

# Demonstration of a New Technology Which Allows Direct Sensor Integration on Flexible Substrates

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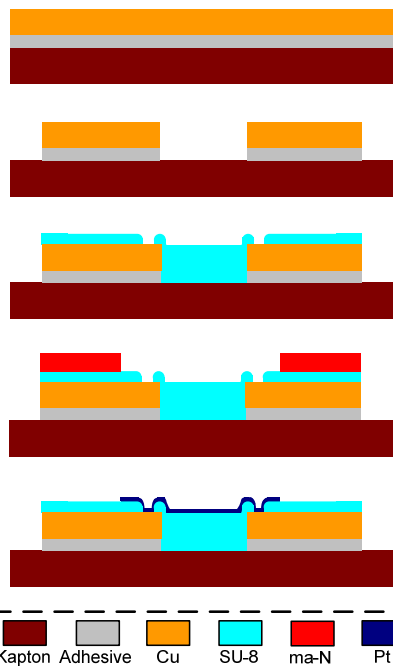
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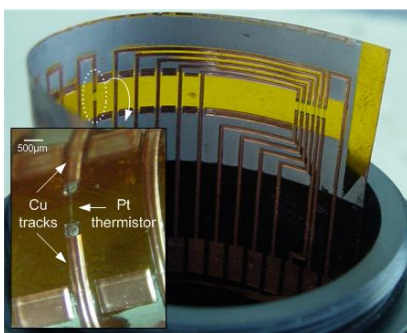
**Session:** Flexible circuits and sensors

## Introduction

The commercial availability of metalized flexible organic films introduced an increasing effort in forming various structures on top of these substrates [1]. Typically, the desired patterns are formed by chemical etching of the metal on selected areas. However, the resulting surface topology induces major restrictions on further process flow steps, thus limiting the fabrication of additional device structures.



**Fig.1:** Main steps of the proposed technology process flow.



**Fig.2:** A photograph of the fabricated device on flexible substrate.

## Technology Description

The proposed technology provides the ability of micro-structure formation on top of macro-structured flexible substrates. Thus a micro-device can be integrated using standard microsystem techniques on top of a flexible platform that implements the corresponding control and read out electronics. The micro-device is directly connected with the underneath electronic circuit.

A layout of the process flow is shown in Fig. 1. The initial substrate is a Pyralux® copper-clad laminated composite, which is constructed of DuPont Kapton® polyimide film with a 12.5µm thick copper foil on one side. The pattern of the copper tracks is defined via chemical etching following the initial lithographical patterning with the positive photoresist AZ. Direct metal deposition in order to establish electrical connections between distinct copper tracks is not applicable, due to the size and nature of the sidewalls of the copper structures. In order to provide a smooth path for the subsequently deposited metal lines, a planarization layer of 15µm thick SU-8 is spin coated. The photoresist is lithographically patterned in such a way that it covers the edges of the structures, while electrical contact of the subsequently deposited metal layer is established through openings (vias) in the SU-8 layer. The 7.5µm thick sacrificial layer is afterwards formed by spin coating and patterning of the negative photoresist ma-N. The specific phototresist spans a thickness range which is compatible with the specific topology, while it provides sidewalls of negative slope. The final step involves the deposition and lift-off of a 30/300nm thick Ti/Pt bilayer.

## Technology demonstration – Temperature sensor fabrication

In order to demonstrate the validity of the proposed technology a series of temperature sensors were fabricated and evaluated on top of a flexible organic substrate. A photograph of the fabricated device is shown in Fig 2. The sensors were implemented through 300 nm thick Pt thermistors, with lateral dimensions of 1.5x0.1mm<sup>2</sup> and can act both as heating or temperature sensing elements. The corresponding TCR was found to be 0.0025/°C. The device exhibits high thermal isolation, due to the materials that it is comprised of (SU-8 and Kapton®) which exhibit low thermal conductivity values (0.2 W/m·K and 0.12 W/m·K respectively), while the overall thickness of the device is less than 100µm. In order to quantify the specific effect, the temperature increase caused by the passing of electrical current through a thermistor fabricated on the flexible substrate was evaluated and found to be 77% higher than that of a corresponding thermistor fabricated on a regular PCB, referring to same power values.

## Conclusions / Summary

A simple method to fabricate micro-devices using standard microsystem technology was demonstrated. The devices are directly connected to macroscale copper structures of commercial flexible copper-clad laminated composites. The constructed Pt thermistors can act as temperature sensing elements, fully integrated to the substrate electronics. A very high degree of thermal isolation of the thermistors is achieved, which makes them suitable for a variety of thermal sensing applications.

## References

1. D. J. Lichtenwalner et.al, Sensors and Actuators A 135 (2007) 593–597.