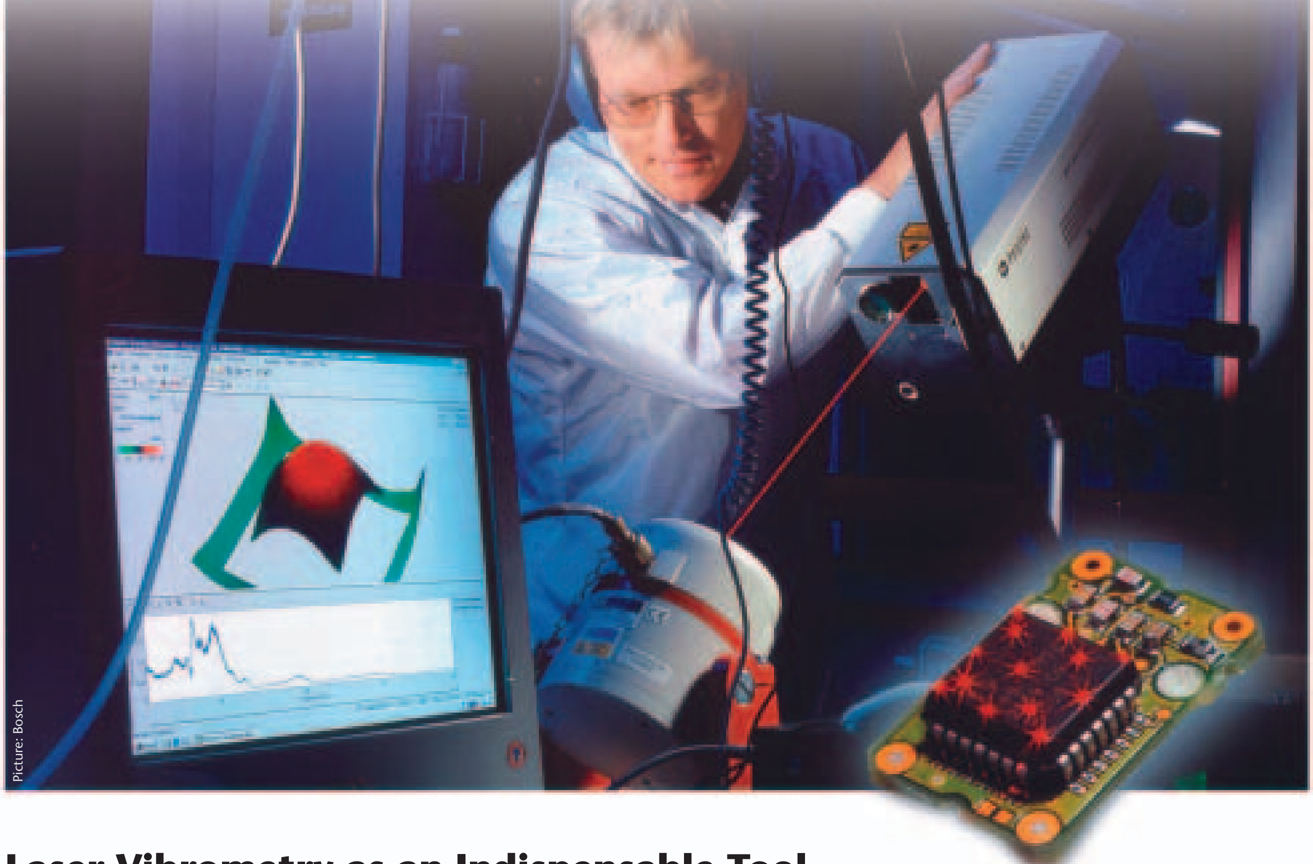
Polytec

MEMS – *Reliable Helpers in Motor Vehicles*



Laser Vibrometry as an Indispensable Tool in MEMS Development

50 years ago, "sensor technology" in a car was limited to a handful of mechanical, or at best, electromechanical instruments, such as tachometers or rev counters. In contrast, a modern car, has numerous microprocessor-controlled electronic sensors and actuators that carry out complex measurement, monitoring and control tasks. An indispensable tool in the development and production of these silent assistants are modern, non-contact optical metrology processes.

Modern sensor elements in cars have to a large extent been realized as micro-components, as so-called MEMS (Micro-Electro-Mechanical-Systems). They compactly combine mechanical, electrical and also electronic functions on a chip. MEMS can thus interact with their environment as sensors or actuators. This means that a system based on MEMS technology can react electrically or mechanically to corresponding physical or chemical "stimulants".

