutionized the process of doing therapy and diagnosis. The design of medical devices able to operate in an intense interaction with organs and tissues is particularly attractive. They are sophisticated tools capable to monitor electrical and chemical biological signals, replace parts of the body and restore compromised physiological functions. These advancements were achieved thanks to an interdisciplinary approach bridging electronics, chemistry, material science, mechanical engineering and medicine. In this complex knowledge blend, organic materials and organic electronics are increasingly proving to play a relevant role. In this dissertation, advancements in this context are reported, approaching this wide field from different point of views: from the proposal for an inert system for chronic implantation, to the study of materials and devices for transient operation in the gastro intestinal tract.

First, a proof-of-concept implantable device for the monitoring of the human bladder volume is proposed as a strategy to improve life quality of patients affected by neurogenic bladder and other lower urinary tract disorders. The system incorporates approved biocompatible materials, and its operation is tested in vitro. Its working principle, based on a capacitive linear encoder integrated with a passive wireless radio frequency resonator, allows a wide sensing range without stringent requirements on materials properties and overall device stability.

Afterwards, materials and devices candidates to be introduced in the context of edible electronics are proposed. Appropriate attention is posed in the selection of valuable materials for the design of active electronic components, electing only edible approved materials, or proceeding with a cytotoxicity assay on promising candidates, in order to provide a preliminary degree of biocompatibility. In particular, an n-type solid electrolyte gated transistor is proposed as a low-power device with good stability in aqueous environments. Effort was spent in understanding the charges accumulation mechanism at the semiconductor electrolyte interface and thus detecting the semiconductor permeability to ions. The characterization overtime shows a device shelf-life over 100 days without evident degradation. These results represent a progress toward a fully transient and edible electronics, suitable to operate in the gastro intestinal tract.

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