

GAS SENSOR TEST CHIP

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ABSTRACT: A new test chip is being developed to characterize conducting polymers used in gas sensors. The chip, a seven layer cofired alumina substrate with gold electrodes, contains 11 comb and U-bend test structures. The structures are designed to measure the sheet resistance, conduction anisotropy, and peripheral conduction of spin coated films that are not subsequently patterned.

INTRODUCTION: The use of organic polymers to detect gasses has been known [1] for several years to be an effective means for gas detection via conductivity changes. These chemoresistors offer significant advantages over other gas detectors in that they operate near room temperature and thus can be used in low-power applications. This effort is directed at developing a gas monitor for the space station but it also has application for personal gas exposure monitoring.

A polymer-based gas sensor is an array of polymer resistors where each chemoresistor has a different sensitivity to various gasses. The gas sensitivity of each polymer is determined by their polymerization and dopant characteristics [2]. The specific gas identification is made using pattern recognition techniques [3] applied to the response of the array to different gases.

At the current time the production of these sensors is limited by their lack of reproducibility. The first step in developing a gas sensor is to characterize the conductivity of the polymer films using a test chip as shown in Fig 1. This chip was designed to measure various aspects of the conduction mechanisms such as sheet resistance, surface conduction, anisotropic conduction, and film non uniformity as well as contact resistance in order to identify reproducibility issues.

TEST CHIP DEVELOPMENT: The development was guided by the limitation that the polymer films can not be pattern once applied via spin coating. The test chip is being fabricated using a two-conductor thick film technology where the conducting polymer films coat the region between gold electrodes thus essentially eliminating gold-polymer contact resistance which is found with aluminum based electrodes [4]. The low-temperature (800°C) cofired ceramic substrates [5] are currently being fabricated using 125- μm linewidths and spaces. The chips have seven screen printed layers as designated in Fig. 1. Bridge and

van der Pauw resistor structures are not applicable, for the films can not be patterned once deposited. The structures, as shown in Fig. 1, are comb and U-bend resistors for characterizing the basic conduction mechanisms and surface resistors for structure-to-structure conduction.

The test chip has only 18 pins as seen in Fig. 1 allowing access to 11 test structures and 3 heaters used to control polymer polymerization. The measurement circuitry, shown in Fig. 2, is used to sequentially place each chemoresistor in the feedback loop of an operational amplifier using multiplexing circuitry. The operational amplifier is a current to voltage converter where a constant current is driven through each chemoresistor. This approach allows ppm (parts per million) changes in conductivity to be detected.

In designing the test chip, the following design principles were used to meet the design requirements:

- a. Common bussing to conserve pins,
- b. Electrode guarding to eliminate stray surface currents,
- c. Kelvin voltage sensing to avoid analog switch resistor voltage drops.
- d. Structure geometry variations to separate contact and sheet resistance.

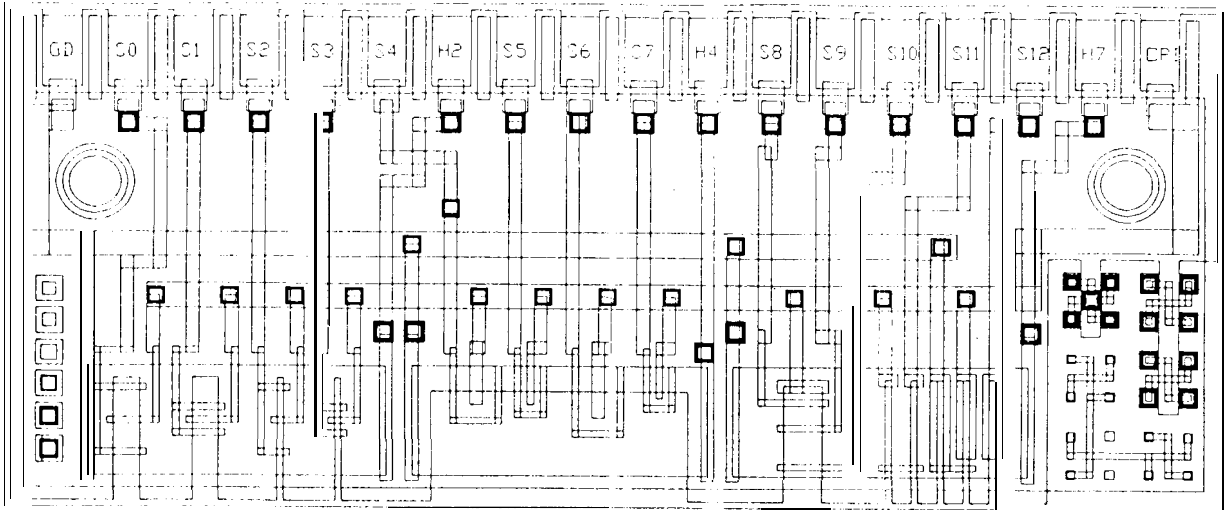
When measuring a particular chemoresistor, all resistors are grounded except for the resistor under test. Currently, chips are being fabricated and results from conducting polypyrrole films are expected in time to be presented at the conference.

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 GASS5821.DWG TEST CHIP

Figure 1. Gas sensor test chip 10 mm x 24 mm where round holes in the substrate facilitate mounting the chip on the spinner.

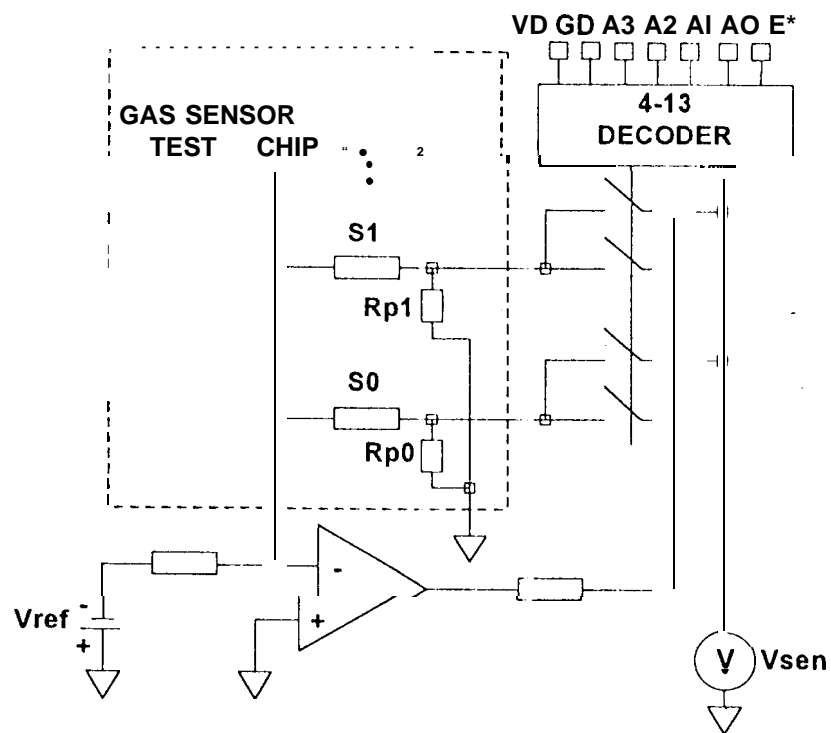


Figure 2. Gas sensor test chip and associated test circuitry where S0-S12 are the chemoresistors and Rp0-Rp12 are peripheral resistors.