Printed Electronics for Sensing

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Digital, additive printing of electronic materials allows rapid, highly customizable fabrication, and low-cost printed electronics are compelling for internet-of-things applications that require large volume of distributed devices, such as in sensor networks and smart packaging. With the recent improvements in solution electronic inks, it is now possible to build independent sensor systems out of printed thin-film devices. In this presentation I will discuss the design rules we learned in the course of developing the fully printed sensor platform.

One of the prototypes (Fig. 1) is a temperature sensor tag [1] consisted of a printed thermistor bridge, a threshold control circuit, and non-volatile memories. The threshold control circuit is based on inkjet printed complementary transistors, and the non-volatile memories are capacitors with ferroelectric polymer dielectric. When the thermistor temperature exceeds a pre-set threshold (above 35°C or below 8°C), the control circuit is triggered to generate a pulse to write into the memory. This temperature sensor tag is self-contained and will be applicable to packaging or environmental monitoring applications.

In electronic systems, components often require different supply voltage for operation. In order to meet this requirement and to optimize power consumption for flexible electronics, a pulsed voltage multiplier [2] is implemented to boost the voltage at specific circuit nodes above the supply voltage. A five-stage pulsed voltage multiplier is shown to provide an output voltage up to 18 V from a supply voltage of 10 V, with minimum 10 ms pulse rise time for a 70 pF load. The printed multiplier allows a single power source to deliver multiple voltage levels and enables integration of lower voltage logic with components that require higher operating voltage, for example, in the case of recording data into memory cells in sensor tags.

Lastly, a readout circuit based on a single-OTFT gain stage is demonstrated for reading ferroelectric (FE) nonvolatile rewritable memories [3]. It was observed that high gain is not required for the readout circuit, due to the large difference in polarization charge between FE memory states. The circuit uses few OTFTs, which leads to higher yield, and does not require matching.

In addition to demonstrating the circuit performance, I will discuss some approaches to tackle the challenges of device variations and stability in printed devices [4], to improve the reliability of the fabrication processes and accelerate the development of printed electronics.

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Fig. 1. OTFT temperature sensor tag (left). Pulsed voltage multiplier (right).

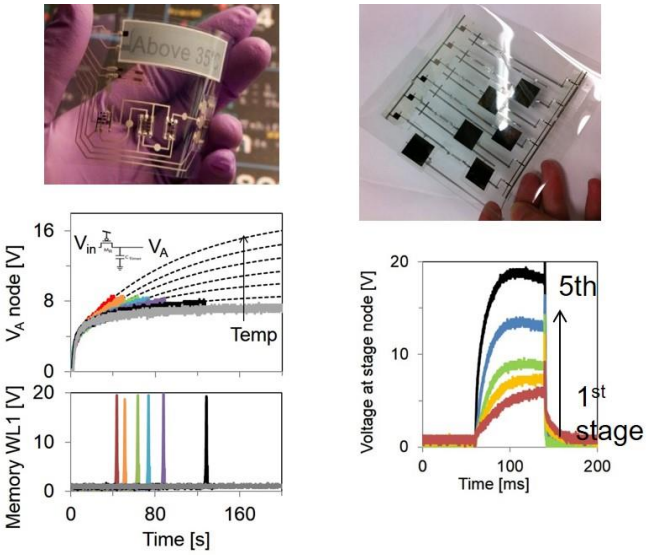

Fig. 2. Circuit schematics and photograph of the printed FE memory readout circuit on plastic foil.