Pressure-Sensor Assembly Technique

An essential underfilling step can be performed without compromising a diaphragm.

John H. Glenn Research Center, Cleveland, Ohio

Nielsen Engineering & Research (NEAR) recently developed an ultrathin data acquisition system for use in turbomachinery testing at NASA Glenn Research Center. This system integrates a microelectromechanical-systems- (MEMS-) based absolute pressure sensor [0 to 50 psia (0 to 345 kPa)], temperature sensor, signal-conditioning application-specific integrated circuit (ASIC), microprocessor, and digital memory into a package which is roughly 2.8 in. (7.1 cm) long by 0.75 in. (1.9 cm) wide. Each of these components is flip-chip attached to a thin, flexible circuit board and subsequently ground and polished to achieve a total system thickness of 0.006 in. (0.15 mm). Because this instrument is so thin, it can be quickly adhered to any surface of interest where data can be collected without disrupting the flow being investigated.

One issue in the development of the ultrathin data acquisition system was how to attach the MEMS pressure sensor to the circuit board in a manner which allowed the sensor's diaphragm to communicate with the ambient fluid while providing enough support for the chip to survive the grinding and polishing operations. The technique, developed by NEAR and Jabil Technology Services Group (San Jose, CA), is described below. In the approach developed, the sensor is attached to the specially designed circuit board, see Figure 1, using a modified flip-chip technique. The circular diaphragm on the left side of the sensor is used to actively measure the ambient pressure, while the diaphragm on the right is used to compensate for changes in output due to temperature variations. The circuit board is fabricated with an access hole through it so that when the completed system is installed onto a wind tunnel model (chip side down), the active diaphragm is exposed to the environment. After the sensor is flip-chip attached to the circuit board, the die is underfilled to support the chip during the subsequent grinding and polishing operations. To prevent this underfill material from getting onto the sensor's diaphragms, the circuit board is fabricated with two 25-micrometer-tall polymer rings, sized so that the diaphragms fit inside the rings once the chip is attached.

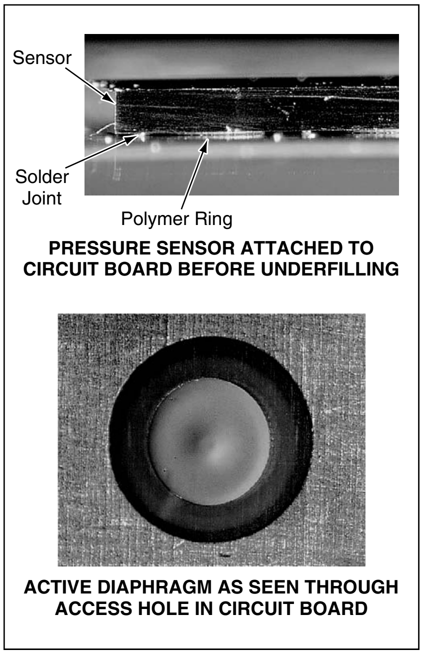

Figure 2. **Critical Components** of the instrument are shown here at two different stages in the assembly process.

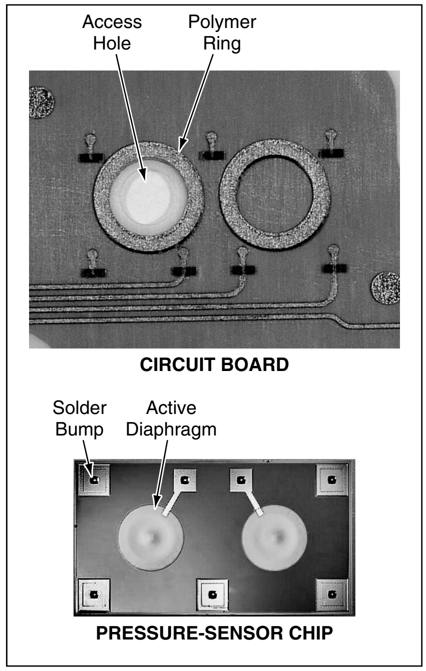

Figure 1. The **Pressure-Sensor Chip and Circuit Board** are shown here as they appear before they are put together by use of a modified flip-chip technique.

During the reflow operation, the solder bumps on the chip melt and spread out over the circuit board's bond pads thus pulling the chip down until its face rests on the top of the two polymer rings. A series of experiments were conducted to determine the optimal size for the solder bumps so that the sensor chip seated properly on the rings while adequate solder joints were formed between the chip and the circuit board. A side view showing the chip and circuit board after soldering, but before underfilling, is provided in the upper part of Figure 2.

With the sensor resting on the polymer rings, the chip can be underfilled without the risk of contaminating the diaphragms. The active diaphragm is shown in the lower part of Figure 2, as seen through the access hole in the circuit board after the chip was attached and underfilled. The technique described provides a means for securely attaching and underfilling a MEMS-based pressure sensor to a circuit board while allowing the diaphragm access to the ambient fluid.

This work was done by Daniel A. Pruzan of Nielsen Engineering and Research for **Glenn Research Center**.*Refer to LEW-17212.*

Wafer-Level Membrane-Transfer Process for Fabricating MEMS

This process is well suited for structures fabricated on dissimilar substrates.

NASA's Jet Propulsion Laboratory, Pasadena, California

A process for transferring an entire wafer-level micromachined silicon structure for mating with and bonding to another such structure has been devised. This process is intended especially for use in wafer-level integration of microelectromechanical systems (MEMS) that have been fabricated on dissimilar substrates.

Unlike in some older membrane-transfer processes, there is no use of wax or epoxy during transfer. In this process, the substrate of a wafer-level structure to be transferred serves as a carrier, and is etched away once the transfer has been completed. Another important feature of this process is that two