As MEMS components in modern cars are increasingly taking on safety-relevant tasks, high sensor precision combined with extremely high, lifelong reliability is of decisive importance. To reach these quality targets, you need precise measurement technology to characterize and verify the system properties of prototypes during development, and for control measurements during MEMS production.

High Reliability is Required of Automotive MEMS

Among the safety-relevant areas of application for MEMS are, for example, brake systems, airbag control or dynamic stability control systems. One of the reasons the reliability requirements are so high is because the components are subjected to tough ambient conditions throughout their whole lives, such

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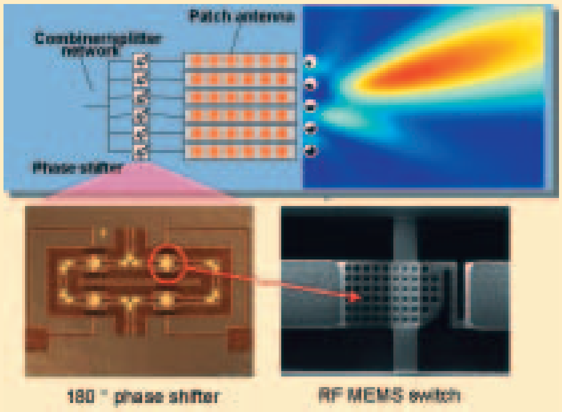

Figure 1: Design of a patch antenna

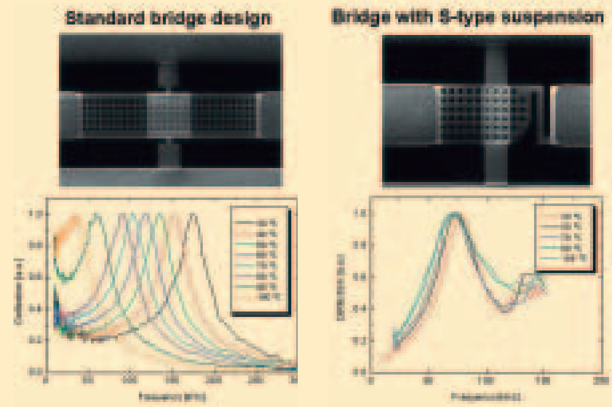

Figure 2: Resonance measurement on MEMS switches

as vibration, temperature changes and corrosion. The defect rates related to the service life of these components are therefore only in the range of a few ppm.

The precision required for sensors when used in the car industry is on the order of 1% over the whole life of the components, which corresponds to 15 - 20 years or an operational performance of approx. 200,000 km.

Of course all these requirements need to be met at the lowest possible production costs.

Vibrometry Makes it all Possible

Laser Doppler Vibrometry, as a flexible, high precision measurement technology, plays a major part in characterizing the mechanical properties of MEMS quickly, without a reaction, and precisely, thus ensuring the high quality of the components.

Single point vibrometers can be used to measure system resonances of the components. The movement properties of MEMS across the whole surface of the component are determined quickly and across a wide frequency range with the aid of special microscope scanning vibrometers. The animated graphic representation of the operational vibration shapes calculated from the readings is decisive in helping to understand the processes examined.

Adaptive Antennas

In high frequency technology there is a broad range of applications for adaptive antennas. The radiation characteristics, or the transmit/receive direction, can be adjusted to the actual traffic conditions.

Regarding radar applications, objects located in various distances can be detected by sequential scanning of the radiation angle and measurement of the time to reach the object and return. The adjustment of the radiation characteristics can be realized using planar patch antennas without any moving parts. Their radiation lobe results from the interference of electromagnetic waves generated by many single antenna elements ("patches").

The patches are switched together in rows and columns resulting in a fixed phase relation. This requires special phase shifters which can be realized by micro system technology. The phase shifters contain various RF MEMS switches which are used to set a fixed value for the phase relation (Figure 1).

The design goal of the Bosch development engineers is a clearly defined switching performance which is independent of ambient conditions and remains constant for the life of the component.

MEMS Design and Vibration Properties

The switch initially realized by the engineers, with a standard bridge design, exhibited switching performance which depended on the ambient temperature, clearly recognizableby the shift in the bridge resonance measuredusing the vibrometer (on the left of Figure 2). The reason for this is the difference in thermal expansion coefficients between the aluminum bridge and the silicon substrate.

