FABRICATION PROCESS FOR A FLEXIBLE TAG MICROLAB

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Abstract (250words)

The aim of this paper is to present an integrated process flow for a smart tag with integrated sensors and RFID communication, a Flexible Tag Microlab (FTM). The heart of the designed container tracing system is an RFID system (Reader + Tag) with gas sensing capabilities on board. In the former prototypes, the chemical sensors were integrated on the reader, whereas the tags where addressed like conventional RFID-tags containing also physical (temperature, humidity and light) sensors. However, this paper will show how the gas sensing reader functionalities are being transferred to the tag, reaching a flexible tag microlab, which represents a real innovation in the field of flexible labels. Key issues for the realisation of the FTM, such us flexible substrates and gas sensor integration technologies will be presented.

The process flow employed for the two metal levels interconnect fabrication will be described in detail. The material used is the DuPont™ Pyralux® AP 8525R double-sided copper-clad laminate, formed by a Kapton foil with a copper layer on each side. The vias and windows openings are performed by femtosecond laser ablation. The copper interconnections are realized by photolithography and wet chemical etching.

The MOX sensors hotplates specially developed to fulfill the FTM constrains in terms of low power consumption has been used to prove two integration technologies into the flexible substrates: Chip on Flex (COF) wire bonding and Anisotropic Conductive Adhesive (ACA) flip chip bonding. Both technologies will be compared and benchmarked for future product developments.

Keywords: RFID-systems, Flexible substrate technologies, MOX sensors, ACA flip chip, COF bonding.

2-Pages summary

RFID tags are often envisioned as a replacement for the current barcodes. These systems are simple wireless transponders with integrated memory chips. Nowadays the challenge in this field is the integration of sensors on board and there are some examples of tags in the market including temperature and humidity sensors. However, there are no commercial labels existing containing chemical sensors. In this work, we present the integration of gas sensors onto flexible substrates together with an RFID transponder to get a Flexible Tag Microlab (FTM) innovative system for food logistic applications. Key issues for the realisation of the FTM, such us flexible substrates and gas sensor integration technologies are described in detail.

A straightforward process flow for flexible substrates fabrication has been implemented. The outline of this process is presented in Figure 1. The material used is the DuPont™ Pyralux® AP 8525R double-sided copper-clad laminate, formed by a 50 μm thick Kapton foil with a 18 μm copper layer on each side. In this procedure, the vias definition in Kapton is performed directly by femtosecond laser ablation. Then, the copper interconnections of the two metal levels necessary for the interconnect are generated by standard photolithography and wet etching. Finally, contacting through the vias was also implemented.

Figure 2 shows the first prototype of the developed FTM. The implemented system is a semi-active tag with a passive read-out and a battery powered sensing part. The main functional blocks include a flexible antenna, a microcontroller for sensor control and signal acquisition, a RFID front-end and a CPLD for signal de-/modulation, commercial sensors (rH, T and light), an EEPROM memory and a thin film flexible battery. For this prototype packaged chips were integrated on the flexible circuit using conventional assembly technologies.

The MOX sensors hotplates specially developed to fulfill the FTM constrains in terms of flexibility and low power consumption[1] has been used to prove two integration technologies into the flexible substrates: Chip on Flex (COF) wire bonding and Anisotropic Conductive Adhesive (ACA) flip chip bonding.

Concerning the Chip on Flex wire bonding a rigid support, called stiffener, is necessary to obtain a more reliable connection between the MOX sensor and the flexible circuit. These materials keep the bond pad area rigid, preventing ultrasonic energy from being absorbed by the flex circuit. Moreover, by cutting a hole in the flex circuit, the die can be mounted directly on the metal stiffener, which can act also as very efficient heat sink. A schematization of the COF process is shown in Figure 3.

On the other hand, flip chip technology using ACAs[2] relies on the uni-directional conductivity, always in the vertical direction, achieved with these adhesive films. The material is placed between the surfaces to be connected and pressure and/or heat is applied to form the bond, as illustrated in Figure 4 (a).

Using both technologies ULPHP have been successfully assembled on test flexible substrates, as shown in Figures 3 and 4(b).

