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WHITE PAPER

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How Posifa Technologies' Digital MEMS Sensor Technology Revolutionizes What Can Go Where in Portable Vacuum Gauges

Introduction

Sensors created using MEMS technology have a number of well-known benefits over their traditional counterparts: small size, repeatability, and lower cost for the same level of accuracy. However, one underappreciated benefit of MEMS technology is the ability it gives designers to partition systems in new ways to create much more flexible end products. In this article, we take a look at a common application for vacuum sensors — the portable vacuum gauge — to illustrate how Posifa Technologies' digital MEMS sensor technology can help to create a much more capable product.

Analog vs. Digital

The traditional thermistor-based Pirani vacuum sensor is analog in nature. It consists of a thermistor, which is connected to the system whose vacuum is to be measured. The raw voltage output from a thermistor-based vacuum sensor must be connected to a sophisticated electrical circuit for amplification, digitization, temperature compensation, and calibration.

Posifa's digital alternative to thermistor-based vacuum sensors is based on a MEMS Pirani chip-level sensor that combines a micro-heater, a thermopile (i.e. thermocouples in series to greatly enhance sensitivity) and a measurement cavity into an area of silicon measuring 0.8 mm x 2 mm before packaging. This chip (Figure 1a) becomes in turn the sensing element of Posifa's PVC4000 MEMS Pirani vacuum transducer (Figure 1b), which integrates microcontroller-based measuring electronics and packs it all into a compact PCB assembly with a connector-terminated wire harness (Figure 1c). This assembly can in turn be packaged into a metal fitting that connects easily to the environment where vacuum needs to be measured (Figure 1d). The resulting micro-Pirani sensors offer better accuracy, repeatability, range, and power efficiency than thermistor-based Pirani sensors, while allowing designers to miniaturize the vacuum measurement application to a greater degree than ever before.

Figure 1a (sensor chip in SMD package), Figure 1b (Pirani vacuum transducer PCB assembly), Figure 1c (transducer + wire harness), Figure 1d (transducer + wire harness packaged in metal fitting)

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A Choice of Integration Strategies

Posifa's digital MEMS micro-Pirani vacuum sensors greatly simplify the transition away from analog gauges by offering a solution that handles amplification, digitization, and temperature compensation straight out of the box. And there are several other benefits. But why would designers want to transition away from analog in the first place?

First, traditional analog thermistor-based Pirani gauges have very high operating temperatures, which tends to shorten their lifetimes. Operating temperatures for Posifa's digital micro-Pirani vacuum gauges are much lower (slightly above the ambient temperature), so their time to wear out is much longer.

Second, for repeatability, nothing beats MEMS technology, which originates in a state-of-the-art semiconductor CMOS fab. This means that Posifa's digital micro-Pirani sensors offer a much higher level of interchangeability, which is one aspect of how they reduce maintenance costs.

Third, this digital technology is able to achieve the level of accuracy needed for handheld vacuum gauge applications at a much lower cost than thermistor-based sensors.

Fourth, because the MEMS sensor elements are so small, there is much more freedom and flexibility in the possibilities for end system design. Posifa's MEMS solution basically rewrites the rules about what can go where, what part of an end product can be easily maintained by an actual user, and what are the consequences of swapping out replacement parts.

Revolutionizing What Can Go Where

To understand what we're talking about, please have a look at the two portable vacuum gauges below. On the left-hand side (Figure 2a) is a traditional analog-based vacuum gauge; on the right side is a prototype of a vacuum gauge using Posifa's digital MEMS sensor (Figure 2b).

Figure 2a. Analog-based vacuum gauge with permanently attached probe;
Figure 2b. Digital MEMS-based vacuum gauge with replaceable probe.

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Both fit easily in the hand. The main difference between them is that the probe on the analog-based gauge is by necessity permanently attached to the user interface, i.e. the reader. It is also essentially dumb. It is simply a device that provides a physical signal that corresponds to the vacuum level; usually it's an uncalibrated, unamplified, undigitized voltage. The manufacturer may have done some trimming to improve uniformity, but the output is rather crude. The probe is essentially not interchangeable.

Posifa's micro-Pirani MEMS approach is quite different. Because the digital sensing element is so small and inexpensive to produce, it's possible to co-locate it in the probe with the signal conditioning circuits and the digital microcontroller unit. In other words, the manufacturer can relatively inexpensively put a complete transducer into the probe, rather than just the sensing element.

Bringing these "smart" elements of a vacuum gauge right into the probe has a number of implications. For one thing the process of swapping out a contaminated or damaged probe starts to make sense since there is no need to recalibrate the sensing element. It's possible to guarantee interchangeability and the same accuracy from one sensing element to another since they're calibrated digitally as part of the manufacturing process and the calibration data is stored in the on-board microcontroller.

In the real world where these gauges are used, being able to easily swap out a contaminated or damaged probe can greatly reduce down-times for technicians. The benefits include but are not limited to improved brand loyalty, since now it's significantly easier to repair a damaged gauge than to simply replace the gauge, and possibly with a competitor's product. The reusable part of the gauge can then focus on optimization for the user interface (such as display and buttons), transmission, and IoT features.

It is possible to imagine a "smart probe" in a Pirani sensor based on analog technology, but the implementation would be impossibly expensive given the requirement for more complicated signal conditioning componentry, which would also likely be too big to fit into the probe's normal form factor. It's one of those things that would already exist if it were practical for it to exist.

The same digital MEMS technology that enables replaceable vacuum sensor probes has the potential to transform many sensor applications across a wide range of markets since it can be used not only to measure vacuums but also air flow, liquid flow, and air velocity, and gas leaks. The point is not to think merely in terms of miniaturization of the sensing intelligence but also its placement and location within the application.

To ask about using our Digital MEMS Sensor Technology, please contact Peng Tu, Posifa co-founder, at +1 650 465-4985 ptu@posifatech.com