Mass Flow Sensors Fit Respiratory & Medical Applications

With the continued expansion of the respiratory industry, MEMs flow sensors will play an important role.

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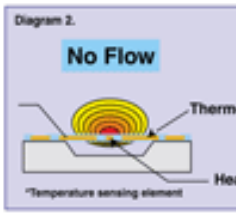
Medical Design

The world market for respiratory products is exploding. Applications include devices such as pulmonary function testing equipment, spirometers, sleep apnea diagnostic

devices, ventilators, nebulizers, CPAP/Bi-level devices, and oxygen supply systems. This increase in respiratory product applications, along with the fact that home-based healthcare is on the rise, has created the need for desirable features such as small sized and lightweight components. This market will only continue to grow as the "baby boomers" enter their later years of life, and home healthcare expands.

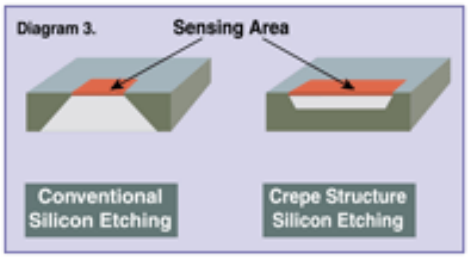
As OEMs respond to these market requirements, engineers are creating a demand for components to accurately measure gas flow rates in this equipment. The requirements include smaller, lighter, more accurate flow sensing devices. Some manufacturers have responded to these challenges through the utilization of MEMS technology (Micro-Electro Mechanical System). This strategy has enabled the development of some of the smallest, most precise mass-flow elements.

OEMs are demanding that sensor packages be able to measure levels as low as several ml/minute, to beyond 200 liters/minute. With cost considerations always present, these flow sensors need to also be developed in consideration of



the wide variety of medical devices in which they could be incorporated. Current major applications include respirators, ventilators, anesthesia delivery and monitoring equipment, and CPAP devices for sleep therapy. For the next generation of oxygen concentrators, the advantages of electronic flow control is being studied as a replacement for the mechanical float-valve that is currently being used.

The concept of the MEMS flow sensor design is to measure the change of temperature across two thermal sensors (see diagram 2). These measurements are then calculated to a flow rate. The flow rate correlates to a specific output voltage, from 1 to 5 VDC (see chart 1). The MEMS sensor design allows the device to measure true mass-flow with an output stated in standard liters per minute.



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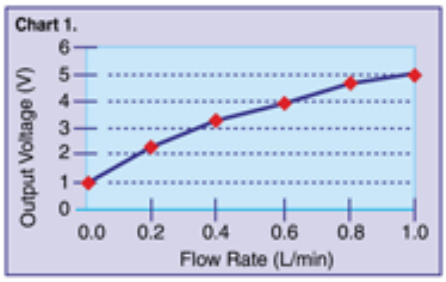
The MEMS technology enables the creation of a very small chip measuring just 1.5 &#215 1.5 &#215 0.4 mm, with an exceptionally high sensitivity which allows it to detect human breathing. To increase the sensing area and prevent heat from escaping from the thermal flow sensor, a unique "crepe structure" was developed (see diagram 3). This crepe structure has an inverted trapezoidal dent, which is formed through an etching process. This etching process corrodes the surface of a silicon wafer or other materials. It removes areas by using chemical liquids or reactive ions. The two most common methods of etching are wet etching and dry etching. Immersing and dissolving the silicon material in a chemical solution accomplishes wet etching. With dry etching, the material is dissolved to form deep grooves using the chemical reaction of special gases. Wet etching is less costly and more productive, while dry etching is more suitable if extremely fine fabrication is needed.

To assure the flow rate is measured properly, a variety of sensor bodies with different cross-sectional areas are available. Additionally, larger flow rates can be measured utilizing a relatively small flow sensor by incorporating a bypass channel

design.



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MEMS flow sensor models that measure in the 20 lpm range are ideal for anesthesia, while versions capable of measuring 200 lpm are more appropriate for CPAP, respirators, and ventilators. Most oxygen concentrators would utilize a 5 lpm version.

While anesthesia gases are typically a mono-directional flow, respirators, CPAP, and ventilators require a bi-directional sensor to detect inhalation and exhalation. The MEMS mass-flow sensors can be produced to perform either function by changing the bias in the internal electronics package. These flow sensors can be calibrated for most of the gases used in medical applications, such as O_2, air, N_20, NO, He, HeO_2, and CO_2 by adjusting for the density (thermal absorption) of the gas.

With expectations of the continued expansion of the respiratory industry, component suppliers are working closely with these OEMs to assure their mass-flow detection device requirements are met. MEMS flow sensors are one such example of a product developed to meet today's ever-changing needs and those of the future.

About the Author

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