Miniaturized sensor and actuator elements based on the heat transport in gases or the ionization of gas particles

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For many years, microsystem-based sensor and actuator elements have had a wide range of applications in industry, especially in automotive engineering. In addition to the classic electromechanical systems (MEMS), such as pressure or acceleration sensors, a large number of other methods have now found their way into industrial applications. These include, in particular, gas sensors and sensors for detecting various dangerous substances.

To determine the characteristics of gaseous substances, either their physical properties (e.g. their optical, electrical or thermal properties) or their chemical behaviour can be used for measurement and differentiation. Among all these methods, the evaluation of the thermal properties is particularly interesting as a very easy to implement method, while methods based on the ionization of the gas particles and the measurement of ion currents are among the most accurate methods currently available. With these two methods a multitude of applications can already be covered, e.g. by combining only these two methods pressure measurement over the entire technical vacuum range is possible. Semiconductor technology offers a very simple way to miniaturize thermal heating and sensor elements in the form of conducting paths on semiconductor chips. More complex, however, is the miniaturization of arrangements for the ionization of gases on a semiconductor chip. The classic possibilities for ionizing gases such as glow wires or radioactive radiation sources are not suitable or mostly undesirable from the user's point of view. Possible solutions are miniaturized field emission electron sources integrated on a chip or electrode structures on a chip to generate low-pressure and low-temperature plasmas. With the methods of modern microsystems technology, even very complex structures can be realized in a simple and reproducible way, e.g. by laser micromachining.

In this presentation the possibilities and limits of these two methods (thermal and ionization) will be shown and a variety of possible applications will be presented and discussed. In addition to vacuum measurement technology, these are the concentration determination of natural gas and hydrogen gas as applications of the thermal operating principle and ion mobility spectroscopy as an application of the operating principle of ionization of gas particles. Furthermore, a concept is presented with which a combined position and motion sensor can be realized based on the thermal measuring method. This sensor has no moving parts at all and operates reliably and without hysteresis over a wide measuring range.