References

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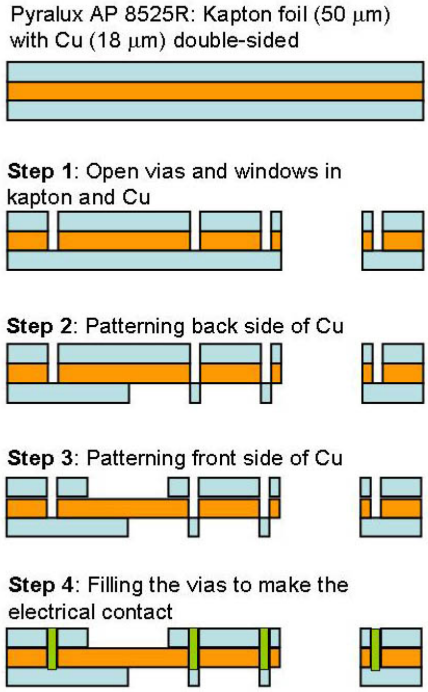


Figure 1. Process design for flexible substrates fabrication.

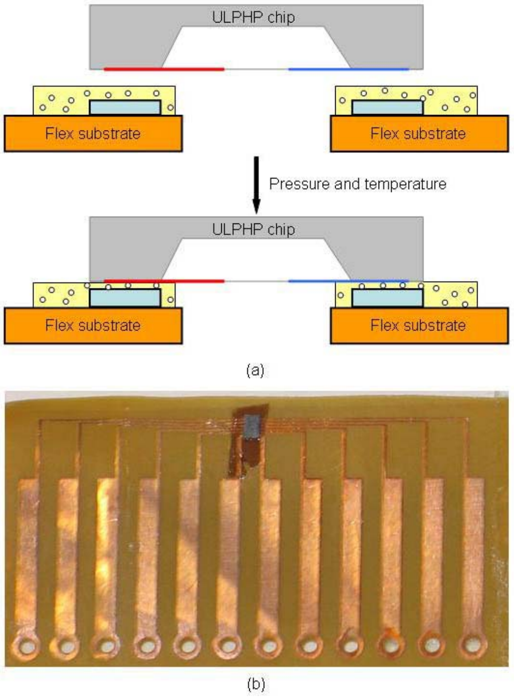


Figure 4. (a) Schematic view of the thermo-compression bonding using ACAs. Conductive particles are trapped between the flexible circuit and the chip pads. (b) ULPHP chip assembled on the flexible substrate.

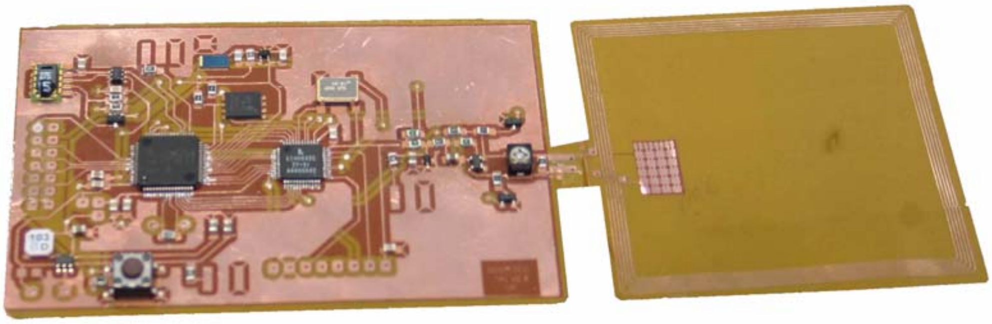
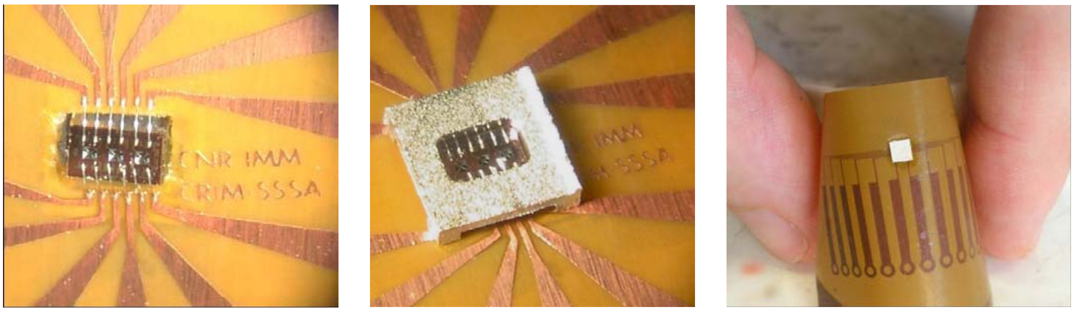


Figure 2. FTM first prototype including rH, temperature and light sensors and a flexible antenna. A credit card size was chosen for the tag.



a) b) c)

Figure 3. Final prototype of ULP gas sensor array die integrated on flex.
Wire-bonded array on stiffener (a), array covered by protection cap (b) and effect of the stiffener during bending of the flex tag (c).