< Losses of fresh fruit are high during storage. A measurement system monitors the concentration of ripening gases and thus establishes the conditions for optimized storage.

GROUP **INTEGRATED SENSOR SYSTEMS**

Sensor monitors ripening process in fruit warehouses

The aroma of fruit is determined by over a hundred components, and is an important quality criterion when consuming the product. A cocktail of scents provides food producers with valuable information, for instance on the ripening stage of fruits. In collaboration with industrial partners, Fraunhofer IPM is developing a miniaturized measurement system for detecting fruit ripening gases, which is intended for use in fruit warehouses and other applications.

According to a study conducted by the WWF, over ten percent of the fruit harvested in Germany spoils during transportation or storage. Optimized climate conditions during fruit storage can significantly reduce post-harvest spoilage and thus minimize both material and financial losses. To make this possible, precise knowledge is needed of the gas composition in warehouses. Increased concentrations of certain gases, for example, indicate premature ripening of fruit which may result in spoilage of the goods. Bacterial and fungal contamination can also be identified from gas concentrations in many cases.

It is the aim of the »FreshFruitLab« Eurostars project to develop sensors that continuously monitor relevant gases in fruit warehouses. Suitable measurement technology is needed to selectively control ripening processes and production steps, such as by feeding in ripening gases or regulating air change. Together with Scemtec Transponder Technology GmbH and Environmental Monitoring Systems EMS B.V. from the Netherlands, Fraunhofer IPM is developing a miniaturized gas sensor system for monitoring fruit ripening processes. The project is initially focused on the ripening gases typical for apples, pears and kiwi fruit. In principle, however, the measurement system is designed to cover a large range of food-related gases, and in the future could therefore be used on a broader scale for quality control in the food industry.

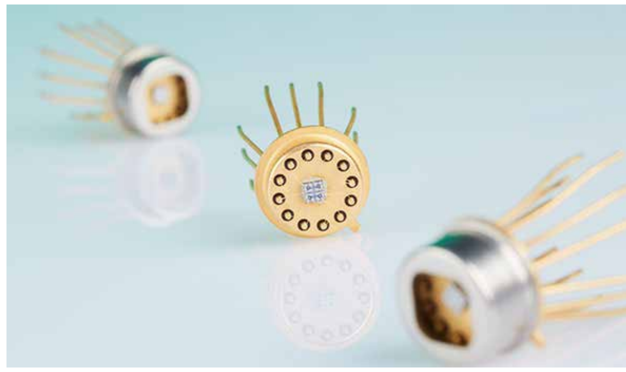
Gas chromatography with semiconductor gas sensors

To perform this highly-sensitive monitoring of fruit ripeness, the scientists use a combination of gas chromatography (GC) and semiconductor (SC) gas sensors as detectors. In order to record the large number of gases produced, commercial chromatographic separation columns are used that have very high separation efficiencies. Silicon-based, micromechanically-produced gas chromatographs are commercially available today. Heat conduction and surface acoustic wave sensors are generally used as detectors. Fraunhofer IPM uses SC gas sensors as detectors in its FreshFruitLab sensor to increase the detection sensitivity from ppm up to the ppb range. SC gas sensors react to almost all reducing and oxidizing gases, and thus not only enable the detection of trace gases, but also the analysis of complex aromas. Volatile organic compounds (VOC) are indicators of fruit ripeness. When monitoring the ripening of apples, pears and kiwi fruit, it is primarily short chain hydrocarbons from C2 to C4 that play a role. Components such as formaldehyde, methyl mercaptan, trimethylamine and sulfur compounds are also of interest for food monitoring. Tin oxide doped with platinum or palladium, lanthanum indium oxide, tungsten oxide and chromium titanium oxide have been identified as suitable, gas-sensitive metal oxides for sensitive detection of these VOCs. The sensor design includes four SC gas sensors based on these metal oxides to allow a wide range of relevant gases to be detected. Each sensing element can be heated separately and placed on a separate sensor platform in order to increase selectivity. The gas-sensitive surfaces measure 45 x 45 μm^2. The sensor array has a total area of 1.6 x 1.6 mm^2.

Low power – high sensitivity

To create a low power sensor, the SC gas sensors are deposited onto microstructured silicon substrates (called microhotplates) in the form of a specially developed, printable, metal oxide ink. There is no need for a photolithography process. These particularly porous, printed layers ensure a favorable ratio of surface to volume, and thus greater sensitivity. The sensor requires 15 milliwatts of power to generate an operating temperature of 400 °C meaning that, in principle, it can be battery operated. All this produces an economical, compact, sturdy device that can be configured for specific measuring tasks and employed as a portable or stationary unit in fruit warehouses. The sensitivity of the system is comparable to the precision of complex lab gas chromatographs, which have previously been tested separately for the monitoring of fruit ripening processes. As far as accuracy and objectivity are concerned, the sensor will always surpass the human nose.

GAS CHROMATOGRAPHY: The human nose is a highly sensitive sensor for volatile organic compounds (VOC). This human sensor is therefore still readily used today to identify the components in a mixture of volatile gases. Gas chromatography (GC) has become established as an analytical technique for characterizing VOCs. In this complex process, samples are evaporated and then broken down into their individual components in a separation column. Compact, reasonably-priced GC systems employing microsystems engineering processes have been produced since the early 1980s.



The semiconductor gas sensor detects volatile organic compounds down to the ppb range. Four gas sensitive surfaces (45 x 45 μm^2 each) are arranged on micro-hotplates with a size of 120 × 120 μm^2.

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