By modifying the bridge geometry, this effect can to a large extent be compensated for, as is shown in the spectrum on the right of Figure 2.

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Scanning Tests

Testing the switching performance in the time domain shows pronounced bouncing or ringing behavior. To get a picture of the actual surface dynamics of the component during switching, tests were carried out using the Laser Scanning Vibrometer (Figure 3).

The visualized results show that, apart from the basic vibration, there are higher harmonics of the bridge surface present in the spectrum of the component. Laser vibrometry also provides important structural dynamic information here to optimize the functionality of the component (Figure 4).

Summary

Many of the advanced safety and comfort features offered in today's cars are based on microsystems using cutting-edge technologies. The most up-to-date optical measurement and testing processes, such as Laser Doppler Vibrometry, ensure that, during the development and production process of MEMS elements, the required functional and quality properties are attained or exceeded, making travel today safer than it has ever been before.

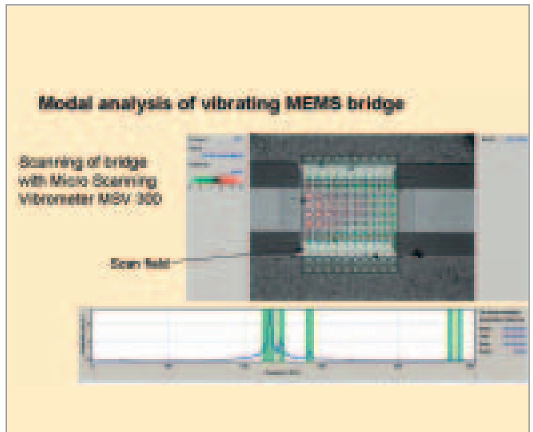

Figure 3: MEMS switch measured by the MSV-300 Microscope Scanning Vibrometer

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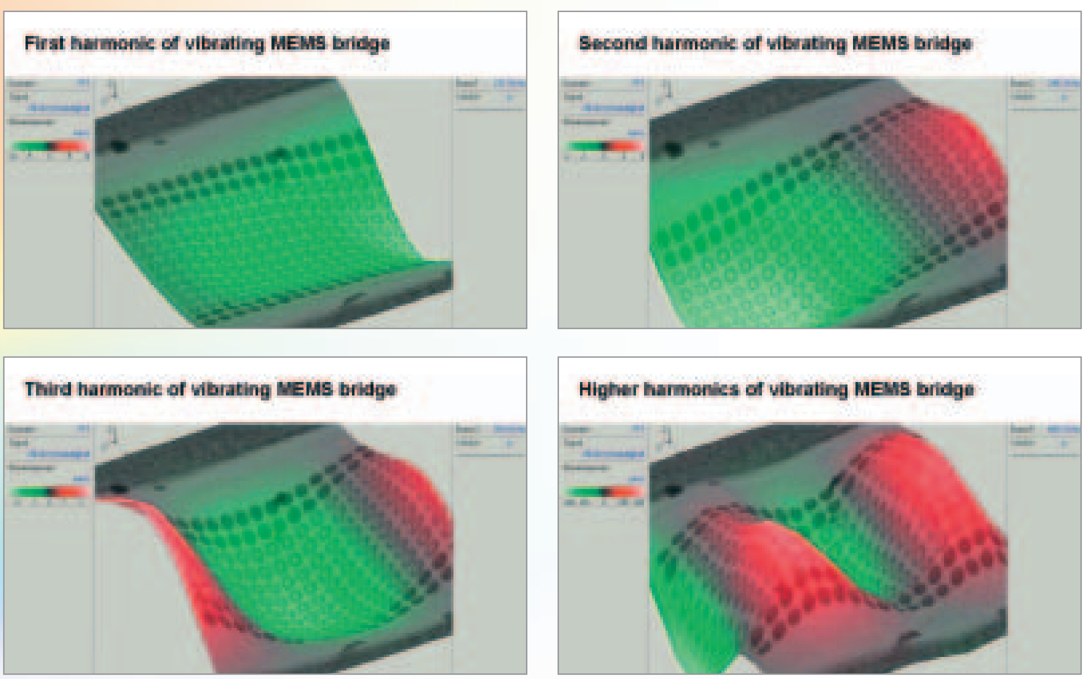

Figure 4: Deflection shapes of the MEMS switch

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