A CMOS MEMS Gold Plated Electrode Array for Chemical Vapor Detection

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Abstract—**This work presents the fabrication and demonstration of an electroless gold plated CMOS-MEMS chemresistor array sensor for selective detection of volatile organic compounds, with conductive polythiophene polymer used as an active sensing material. Chemresistor electrode fabrication involves post-CMOS etching and electroless plating steps. An electroless gold plating process selectively deposits gold onto the CMOS aluminum electrodes to provide ohmic contact to the polymer layer. Electroless gold techniques are optimized to provide for a sub-micron vertical gap between the chemresistor electrodes. Polymer solutions are then deposited onto electrodes using drop-on-demand inkjet printing. Measured device response to methanol, acetone, and acetonitrile vapors demonstrates feasibility.**

I. INTRODUCTION

Applications such as environmental monitoring, fire safety and homeland security require portable and inexpensive gas analyzers. Current commercial products are bulky and difficult to integrate. Therefore, there is a need for single chip implementation for electronic nose analysis [1]. Electronic nose analysis requires sensor arrays of either repeated sensing modes or mixed modes, or both. The cumulative responses of individual sensors determine a pattern for analysis of complex mixtures [2]. Total integration using CMOS-MEMS technology has many advantages: direct CMOS integration, miniaturized device size, the ability to array devices, and system portability.

The ultimate goal of the current work is to develop a design in CMOS-MEMS to serve as a single platform for both gravimetric and conductimetric sensing. The co-existence of the two modes in one transduction element provides for a direct correlation between two signal response types. It is believed that this will enhance selectivity and analysis of vapor mixtures.

In prior work we have demonstrated the use of CMOS-MEMS cantilevers as mass sensitive organic vapor sensors [3] [4]. The device consists of a cantilever with a plate attached to the end of the cantilever, as shown in Figure 1 [3]. The end plate serves as a well and target for drop-on-demand ink jet printing to functionalize the device with polymers with varying vapor sensitivities. Our vision of a dual-mode, single platform design incorporates vertical electrodes in the target end plate for conductimetric sensing.

With that ultimate goal in mind, we report on a first generation device design in CMOS-MEMS that incorporates electroless gold techniques to provide ohmic contact for conductive polymer. Materials used for the electrodes are limited by the CMOS process provided by the foundry. Aluminum is used as the metals interconnect, but provides poor contact resistance to the polymers. Electroless gold techniques are used for selective deposition onto exposed CMOS aluminum electrodes.

There have been previous efforts in CMOS post-processing using electroless gold techniques with carbon black polymers as the conductimetric sensing material [5]. Electroless gold deposition in that work implement relatively thick (~11 μm) lateral electrodes. In the present work, an electroless method described by [6] is modified to achieve thinner electroless metallization stack (~ 0.29 μm) to accommodate for a sub 1 μm vertical gap between the electrodes.

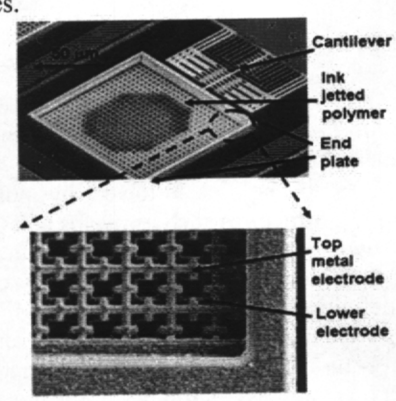

Figure 1. SEMs of first generation device design. The device is released but gold has not been incorporated.

II. ARRAYED DEVICE DESIGN

A. *Vertical Chemresistor Design*

Ink jet printing is chosen as a convenient method to functionalize the individual sensors with various polymer types. Polymer which is suspended in solution is deposited