Test Structures Applied to the Rapid Prototyping of Sensors

Martin Buehler and Li-Jen Cheng
MS 302-231
Microdevices Laboratory
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109
Tel 818-354-4364
FAX: 818-3934540
e-mail: martin.g.buehler@jpl.nasa.gov
and
Dennis Martin
Halcyon Microelectronics
Irwindale, CA 91706

Oral presentation preferred

ABSTRACT

Recently, test structures were used to aid in the rapid development of a gas sensor and pressure sensor. These sensors were fabricated using co-fired ceramic technology and a multiproject approach, This talk will describe results obtained from a ceramic substrate which contained 36 chips with six variants including the sensors, process control monitors, an an interconnect chip. As far as the authors know, this is the first implementation of multi-projects in co-fired ceramic substrate. The gas sensor is being developed for the Space Shuttle and the pressure gage is being developed as a Martian barometer.

INTRODUCTION

The use of multi-project wafers has been used by the MOSIS project since the early '80s [1] for the fabrication of custom integrated circuits. This approach has proven to be essential in rapid prototyping of commercial chips but also at universities who rely on the MOSIS service in teaching integrated circuits.

In this effort, which calls for the development of two very different sensors, the multi-project approach was used when designing the sensors into a co-fired ceramic substrate [2] depicted in Fig. 1. This substrate contains eight layers

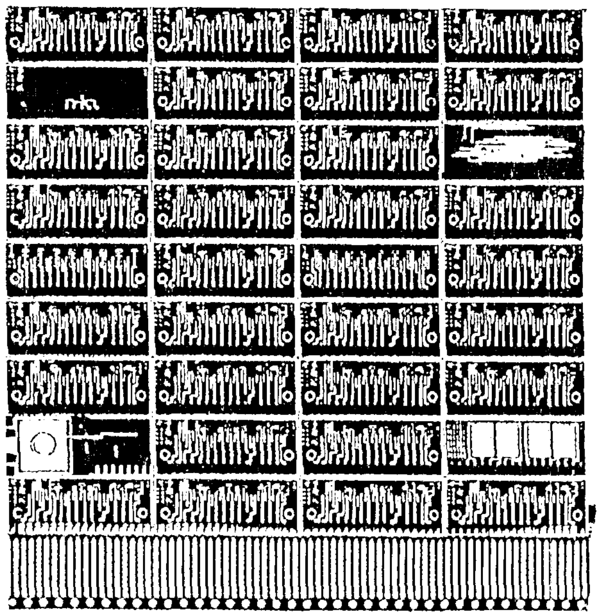

Figure 1. Multi-project co-fired ceramic substrate 9.0 cm x 9.6 cm and a row of electrical contacts shown at the bottom.

including the first laser layer used to cut holes in the ceramic (Al_2O_3) substrate and to perforate the periphery of the chips aiding in their separation. The other seven layers are used in layer screen printing. Electrical contacts, on **1.25-mm** centers, are soldered to the bottom row of chips using C-clips depicted at the bottom of the substrate. Once applied, the bottom row of chips are removed and the contacts soldered to the next row.

The chip found on the substrate shown in Fig. 1 contains six variants which are depicted in Fig. 2, The chips are (a) an initial version of

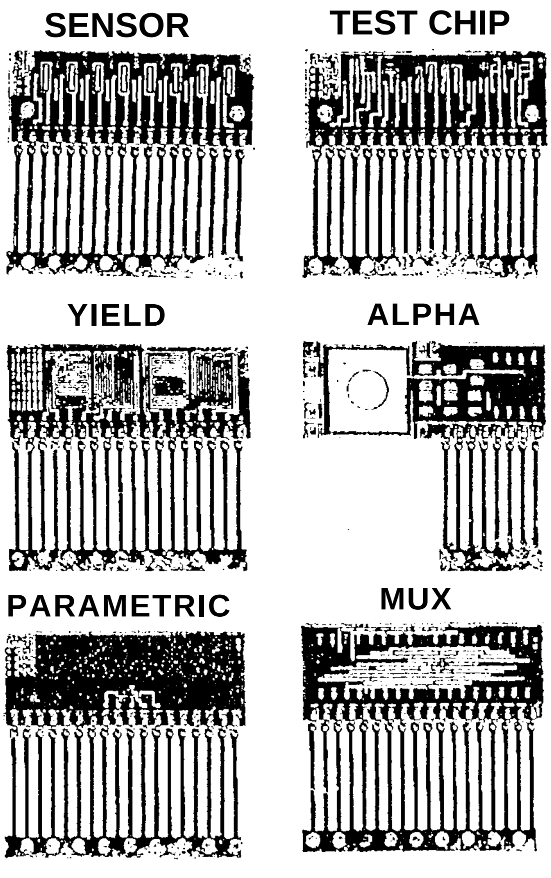

Figure 2, Six variants found on the multi-project substrate shown in Fig. 1.

