Keeping homes safe

A sensor developed from nanotechnology packs a wallop of healthy, safe and green capabilities for 'smart buildings'

The concept of smart buildings was first introduced in the early 1980s as "a new generation of buildings that almost think for themselves called intelligent buildings".

Today's advanced technology has moved beyond wireless video monitors and remote access to locks and lighting. Among new advances, an interdisciplinary research team at the Georgia Institute of Technology has developed and manufactured electronic sensors that can wirelessly alert users to the presence of chemical vapours in the atmosphere.

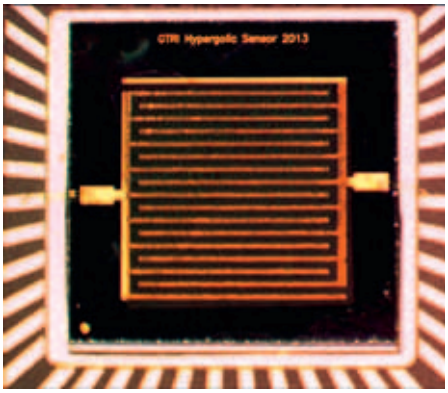
All of this in a device about the size of a Compact Flash card and the scientists even plan for the future designs to be small enough to fit multiple sensors on a penny. They are sure that this new sensing capability moves smart buildings from installing and operating building-related technologies to the installation and use of advanced and integrated building technology systems.

This makes it possible to construct and operate buildings more efficiently; to provide productive, healthy and safe spaces for the occupants and visitors; to create an energy-efficient and sustainable environment; and to differentiate and improve on the buildings' marketability.

Future potential

The work being done at the Georgia Tech Research Institute (GTRI) has great potential to create exceptional applications for smart buildings, healthcare and other fields. The new gas sensor design, developed by Dr Xiaojuan (Judy) Song and Dr Chris Valenta at GTRI, already integrates nanotechnology and radio-frequency identification (RFID) capabilities.

This new type of sensor is composed of an array of sensors that use carbon nanotubes and other nano-materials to detect specific chemical vapours. The RFID integrated circuit wirelessly informs users about the presence and concentrations of those vapours at a safe distance. These devices can monitor carbon monoxide (CO), which can provide an early warning of a defective heating system. They can also send alerts about increased or even deadly CO concentrations, which according to the experts is a potential source of danger in millions of households worldwide. Based on the programmable digital technology, the RFID component can provide greater security, reliability and range.



Wire-bonding completed sensor package

Aerosol jet printed CNT sensing film on pre-fabricated interdigitated electrodes

In addition, it is much smaller than earlier sensor designs that were based on non-programmable analogue technology. The present GTRI sensor prototype is 10cm^2 but further designs are expected to squeeze a multiple-sensor array and an RFID chip into a 1mm^2 device printable on paper or on flexible, durable substrates such as liquid crystal polymer.

Mass production

Although the effectiveness of the ultra-sensitive gas sensor has been demonstrated through the testing of proof-of-concept prototypes, being able to mass produce high-quality and reliable sensors is an area currently being focused on. Dr Chuck Zhang and Dr Ben Wang, professors at the School of Industrial & Systems Engineering and Georgia Tech Manufacturing Institute (GTMI), are working with others to develop a robust manufacturing process using the emerging printed electronics manufacturing technique – Aerosol Jet printing (AJP).

In the early prototyping fabrication of the sensors, the GTRI team used an inkjet printing process. The sensor performance testing indicated that the inkjet-printed sensors did not provide the needed sensitivity and repeatability. Recently, using the Optomec Aerosol Jet 300 System, the GTMI researchers successfully fabricated several batches of the gas sensors with higher repeatability and four times the sensitivity compared to those made by the inkjet printing process.

The improved sensor performance and quality are a result of the AJP's capability of finer feature sizes, more uniform ink deposition and superior process control. The research team is now working on scale-up manufacturing to enable production of low-cost sensors that could be used in buildings everywhere to identify the location and intensity of harmful internal environmental conditions.

By feeding air quality information to intelligent air-conditioning systems, the sensors will help to save on energy consumption and reduce CO_2 emissions for safer and more efficient buildings.