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Membrane Surface Stress Sensors

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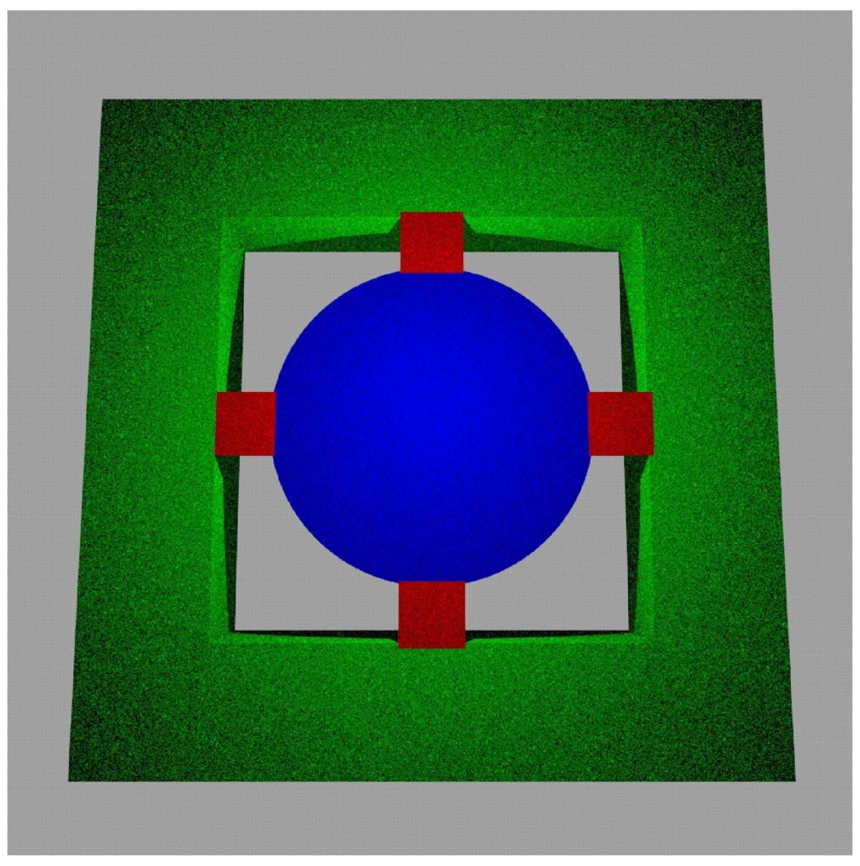


Fig. 1. *Schematics of a membrane-type surface stress sensor (MSS). The actual diameter of the round membrane (shown in blue) is 1000 µm and its thickness is 4 µm. The membrane is suspended by four sensing beams with integrated p-type piezoresistors (shown in red), representing a full Wheatstone bridge. A solid supporting frame (green) holds the sensor.*

Abstract

In recent years, mechanics has experienced a revival, as microfabrication technologies and nanotechnology have been applied to produce tiny structures. Based on atomic force microscopy technology [1], cantilevers have also been employed for sensing [2]. Adsorption of molecules on a functionalized surface produces a surface stress change, which results in bending of the cantilever. Such deflections in the nanometer range are usually measured using the laser beam deflection technique. The experimental setup required is still of tabletop size. We use here piezoresistively read-out membranes [3-5], which allow a very compact design of read-out electronics. Furthermore, no time-consuming optical alignment is necessary.

Membrane Surface Stress Sensors

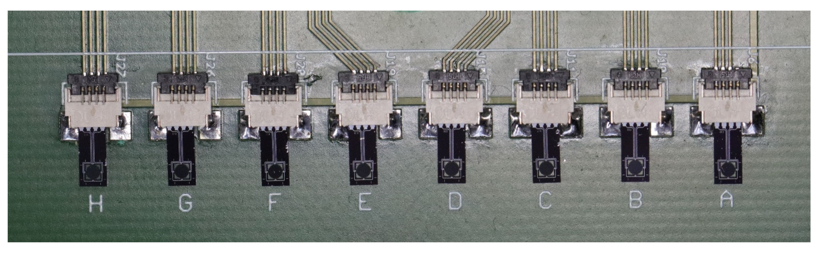


Fig. 2. *Eight MSS chips from NanoWorld AG mounted in ZIF sockets on the electronics board. Each chip can be replaced individually.*

Each membrane is coated with a different polymer solution (12 µL) in a very easy way using a standard laboratory pipette. The coating process produces a homogeneous polymer layer of a thickness of typically 1 micrometer. The applied coatings include polymers such as carboxy methyl cellulose, poly-(vinylpyridine) or poly-ethylenimine at a concentration of 1mg/mL in water.

