



Microelectromechanical components **Two billion Bosch MEMS sensors** Production volumes growing steadily since 1995

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- ▶ 13 years for the first billion, just three for the second
- ▶ Bosch is the global market leader in MEMS sensors
- ▶ Main customers in the automotive and consumer-electronics industries

Bosch sets a new production volume record: the technology company has manufactured two billion MEMS (micro-electro-mechanical systems) sensors since production began 16 years ago. While it took 13 years to produce the first billion, the two-billion mark was recently crossed, just three years later. And production volumes are still growing. Recently, annual production has reached almost half a billion units – more than 1.3 million every working day.

Bosch is by far the world leader in the MEMS sensor market. The automotive and consumer electronics industries are the biggest users of these sensors, and Bosch serves them via its Automotive Electronics division and its Sortotec and Akustica subsidiaries.

Basic research in the 1980s led to the “Bosch process”

Bosch is one of the most experienced players in the development and production of micromechanical sensors. It was Bosch researchers who developed the basic technology of bulk and surface micromachining from the middle of the 1980s onward; this is why one of the main production processes is known in the industry as the “Bosch process.” It is the key to high-volume production.

Economic success was quick to follow the start of production in 1995. The research was honored with prestigious awards: the European Patent Office’s European Inventor Award 2007, and the 2008 German Future Prize, Federal President’s Award for Technology and Innovation.

Bosch MEMS sensors are just as precise and reliable when measuring variables such as pressure, acceleration, yaw rate, or flow rate as they are determining the direction of the Earth's magnetic field. The sensors use microscopically small springs, bars, weights, or membranes to make their measurements. The structures etched into their silicon substrate are just thousandths of a millimeter across. Since micromechanical sensors produce only weak electrical signals, experts have integrated electronics either into the component housing beside the sensor or sometimes even directly on the same chip. These take the weak signal and either process it, amplify it, or convert it into digital data. In this way, MEMS sensors can provide measurements directly to control units.

MEMS for automotive technology

The first market for MEMS sensors was in automotive electronics. Here, the miniaturization of sensors plays only a secondary role. Reliability and robustness are much more important. Bosch Automotive Electronics now produces several hundred vehicle-specific varieties of micromechanical sensor that make cars cleaner and safer, more economical and more comfortable. Each year sees an increase in the number of different varieties and in overall volumes. A modern car features up to 100 of these sensors – and the number is growing. For instance, they are the “senses” for injection systems in gasoline and diesel engines, they are what makes life-saving airbags deploy, and they are an essential part of the ESP anti-skid system.

MEMS for mobile consumer electronics

In consumer electronics, MEMS sensors make mobile devices such as smartphones or laptops safe, convenient, and user-friendly. The demands of this sector are fundamentally different from those of the automotive industry. For devices to be practical, the sensors they contain need to be tiny, and they must use very little power to conserve battery life. But most important of all, sensors must be cost-effective if many millions are to be used. Today's smallest Bosch Sensortec MEMS sensors have an edge length of two millimeters and are less than one millimeter high, and their standby power consumption is even lower than the battery's self-discharge rate.

In navigation devices and cell phones with a navigation function, MEMS pressure sensors' measurements of changes in altitude are accurate enough to allow for navigation even within a multi-story building. MEMS acceleration sensors make it possible to use hand movements to control devices, switch the display of content from portrait to landscape format,

prevent the loss of data on hard drives when a notebook is dropped, and open up new worlds of experiences to users of new game consoles.

The latest development is a triaxial MEMS magnetic field sensor. By measuring the Earth's magnetic field, it can determine the geographic direction. An integrated triaxial MEMS acceleration sensor compensates for errors caused by inclines, allowing this digital compass to maintain its accuracy whatever its position. The possible uses of this fusion of sensors extend far beyond those of a traditional compass and into the realm of augmented reality. A smartphone containing a digital compass could, for example, be used during a sightseeing tour of a city to display information about whichever sight users are pointing their phone at.

MEMS microphones for consumer applications are the specialty of Bosch's Akustica subsidiary. These tiny microphones, measuring just a few millimeters, stand out for their small size, robustness and immunity to high-frequency signals from surrounding circuitry and displays, enabling consumer device manufacturers to integrate two or more microphones for enhanced noise suppression.

The potential for new developments in the consumer market is as high as ever, so we can expect further spectacular innovations based on MEMS components in the years to come.

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Automotive Technology is the largest Bosch Group business sector. In 2010, its sales came to 28.1 billion euros, or 59 percent of total group sales. This makes the Bosch Group one of the leading automotive suppliers. The roughly 167,000 Automotive Technology associates worldwide work in seven areas of business: injection technology for internal combustion engines, powertrain peripherals, alternative drive concepts, active and passive safety systems, assistance and comfort functions, in-car information and communication, as well as services and technology for the automotive aftermarket. Bosch has been responsible for important automotive innovations, such as electronic engine management, the ESP® anti-skid system, and common-rail diesel technology. In fiscal 2011, the Bosch Automotive Technology business sector expects its sales to reach some 30 billion euros by the end of the year, with a workforce of 177,000.

The Bosch Group is a leading global supplier of technology and services. In the areas of automotive and industrial technology, consumer goods, and building technology, some 285,000 associates generated sales of 47.3 billion euros in fiscal 2010. For 2011, the company forecasts sales of more than 50 billion euros and a headcount of a good 300,000 by the end of the year. The Bosch Group comprises Robert Bosch GmbH and its more than 350 subsidiaries and regional companies in over 60 countries. If its sales and service partners are included, then Bosch is represented in roughly 150 countries. This worldwide development, manufacturing, and sales network is the foundation for further growth. Bosch spent 3.8 billion euros for research and development in 2010, and applied for over 3,800 patents worldwide. With all its products and services, Bosch enhances the quality of life by providing solutions which are both innovative and beneficial.

Additional information can be accessed at www.bosch.com, www.bosch-press.com, and www.125.bosch.com.