the gas SENSOR chip, (b) TEST CHIP for gas sensor development, (c) Y] ELD chip used to detect pinholes between layers and via continuity, (d) Al .PHA chip is a pressure sensor, (e) PARAMETRIC chip used to determine the layer sheet and via resistances, and (f) MUX chip used to interconnect two multiplexer circuits. The TEST CHIP, was described at ICMTS 1996 [3] and was used to establish the baseline response for the polypyrrole gas sensing layers.

The presentation will include a discussion of a pinhole test develop to screen the chips at incoming inspection and a presentation of the resistivities of the various layers used to fabricate the chips.

The pressure-sensor alpha chip uses the principle depicted in Fig. 3 in which an alpha-particle source (Am-241) is used to ionize air molecules which are attracted to a cathode plate and detected at the input to an operational amplifier.

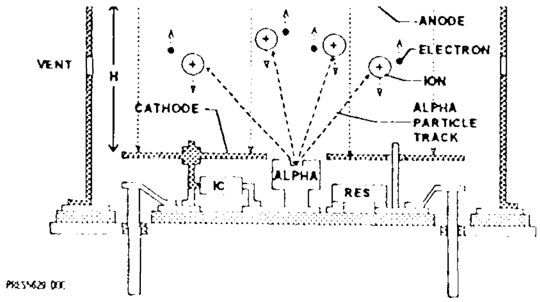

Figure 3. Configuration of the alpha-particle gas-pressure sensor where the distance between the anode and cathode is 11 [4].

Results from this chip arc shown in Fig. 4 where the height of the alpha source was varied above the cathode. These experiments are being used to determine the optimal performance of the sensor, In this case the optimum height of the alpha source is about S rnm above the cathode. The alpha chip was designed with guard circuitry and this has allowed the measurement of ion currents in the pA range.

The development of this pressure sensor is motivated by the fact that it has no moving parts and has a good chance of surviving the landing force of 80,000 G's up arrival at Mars.

A series of test sensors are planned in order to meet the Martian pressure sensing requirements which require current measurements in the 10-fA range using a 1-μCi Am-241 source.

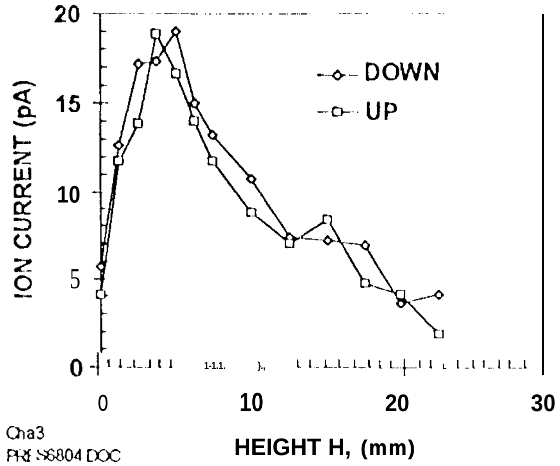

Figure 3, Pressure sensor response to Am-241 held at a distance, H, above the cathode.

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Combining two very different projects on the same ceramic substrate. produced several benefits. Both time and cost were saved by the simultaneous fabrication of the gas and pressure sensors. Also the pinhole problem was shared between the efforts and this improved the performance of both sensors. As far as the authors know, this is the first implementation of multi-projects in co-fired ceramic substrate.

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REFERENCES:

1. V. Tyree, MOSIS Project (private communication) and W'. Hansford, "Automated Process Monitor Generation," Proc. of the Interntl. Conf. on Microelectronic Test Structures, Vol. 7, 1'74-177 (March 1 994).

2. D. A. Doane and P. D. Franzon, eds, "Multichip Module Technologies and Alternatives: The Basics," Van Nostrand Reinhold (New York, 1993).

3. M. G. Buehler and M. A. Ryan. "Gas Sensor Test Chip, " Proc. of the Interntl. Conf. on Microelectronic Test Structures, Vol. 9, 10S-110 (March 1996).

4. M. G. Buehler, L. D. Bell, and M, H. Hecht, "Alpha-Particle Gas-Pressure Sensor," Journal of Vacuum Science and Technology, Vol. A 14(3), 1281-12S7 (May/June 1996).