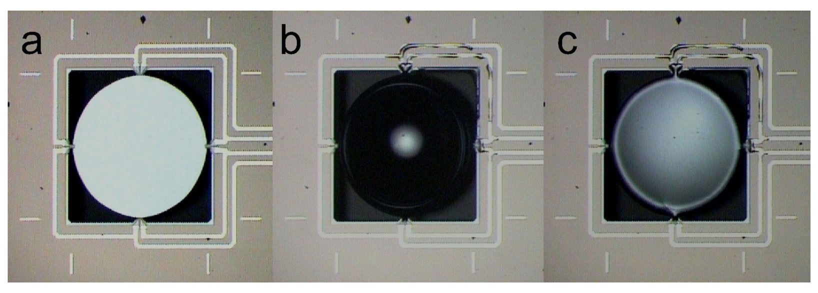


Fig. 3. *Simplified coating of MSS using a pipette: (a) uncoated membrane, (b) membrane coated with liquid, (c) solid polymer coating on the membrane after evaporation of solvent (water).*

Readout electronics

The readout electronics consists of a commercial data acquisition (DAQ) board (National Instruments USB-6218 OEM, 16 bit ADC, universal serial bus powered) and an additional board mounted on the DAQ board housing the 8 membrane sensors, Wheatstone bridge circuits and amplifier electronics, as well as two piezo-actuator driven membrane pumps (Bartels Mikrotechnik) for aspiring of gaseous samples and purging with nitrogen gas (Fig. 4).

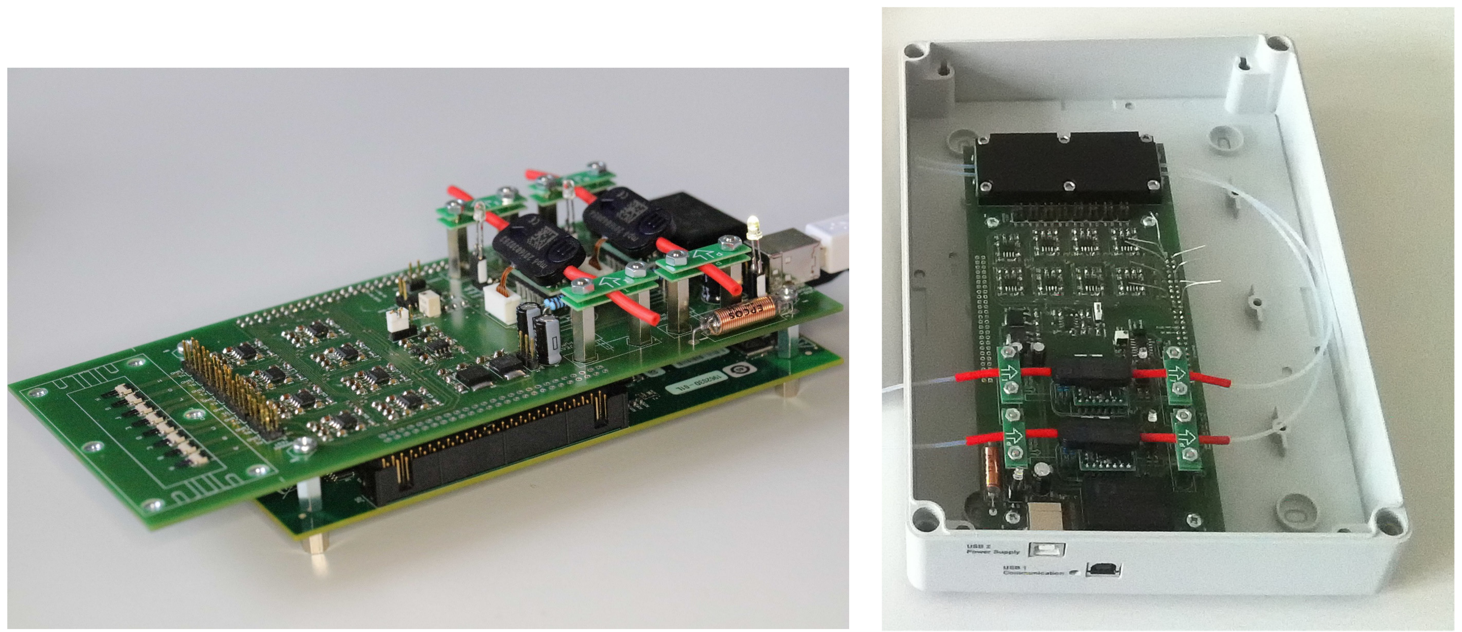


Fig. 4. *MSS readout electronics (USB powered).*

Left: Electronics boards. Lower level: DAQ board. Upper level: sensor readout and gas handling using micropumps.

