DESIGN AND MODELING OF MICROBEAM GAS SENSOR IN CMOS TECHNOLOGY

Ioana Voiculescu, Mona Zaghloul, George Washington University, Dept. of Electrical & Computer Engineering, Washington, DC 22052

R. Andrew McGill, Naval Research Laboratory, Code 6375, Washington, DC 20375

A gas or chemical sensor is a transducer capable of interacting with gas(es) and resulting in an electrical signal that can be readily monitored. Conventional devices are relatively large and have millimeter sized dimensions, however with the advent and maturation of MEMS based technology and devices, there exists many opportunities to drastically reduce the size, cost, and power consumption of gas sensing devices. Typical chemical sensor systems today are hand held, but with MEMS type transducers and other MEMS system components (pump, valve, collector), it should be possible in the near future to fabricate match box sized systems, and systems that are inexpensive in volume, so that they can be considered disposable [1].

The MEMS based transducer that is investigated in this work is based on a microcantilever, which acts as a resonating beam microbalance, fig.1. The microcantilever is coated with a sorbent polymer with an affinity for the gas of interest [2].

The sensing principle of mass-sensitive transducers involves sorbing gas molecules and literally weighing them. For devices that are operated in a resonant mode, the mass uptake can by monitored as the shift in resonance frequency. For this purpose a very sensitive balance is needed: the resonating beam microbalance. The polymer sorbent layer is a critical component and to a large degree controls the type of analyte for which the transducer can effectively work with. When the mass of the cantilever increases, the resonance frequency decreases. In an array format with different polymer coated cantilevers, the pattern of responses can be used to fingerprint the gas of interest. The microbeam under consideration in this work is operated in a piezoresistive configuration, using polysilicon resistors, fig.1.

The cantilever, which acts as a resonating beam microbalance, can be processed using CMOS technology, fig.2 [3]. In addition, CMOS technology allows the incorporation of polysilicon heaters which can be used for rapid electrothermal desorption of sorbed gases or vapors from the polymer layer.

In this paper we report on the design, and modeling of electrically excited silicon oxide resonators fabricated by CMOS technology followed by chemical postprocesing. We analyze microbeams with a variety of shapes and dimensions to optimize the resonant frequency, and to allow for increased sensitivity, while also providing a relatively large surface area to coat with the sorbent polymer.

We simulate the resonance frequencies for the four lowest modes of the microcantilever using the ANSYS finite-element analysis program 5.7. In addition to modeling the mechanical behavior of the microbeams, we simulate the thermal properties of the cantilever that result from the application of the silicon heater.

The optimized shape, dimensions, and thermal properties of the microcantilever used for gas sensing will be reported.

References:

1) H. Baltes, D. Lange, A. Koll, The electronic nose in Lilliput, IEEE Spectrum, September 1998, pp.35-38.
2) E. J. Houser, R.A. McGill, T. E. Mlsna, V.K. Nguyen, R. Chung, R.L. Mowery, Sorbent coatings for detection of explosives vapors: applications with chemical sensors, Proceedings of the SPIE, Orlando, FL, vol. 3710,1999, pp. 394-401.
3) G. K. Fedder, S. Santhanam, M. L. Reed, S. C. Eagle, D. F. Guillou, M. S. –C. Lu, L.R. Carley, Laminated high-aspect-ratio microstructures in a conventional CMOS process, Sensors and Actuators A57 (1996), pp. 103-110.

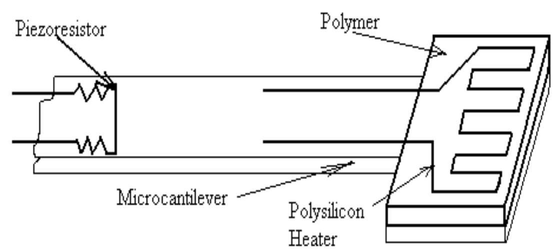

Fig.1 Microcantilever gas sensor

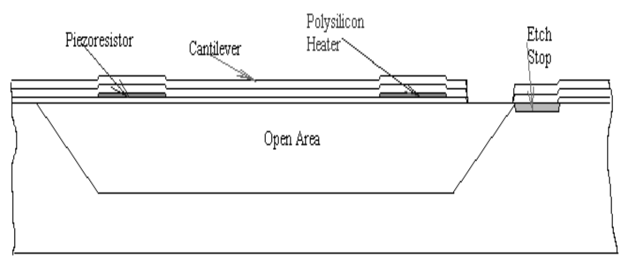

Fig.2 Microcantilever in CMOS technology

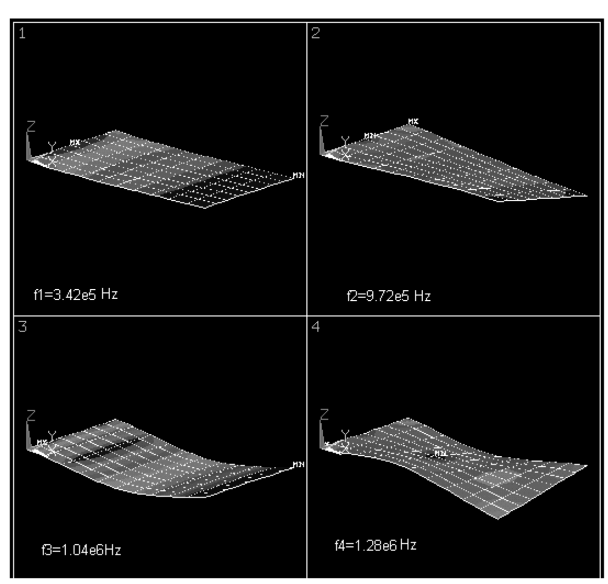

Fig.3 First four modes of the microbeam simulated using the finite-element program ANSYS.