SUMON2 – Hybrid Sustainable Bio-monitoring Test Strips with Dedicated Ultra-low-power ICs

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Multiple functional sub-components were integrated onto a single sustainable substrate, including printed sensors and coils, and a dedicated CotS AFE for electro-chemical sensing. This demonstrator is a major milestone towards sustainable devices made of printed electronics and integrated ICs, to allow for multi-analyte sensing.

Monitoring of biochemical analytes is a growing trend for which many products are already on the market: disease detection, food pathogens detection, body fluids monitoring for sport or health, etc. Most of these sensors are and will remain short-lived and involve coupling a disposable sensor to a costly and bulky reader device performing the analysis. CSEM addresses this by integrating the sensor management and connectivity on the same miniaturized, expandable, and sustainable sensor substrate. Instead of addressing multiple pieces of miniaturized equipment, the user would just have to take another same test strip from the bottle and dispose of it after use. This scenario applies for sensing in biofluids (e.g.: saliva, urine, perfusion bags), where the device is activated at the start of use and discarded after operations.

The disposable sensor and reusable reader combination is an attractive business model for many applications (e.g.: chronic diseases, therapy monitoring) but not sustainable for applications that don't require repeated monitoring (e.g.: infectious diseases, pregnancy) or in extreme remote conditions. For such cases, the opportunity of offering disposable sensors providing quantitative results would be a game changer. After the success of SUMON23's building block demonstrator, the next step towards this goal is to integrate the various components needed for the test strip onto a single substrate using printed electronics technologies and sustainable materials.

The architecture of the proposed test strip is shown in Figure 1. A brief description of each component is given below.

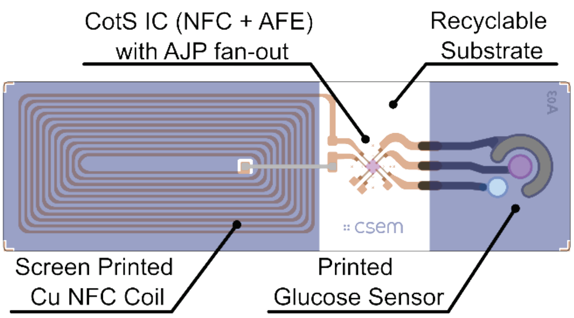

Figure 1: Architecture of SUMON24 prototype showing the integration of printed NFC coil and glucose sensor components with a CotS IC.

Sensor: The miniaturized enzymatic glucose sensors for saliva testing are screen-printed on a polymer film (Figure 2), including custom electrodes. The sensors were prototyped, characterized, and quality controlled by means of calibration curve in artificial saliva and subjected to interferences testing and lifetime storage stability testing.

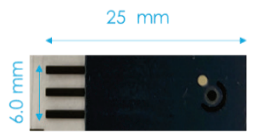

Figure 2: Biochemical sensor.

NFC Coil: The test strip involves an NFC coil tailored to function without the need for an additional tuning capacitor. Test coils were modelled, fabricated, then characterized. The design was then iteratively adjusted to converge on a coil architecture that was both fabricable with printing technologies and would have suitable resistance and inductance to function at the targeted frequency of 13.56 MHz. Empirical results from coil measurement were found to match well with the model values. Figure 3 shows the realized test coil, with comparison of simulated design and printed device.

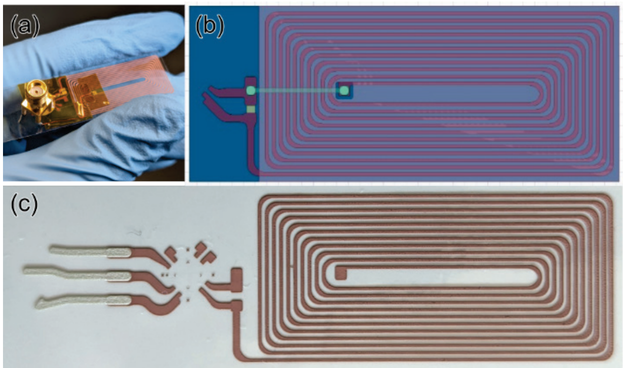

Figure 3: Screen-printed copper NFC coil for the test strip, including (a) as tested, (b) as modelled, and (c) as printed.

System-on-Chip: Ultimately, the test strip will consist in a System on Chip (SoC) containing an analog front-end, a wireless transceiver, a power management unit and a microcontroller. While this multi-analyte SoC is being developed internally, the present iteration utilizes an off-the-shelf solution (SiliconCraft4341), able to measure a single analyte, to allow for investigating the integration of the bare die IC onto the substrate. Feasibility studies have confirmed that this is possible with aerosol-jet printed fanouts, and similar studies are underway for making this connection using flip-chip technologies. Figure 4 shows images of the aerosol-jet printed fanouts connecting the off-the-shelf chip to screen-printed copper interconnects.

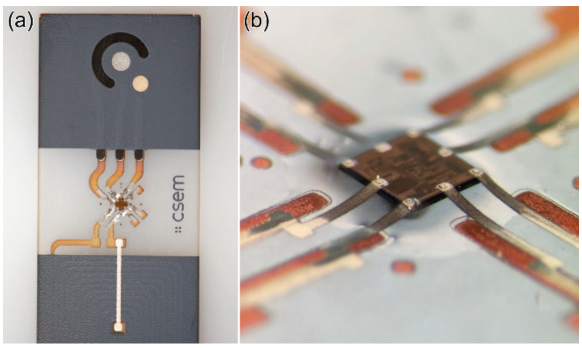

Figure 4: Integration of the SiC4341 IC with a screen-printed copper fanout via aerosol-jet printing, as seen from (a) a top-down view and (b) an oblique angle.

The excellent results and encouraging yield validate the approach and constitute a great milestone towards the objective of fully disposable devices made of printed electronics and electronic components. Following this success, the design will be expanded to include multi-sensing capabilities utilizing the CSEM custom designed ASIC.