Chip-size micro-electro-mechanical sensors for particles in the air will provide inexpensive warning system to asthmatics, sense unhealthy air in cars and trucks, improve factory floor occupational health.

The MEMS Particle Monitor is a chip-size technology that senses and relays information by radio signal about particle concentration in the air. It can be mass-produced cheaply, and incorporated in any kind of stationary or mobile device—cell phones, vehicles, in homes and workplaces, and even on clothing.

It has been developed by Michael Apte and Lara Gundel and co-workers at the Berkeley National Laboratory’s Environmental Energy Technologies Division, and Richard White and Justin Black of the Berkeley Sensor and Actuator Center at UC Berkeley.

How It Works

The monitor determines the particulate mass deposited as a function of time on a micro-fabricated electronic resonant mass sensor (film bulk acoustic resonator, FBAR) coupled to a CMOS oscillator circuit chip. As the deposited mass of particulate matter increases, the resonator frequency decreases.

Thermophoresis is the principle used to cause particles to deposit on the mass sensor—a microscopic electrically powered resistive heater produces a thermal gradient in a gaseous medium that causes particles to deposit on the resonator.

The present prototype has a volume of 250 cm³, a mass of 0.114 kg, and a power consumption <100 mW. With some minor redesign, the monitor could be made considerably smaller and lighter. It is designed to be battery powered.

Performance

Measurements made in an environmental chamber and in a residence in Berkeley showed excellent correlation of the monitor’s response with that of standard test equipment for PM2.5 particles. The limit of detection (LOD) of the prototype design was found to be 18 µg-m⁻³. The results of initial design testing identified ways to reduce the LOD by a factor of 10.

Industry Interest

Another round of development is needed before the device can be commercialized. At least one major manufacturer has agreed to support this effort with in-kind support if additional venture capital becomes available.

Potential Applications

Asthmatics’ warning system—Embedded in cell phones and other devices, the chip can sense levels of particles of concern to sensitive asthmatics. A population of particle sensing phones reporting via a cellular network can create real-time, graphical information of dirty air zones for asthmatics to avoid.

Vehicle unhealthy air warnings—Embedded in diesel-powered cars and trucks, and buses, it can trigger an alarm or control ventilation when the particle concentration of interior air becomes hazardous.

Factory floor health—Embedded in industrial facilities, in fume hoods, or on personal protective clothing, the MEMS particle sensor can trigger warnings when particle concentrations exceed OSHA standards.

Air quality monitoring—Air quality authorities can use networks of sensors to monitor the particulate concentration of air quality districts, and issue “Spare the Air” warnings in real-time.

Air quality and health research—Arrays of mobile particle sensors with cellular geo-positioning and communication capabilities can be used to improve population exposure estimates for critically needed environmental health research.

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