**Ph.D. in Information Technology**
**Thesis Defense**

**November 28, 2022**
**at 10:00**
**Room Alpha**

**Francesco MODENA** – XXXIV Cycle

## LARGE ARRAYS OF WATER-GATED THIN FILM TRANSISTORS FOR ULTRA-SENSITIVE BIOSENSING APPLICATIONS

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**Abstract:**

In the last few decades, Organic electronics emerged as one of the most promising fields in research, setting the premises for an entire range of new applications, taking advantage of unique properties like flexibility of materials and substrates and the possibility to process them through cheap, solution-based techniques.

Electrolyte-Gated Thin Film Transistors (EGTFTs) combine such properties with the ability to work by incorporating liquid electrolytes, and in particular aqueous electrolytes. This allows to generate high electronic signals with sub-volt operation, making these devices able to operate as biosensors directly in the environment and in the conditions ideal for the biomolecules and biomarkers under investigation.

This dissertation recaps the state of the art of biosensor devices before addressing specifically EGTFTs, identifying the parameters that can be optimized in order to fabricate ultra-sensitive devices and achieve single molecule detection. A fabrication method for these devices on flexible plastic substrates employing large-area, scalable techniques like inkjet-printing is proposed, demonstrating EGTFTs able to achieve single molecule detection of critically important biomarker like MUC1 and KRAS, identified as possible precursors for the early diagnosis of pancreatic cancer.

The fabrication process is then extended to the realization of 4x4 and 8x12 arrays of EGTFTs, compatible with commercial ELISA well plates for an easy implementation of a possible diagnostic platform, based on this system, with already existing practices and machinery commonly employed in modern diagnosis. In fact, large matrices of biosensors are necessary in practical applications for performing multiple assays in parallel, across several different biomarkers and including at the same time the evaluation of calibration curves.

Finally, fully printed 4x4 arrays are demonstrated, by directly inkjet-printing all components of the transistors, comparing then their performances with the devices realized previously, and confirming how printed electronics is a discipline indeed able to produce devices with outstanding electronic properties, without relegating them to a proof-of-concepts level, but can make the next step necessary towards industrial, large area production and commercialization.

## PhD Committee

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