# Ultra-Low Power MEMS Gas Sensors and Efficient Pre-concentration using Microfluidic Devices for Salmonella

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## Abstract

A MEMS based thermal conductivity detector has been developed for ultra-low power gas sensing. The sensor operates by monitoring changes in thermal conductivity of the gas ambient in response to rapid heating. The MEMS micro-bridge of dimensions 100 $\mu$m long and 1 $\mu$m thick, consists of a doped polysilicon beam passivated with a 200 nm silicon nitride layer. The transient resistance changes at constant temperature and constant power, was investigated in dilute gas mixtures. Simulations and experimental results are presented and compared for the time resolved and steady-state regime of the sensor response. The time constant of the exponential heating transient was found to be a linear function of the thermal conductivity of the gas ambient. Ultra-low power gas sensors for portable sensing of the environment are an area of increased interest for the internet of things.

We have investigated functionalized magnetic beads and magnetic cilia for target pre-concentration needed to improve sampling in food safety. Beads are localized using defined NiFe features in a channel and an array of cilia are microfabricated using a NiFe thin film. The motion is driven with an external magnetic field provided by a rotating magnet. The cilia generate an asymmetric motion, in which the difference between forward and recovery strokes are a function of drive frequency, fluid properties and cilia dimensions. The dependence of the ciliary motion can be related to a non-dimensional number based on the forces acting on the cilia. To evaluate capture fluorescent particles are introduced into the flow. We have demonstrated active mixing using arrays of cilia which generate fluid pumping in the channel. In addition, modeling of the mixing and capture has been carried out with Lattice Boltzmann methods in three-dimensions. We show that orbiting microbeads can lead to rapid fluid mixing at low Reynolds numbers. Monte Carlo simulations of *Salmonella* capture by the microbeads are used to evaluate the ability of the system to capture target bacteria.

### Biosketch

Peter Hesketh received a B.Sc. in Electrical and Electronic Engineering from the University of Leeds (1979) and was a Thouron Fellow at the University of Pennsylvania, obtaining an M.S. (1983) Ph.D. (1987) in Electrical Engineering. He worked in the Microsensor Group at the Physical Electronics Laboratory of Stanford Research Institute and then Teknekron Sensor Development Corporation before joining the faculty at the University of Illinois in 1990 in the Department of Electrical Engineering and Computer Science. He is a Professor of Mechanical Engineering at Georgia Institute of Technology, Member of the Parker H. Petit Institute for Bioengineering and Biosciences, Member of the Institute for Electronics and Nanotechnology, and Director of the Micro and Nano Engineering Group in the School of Mechanical Engineering. His research interests include micro/nanofabrication techniques, MEMS based chemical gas sensors and gas chromatography systems, micro-magnetic actuators and microfluidics for sample preconcentration of microbial contamination. He has published over eighty journal papers and edited sixteen books on microsystems. He is a Fellow of the AAAS, ASME, ECS, a member of ASEE, Sigma Xi, and IEEE. His is married to Ann Marie with two children Gabriel and Lillian Hesketh.