MEMS-Based Embedded Sensor Virtual Components for SoC

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Introduction:

Advancement in MEMS-based sensors brings a new challenge for system-on-a-chip (SoC) design integration where analog and digital circuits coexist on a common substrate with the actual sensing platform. Integration of these MEMS-based sensors into an SoC requires a sensor core or virtual component (VC) that is compatible with the digital design strategy for a larger system design. At present there are no sensor VCs in CAD libraries for SoC integration. The purpose of this paper is to introduce a gas sensor VC that is compatible with SoC design methodology.

Gas Sensor Platform:

The microhotplate is the basic MEMS structure used as a building block for the gas sensor VC [1]. This microhotplate incorporates a polysilicon heating element, a polysilicon or aluminum temperature sensor, and a metal-oxide sensing film to form the gas-sensing platform. Fig. 1 shows the layout, micrograph, and a schematic symbol of the gas sensor platform.

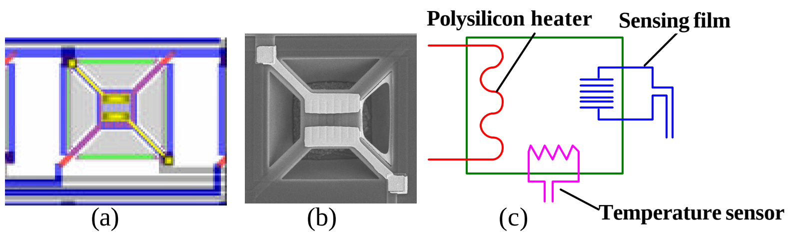


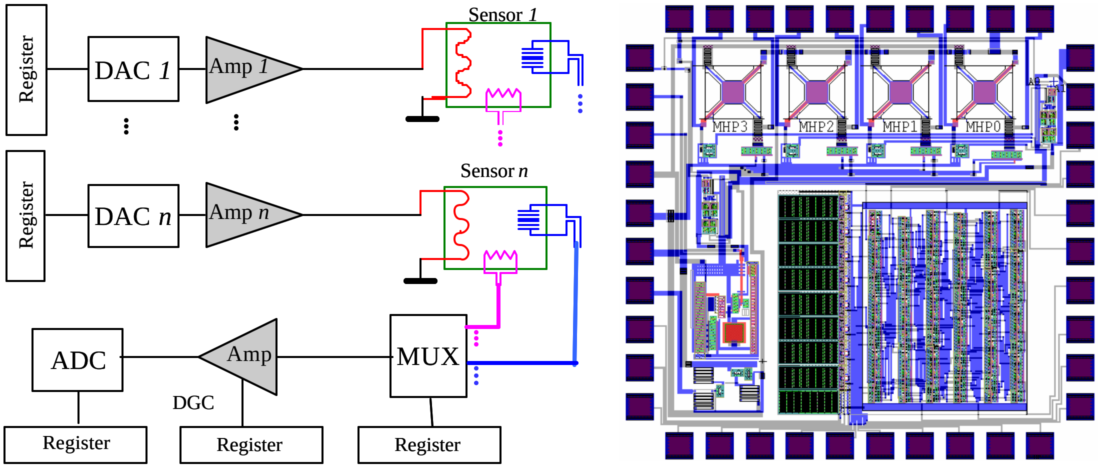
Figure 1. Gas sensor platform. (a) layout (b) micrograph (c) schematic symbol.

An array of the gas sensor elements is fabricated with different sensing film characteristics by controlling heater temperature during film deposition [2]. In this work a gas sensor VC with an array of four sensing elements is presented.

Gas Sensor Virtual Component design:

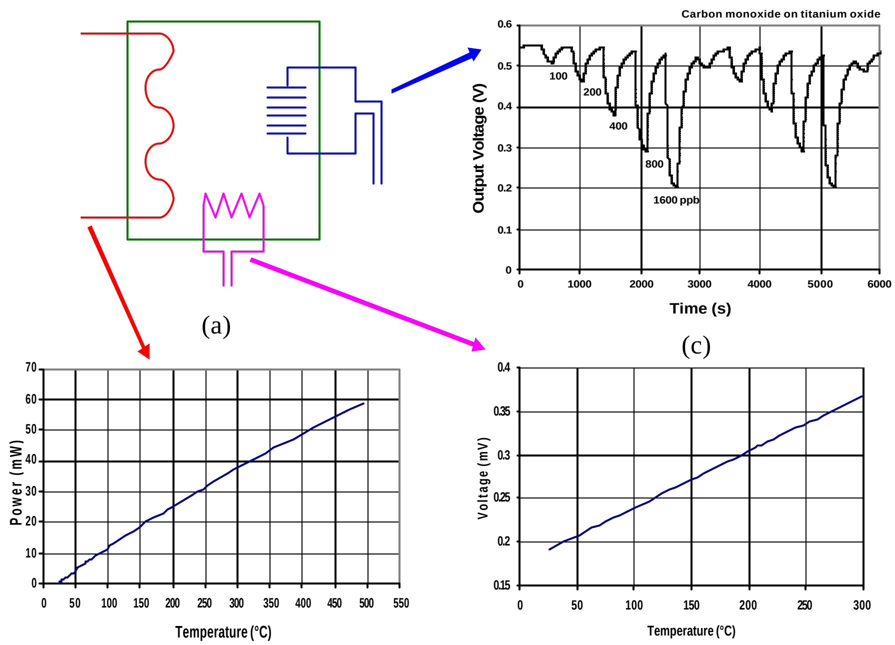
The gas sensor VC encloses the sensor with analog circuitry into a digital shell so that all interface connections to the VC are digital. Fig. 2 (a) shows a block diagram of the gas sensor VC. The circuit topology shown is for an array of n gas sensors. Registers associated with digital-to-analog converters (DAC *1* ... DAC *n*) control heater power for the corresponding sensor's heating element through an amplifier. A register associated with the multiplexer (MUX) selects the temperature sensor or gas sensing film signal of any desired sensor. A register associated with the digital gain control (DGC) amplifier controls its gain, and the register associated with the analog-to-digital controller (ADC) contains the temperature or gas sensing film conductance data of the desired sensor. A DGC amplifier is used to improve dynamic range. Fig. 2 (b) is the layout of the gas sensor VC with an array of four gas sensing elements, decoders, ADC, and amplifiers, all of which is fabricated in 1.5 µm standard CMOS technology. Finally, post processing is performed to realize the MEMS gas sensing structures.

Characterization results of the various components of the sensor of fig 3(a) are given in Figs. 3(b)-3(d). (b) shows the thermal efficiency (7 °C/mW) of the microhotplate. (c) depicts a typical metal-oxide gas sensor response. (d) shows temperature sensor response. The sensor is biased with 10 mA constant current source. A van der Pauw structure is used for the temperature sensor.



(a) (b)

Figure 2. Gas sensor VC. (a) Block diagram (b) layout.



(a) (c)

(b) (d)

Figure 3. Gas sensor characterization results. (a) symbol (b) heater efficiency (c) Typical sensing film response to varying gas concentrations (d) Temperature sensor response.

References:

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