Ultra-Fast Chemical Sensing Microsystem Employing Resistive Nanomaterials

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Abstract

This paper reports a novel ultra-fast chemosensor array microsystem for the rapid detection of volatile organic compounds (VOCs). The sensing device consists of an array of 80 miniature resistive sensors on a 10 mm by 10 mm silicon substrate; the sensors are configured in 5 rows of 16 elements (see Figure 1). Each sensor can be individually coated though in this application each row has been deposited with a different carbon black/polymer composite nanomaterial, namely, poly-stylene-co-butadiene (PSB), poly-ethyl-co-vinyl-acetate (PEVA), poly-ethylene-glycol (PEG), poly-4-vinyl-phenol (PVPH), and poly-caprolactone (PCL). Each sensor is only 220 µm by 200 µm with an inter-electrode gap of 20 µm. A microchamber is designed to delivery test analytes to the sensor array which sits on top of the sensor die as shown in Figure 2. Two 16-bit ADCs provide high-resolution measurement through an in-house designed multiplexing system to access the sensor array at a scan rate of 6 ms/sensor.

Although gas-sensitive sensor arrays have been an active area of research, they are typically made up of either a small number of discrete sensors or an array with same sensing material [1]. As each sensor can be individually coated it is possible to have high sensor diversity within a very small area. In addition, by employing a low volume test chamber, with a high sample throughput, it is feasible to have ultra-fast analysis of test samples and so obtain a spatial-temporal 3D fingerprint of the odour. In addition, such a system will have the accustomed benefits of miniaturisation, e.g. low sample consumption and an ease of portability. Figure 3 shows the typical response to a 5 sec pulse of ethanol and toluene vapour at flow rate of 400 sccm. By employing a fixed pulse technique both the amplitude and dynamic characteristics of the response can be used to aid characterisation. Response times below 300 ms can be achieved with these materials and study of flow rate and concentration response has been characterised elsewhere [2]. With a 3D fingerprint as shown in fig. 4, an image pattern classifier can be used to provide an easy discrimination. We believe this type of fluidic configuration will provide better discrimination of complex vapours and odours.

Keywords: Sensor array; microchamber; matrix; 3D fingerprint;

References

[1] J.A. Dickson, M.S. Freund, N.S. Lewis, R.M. Goodman, *An integrated chemical sensor array using carbon black polymers and a standard CMOS process,* Technical Digest of the Solid-State Sensor and Actuator Workshop, pp. 162-165, 2000.

Figures

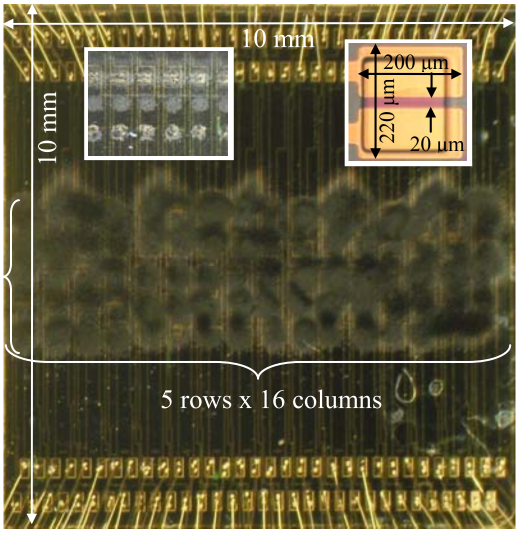


Fig. 1: Sensor array microchip with 80 miniature sensors (with deposited array and single sensor cell).

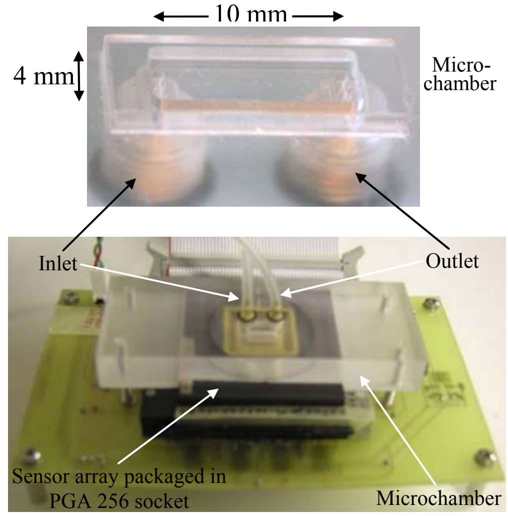


Fig. 2: Microchamber and the assembled microsystem.

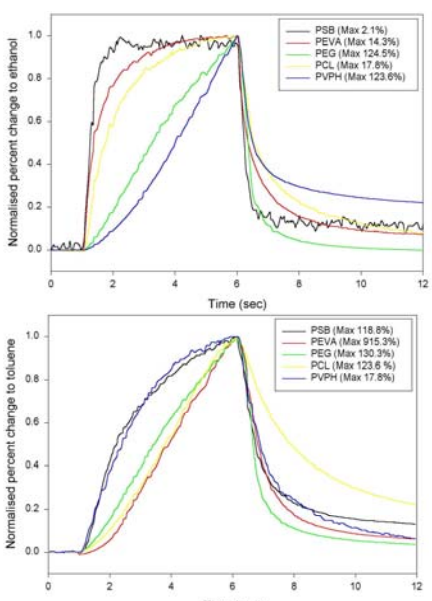
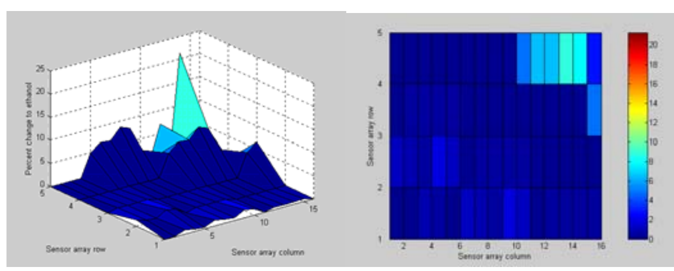
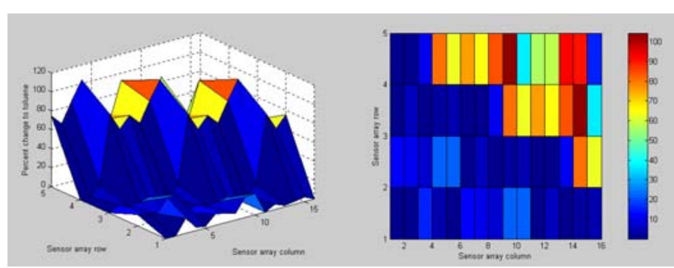


Fig. 3: Typical sensors response to ethanol and toluene vapour.



(a) Sensor array fingerprint for ethanol at t = 1.5s.



(b) Sensor array fingerprint for toluene at t = 1.5s.

Fig. 4: 3D fingerprint of ethanol and toluene vapour.

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Biography: Su Lim, TAN was born in Singapore and graduated in 1999 with a first degree at Nanyang Technological University in Computer Engineering. He is current working towards his PhD at the Sensors Research Laboratory at Warwick University under the supervision of Prof. Julian W. Gardner. His research interest includes vapour sensor and sensor array microsystem design.