Right: Operational device in chassis.

Control, data acquisition & analysis software

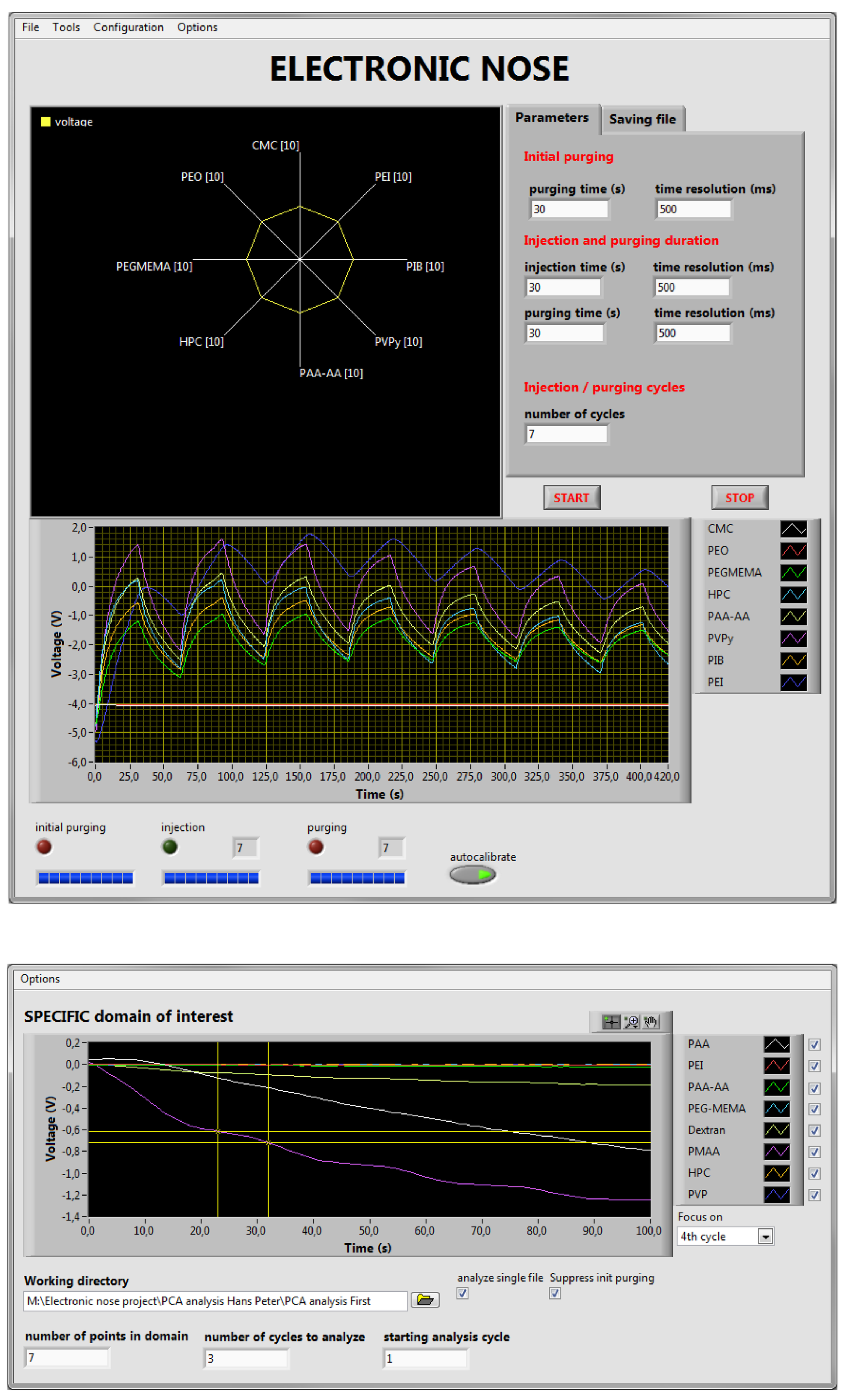
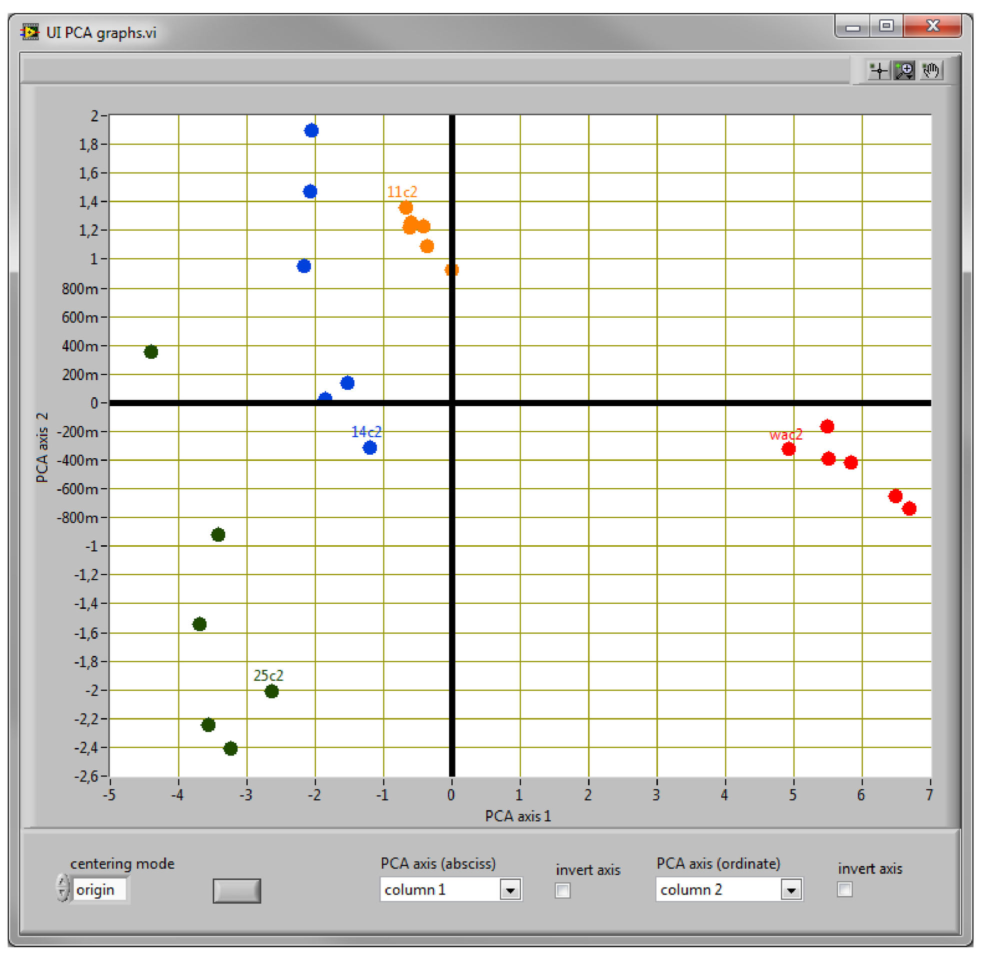


