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Design, Fabrication, and Evaluation of Highly Sensitive Compact Chemical Sensor System Employing a Microcantilever Array and a Preconcentrator

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We developed a highly sensitive compact chemical sensor system employing a polymer-coated microcantilever sensor array and a thermal preconcentrator. The design, structure, fabrication, and experiment results are reported here. This sensor system had 1) a sub-ppb detection limit concentrated by a preconcentrator and 2) analytical function by thermal desorption of the preconcentrator and multiple cantilevers (acting as the mass sensor) with different polymers. The preconcentrator contained 0.03 g of carbon fiber, and absorption/desorption were controlled by the temperature from room temperature to 520°C. The sample gas was introduced into the preconcentrator using a miniature air pump at a flow rate of 2.0 L/min. Four silicon microcantilevers in one silicon chip fabricated by micro-electromechanical systems (MEMS) technology were packaged in a ceramic flat package and driven by a PZT actuator plate mounted in the package. Using the 4th vibration mode (resonant frequency: 764 kHz) of a polybutadiene (2.52 μm thick)-coated cantilever, the sensitivity was 514 Hz/ppm for toluene and 850 Hz/ppm for p-xylene with a 5 min preconcentration time. The preconcentration factor and system efficiency of sensing were estimated to be 830 and 0.78, respectively, for toluene. The estimated detection limit of the sensor system was less than 1 ppb for toluene and p-xylene with a 10 L sample volume, which was good enough for application to environmental monitoring. Separate detection of the mixed toluene and p-xylene was also achieved in the form of different time peaks during the heating preconcentrator operation.

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