

Ultra-low-power electronics and devices for a multisensing RFID tag

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A multisensing flexible tag microlab (FTM) with RFID communication capabilities and integrated physical and chemical sensors for logistic datalogging applications is being developed. For this very specific scenario, several constraints must be considered: power consumption must be limited in order to allow long-term operation, reliable ISO compliant RFID communication must be implemented, and special encapsulation issues must be faced for reliable sensor integration. In this work, the developments on application specific electronic interfaces and on ultra-low-power MOX gas sensors in the framework of the GoodFood FP6 IP will be reported.

The electronics for sensor control and readout as well as for RFID communication are based on a ultra-low-power MSP430 microcontroller from Texas Instruments together with a custom RFID front-end based on a CPLD programmable logic and some analog passives, and are designed to allow passive ISO15693 compliant RFID communication in the range up to 1 meter. A thin film battery for sensor operation is included, allowing data acquisition and storage when no reader field is present. This design allows to access both the traceability and sensor information even when the on-board battery is exhausted.

The physical sensors for light, temperature and humidity are commercially available devices, while for chemical gas sensing innovative MOX sensors are developed, based on ultra-low-power micromachined hotplate arrays specifically designed for flexible tag integration purposes. A single MOX sensor requires only 8.9 mW for continuous operation, while temperature modulation and discontinuous sensor operation modes are implemented to further reduce the overall power consumption.

Keywords: RFID, Ultra-Low-Power, MOX sensors, logistics

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One of the main targets of the GoodFood project (FP6-IT-1-508774-IP “Food Safety and Quality with Microsystems”) is to improve the food quality control during transport, storage and vending through the development of a flexible tag microlab (FTM). Today’s food monitoring systems rely on expensive and bulky sensors suitable only for specific measurement tasks. GoodFood develops a label that follows the products along all the food chain acquiring data and registering the overcoming of several thresholds in terms of temperature, humidity, light and gas concentrations. At the end of the chain the information will be available for the consumer or end user through an Ambient Intelligence (AmI) platform. In this work, the ultra-low-power tag electronics and the MOX sensors developed for the flexible tag microlab application are presented.

CUSTOM TAG ELECTRONICS

To ensure a sufficient operating time of the flexible tag, the overall power consumption must be kept very low, both for the RFID communication and for the sensor operation. The developed flexible tag is equipped with a thin film battery in order to allow continuous sensor data acquisition, even when no RFID reader field is available. This is an important feature for this application, since the presence of a reader continuously providing power to the tag can not be assumed in real-world logistic scenarios.

In this work the RFID communication is handled by a ultra-low-power Texas Instruments MSP430 microcontroller and a custom RF front-end based on a CPLD programmable logic array and some passive components. The antenna is defined directly on the flexible substrate, and consists of a 5 loops copper inductor of 80 cm total extension. The RFID communication is passive, meaning that no battery power is necessary for communication purposes, and therefore the traceability information as well as the data acquired by the sensors is accessible even when the on-board battery is exhausted. Furthermore, the RFID communication is ISO15693 compliant in order to allow easy integration into already existing logistic facilities.

On the other hand, the sensor control and readout, handled by the same MSP430 microcontroller, requires the on-board thin film battery for powering. Therefore the power consumption of all the sensors must be minimized in order to allow a sufficient lifetime of the sensing part of the tag. The physical sensors are commercially available low-power devices, in particular a temperature and relative humidity sensor from Sensirion is used together with a light sensor (photodiode). For the chemical sensing part, innovative ultra-low-power MOX sensors were developed, based on micromachined hotplate arrays specifically designed for the RFID tag application.

ULTRA-LOW-POWER MOX SENSORS

Ultra small footprint and Ultra-Low-Power MOX sensor hotplates were developed using front-side Silicon bulk micromachining technology. They feature a $1.0 \times 1.5 \times 0.3 \text{ mm}^3$ die footprint, contain an independent array of 4 micro-hotplates with $80 \mu\text{m}$ circular active area, and consume as low as 8.9 mW at continuous 400°C operation (see Figure 1). The use of Platinum for the metallization results in a low heater resistance, which makes these hotplates compatible with low voltage operation on the tag. Discontinuous temperature operation is being implemented to further decrease power consumption of the MOX sensors.

Sensing materials are deposited by drop coating technique, allowing easy deposition of different materials on a single array, in order to perform pattern recognition on the acquired data and enhance the gas sensing selectivity.

DESIGN OF MOX SENSORS FOR FLEXIBLE TAG ENCAPSULATION

The ultra-low-power MOX sensors were designed in order to be reliably encapsulated into the flexible tag, though being exposed to the gas atmosphere to be sensed. In particular, using front-side bulk Silicon micromachining with TMAH etching the suspended membranes are released from the front of the wafer, leaving a massive Silicon surface on the back-side of the dies. This feature allows easy handling of the dies and flip-chip integration into the flexible circuit, as well as polymer casting for reliable encapsulation.

OUTLOOK

The prototypes developed show the feasibility of fabricating a multisensing flexible tag microlab for food logistics applications. The energy balance of the system can be evaluated in real operating conditions, and in-field measurement campaigns can be performed. Nevertheless, the actual prototypes are large and based on several discrete components, as can be seen in Figure 2. For future applications in case of mass-market perspectives, the overall dimensions and the complexity of the flexible tag microlab can be greatly reduced by ASIC development, integrating the microcontroller, the physical sensors as well as the RFID front-end electronics into a single chip. Furthermore, the use of a replaceable thin film battery for the sensing part can result in non-disposable tags which could be reused if cost issues are crucial for the specific logistics application.

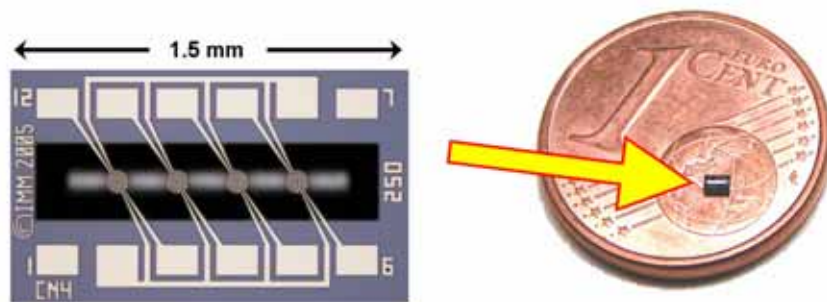


Figure 1: Detail of the Ultra-Low-Power MOX sensor hotplates

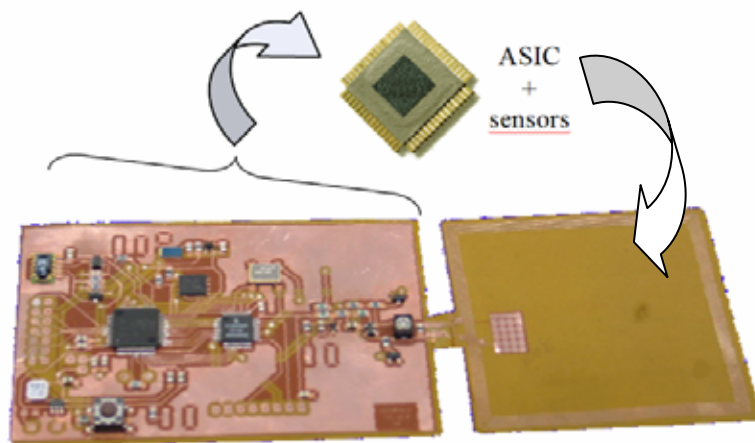


Figure 2: Flexible Tag electronics + antenna, and the perspective of future ASIC development