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Bosch sees huge potential in tiny MEMS

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Robert Bosch GmbH claims to be the world's largest manufacturer of MEMS-based sensors, with production levels that exceed 100 million MEMS chips per year. In 2005, the company spun off subsidiary Bosch Sensortec GmbH to expand its MEMS offerings beyond automotive applications and into consumer and other products. Bosch has also licensed its proprietary deep-reactive ion-etching MEMS production technique to SiTime Corp. for the manufacture of oscillators and timing chips. In this conversation with *EE Times*, Horst Münzel, sensor engineering VP, and Bosch Sensortec general manager and CEO Frank Melzer recounted the history of MEMS development at Bosch and shared the company's plans for the technology.

Münzel: We admit that we've come late to the market, but we have an excellent design and huge experience in pressure sensor manufacturing, and our customers are keen to get this product into their hands.

EE Times: When did you begin MEMS development work?

Horst Münzel: We began our research on micromachining over 20 years ago, but our earliest work did not lead directly to products. When I joined the company in 1989, we were only four MEMS engineers. Today, we have over 350 engineers working exclusively on MEMS chips.

When did you introduce your first MEMS chip?

Münzel: In 1993. It was an integrated pressure sensor housed in a metal can for engine management. The sensor had better than 1 percent precision across its temperature range. Car makers used it to measure manifold air pressure so reliably that it is still in volume production today.

What was your next micromachined product? Is it also still manufactured today?

Münzel: Our next product was another bulk micromachined MEMS part—a mass flow sensor with a very thin membrane, which is also used for engine management. It uses a calorimetric principle to measure airflow. It was a breakthrough product for us—so fast and accurate at measuring mass in airflow that it dramatically lowered fuel consumption and emissions, resulting in a more efficient engine.

After 11 years, it is still in high-volume production. This is one of the characteristics of the automotive business: You need to spend a lot of time up front making a very low-cost and reliable device, but once it has proved itself in automotive production, you can continue making it for many years. In fact, you have to continue production, since the lifetime of a car is very long.

When did you first start researching surface micromachining?

Münzel: We first began in 1992, but the state of the art in surface micromachining in those days was not manufacturable in high volumes. Other MEMS suppliers at the time used very thin poly layers—so thin that they were too stress-sensitive. And the procedures for releasing the mechanical structure from the sacrificial materials surrounding them were just not mass producible.

So our first invention was our epitaxial polysilicon (epi poly) and deep-reactive ion-etching (DRIE) process, which enabled us to create structures perpendicular to the surface with variable geometries. Then we invented a release process using a dry hydrofluoric acid process, which was another breakthrough. This release process was much simpler than what our competitors did at that time. Finally, we invented a wafer-scale encapsulation technology so stable that we could assemble and package our MEMS chips in inexpensive plastic packages.

What was your first MEMS part to use DRIE?

Münzel: It was the world's first accelerometer to be housed in a plastic package, which provided a cost advantage compared with the very expensive ceramic and metal housings offered at the time. And because of the stability of our thick, deep MEMS structures, our surface-micromachined MEMS chips also offered a reliability advantage.

This technology has endured until today. In 2005, we crossed the 100-million mark for our MEMS sensors in automotive applications.

So do you use the DRIE process for all your sensors?

Münzel: We use epi poly with dry etching and wafer encapsulation with all our inertial sensors —accelerometers and gyros. For pressure sensors, we have to form a membrane for this process. We used bulk micromachining in the past. But for the next generation, we are using surface micromachining based on a porous-silicon process.

Why was Bosch Sensortec established?

Münzel: Because we see emerging demand for non-automotive MEMS sensors. For consumer products, the way you approach customers, the timing of delivery and the sensors themselves have different requirements, so we founded Bosch Sensortec to serve these new markets. Our automotive sensors remain within the Bosch Automotive Electronics Division—the division that pioneered MEMS at Bosch.

Melzer: Future MEMS devices will include sensors with a broader range of functionality and a much better price/functionality ratio.

Frank Melzer: Bosch Sensortec was founded in 2005. It works closely with the Automotive Electronics Division. We rely on Bosch core expertise in product development and mass production. But the development times and product life cycle in our markets are shorter. To adapt our organization to the requirements of new markets in the fastest possible way, we set up Bosch Sensortec as an independent entity.

What is the range of MEMS devices that Bosch Sensortec manufactures? Are these the same designs used by Bosch for automotive accelerometers and pressure sensors?

Melzer: As of today, we manufacture accelerometers and pressure sensors. They are totally new products, but they run on the same technology platform base and are manufactured in the same wafer fab. We have special designs for consumer products. For instance, our SMB380 acceleration sensor has a much lower power consumption and is much smaller in size than any automotive sensor.

What new types of MEMS devices do you plan to develop in the future?

Münzel: For automotive, we are developing a tire pressure sensor that is quite complex in terms of chip functionality. It includes a complete RF transmitter and a low-frequency transceiver, plus it must have very low power consumption. This device has to survive at least 10 years in the tire without changing batteries.

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Is it a single-chip solution?

Münzel: Single package, two chips.

How do you protect it from the dirty environment inside a tire?

Münzel: We have a lot of experience in protecting the MEMS circuitry in our sensors—we manufacture 40 million pressure sensors for engine management, occupant safety and exhaust applications. These are applications with critical ambients and high corrosion potential.

What other types of MEMS sensors do you have under development?

Münzel: Just to mention one example, we are developing a CO_2 sensor that can measure both ambient temperature and CO_2 concentrations down to 300ppm. Customers are sampling it.

Where will it be used?

Münzel: Automotive makers will use the sensor to optimize energy consumption in cabin air-conditioning systems.

I know you already have MEMS gyroscopes for detecting rollover in cars, but do you have any MEMS gyros under development for consumer markets?

Melzer: There is a lot of interest in gyros, but they have the disadvantage of larger die, higher cost and higher power consumption, all of which are not acceptable in consumer apps. Most of the apps do not really need a gyro but can live with three-axis acceleration sensors.

How do you see the future in MEMS sensor for consumer electronics?

Melzer: Future MEMS devices will include sensors with a broader range of functionality and a much better price/functionality ratio.

- **R. Colin Johnson**
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