Fig. 5. *LabView-based control, data acquisition, processing and analysis software. A consecutive series of injection and purge cycles of various gaseous analytes is measured and evaluated in the electronic nose software. Injection / purging times and number of cycles can be set, as well as number and position of key data points for principal component analysis (PCA). In PCA the individual gaseous analytes are clearly separated and recognized.*



Results & Conclusions

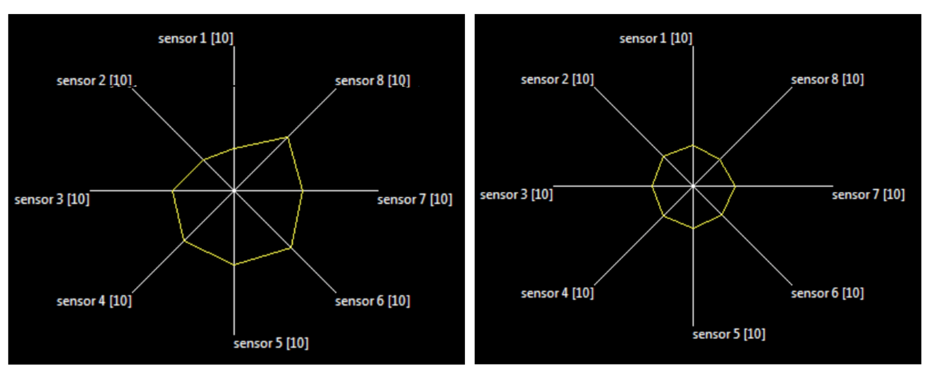


Fig. 6. *Radar plots of two different gaseous samples. The axes represent the magnitude of the corresponding sensor signals at a specific time. The radar plot representation allows a quick decision, which analyte has been detected.*

MSS represent a simple tool to reliably recognize gaseous analytes. In addition to electronic nose applications, such as detection of solvent or food vapors, there is also a great potential in medicine. Several diseases are connected with the presence of certain volatile gaseous constituents in patient's exhaled breath. Investigation of breath samples of head & neck cancer patients and healthy control persons allowed to identify the cancer patients without invasive biopsy collection [5]. Breath samples from cured cancer patients were found to fall into the group of healthy control persons.

Acknowledgments & References

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