DEVELOPMENT OF AN IMPLANTABLE MICRODIELECTROMETRY SENSOR†

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Microdielectrometry is a sensor-based method for the measurement of low-frequency dielectric and conductive properties of relatively weakly-conducting materials such as resins, plastics, adhesives, rubber, thin films, and dielectric oils [1,2]. The sensor is a silicon integrated circuit that includes an interdigitated electrode pair, matched FET's, and a diode temperature sensor. The measurement instrument in its most recent form includes digitally generated excitation signals and synchronous digital extraction of response parameters using Fourier transform methods [3]. This paper reports the development of a sensor/package combination that permits the Microdielectrometry probe to be used in a wide variety of materials-processing environments, including chemical reaction vessels and laminating presses.

The sensor/package combination is based on flexible circuit-board concepts. The sensor chip is fabricated in NMOS silicon-gate technology, and is laid out so that the eight bonding pads are at one end, the transistors toward the middle, and the electrodes at the other end (actually occupying 3/4 of the total chip area) [4]. The chip size is 2.5 x 5 mm. The sensor package is fabricated out of laminations of copper and Kapton®, each layer with its own pattern. The lower Kapton® layers have space for the entire chip, while the topmost layer has two openings, one for the interdigitated electrodes, the other for the contact pads. The copper layer is etched into eight leads that overhang the pad opening and register with the chip pads.

The packaging procedure is, first, to bond the chip to an adhesive carrier layer, second, position the package and affix it to the adhesive layer, third, form the eight wire bonds, and, fourth, fill the bond pad opening with an epoxy resin which, when cured, encloses the bonds and active device regions. The final thickness of the chip/package combination is 0.45 mm. The flexible ribbon cable portion of the package which connects the chip to the electronics can be as long as 40 cm, and is 0.15 mm thick. The sensor can drive an additional 3 meters of cable, if required.

Sensors packaged in this manner have been successfully inserted into chemical batch reactors for reaction end-point determination, and have been laminated into epoxy-glass circuit boards and other composite laminates for cure monitoring at temperatures up to 250°C and at pressures up to 1000 psi.

References

1. N. F. Sheppard, Jr., D. R. Day, H. L. Lee, and S. D. Senturia, "Microdielectrometry, Sensors and Actuators, 2, 263-274 (1982).

2. S. D. Senturia and S. L. Garverick, "Method and Apparatus for Microdielectrometry, U.S. Patent No. 4,423,371, Dec. 27, 1983.

3. M. C. W. Coln, Ph.D. Thesis, Massachusetts Institute of Technology, 1984, unpublished.

4. H. L. Lee, M. S. Thesis, Massachusetts Institute of Technology, 1982, unpublished.

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