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Nanostructured Palladium in Methane Detection

In potentially hazardous atmospheres, the speedy detection of combustible gases is a priority, and for the natural gas industry early detection of methane is essential. One common method of detecting combustible gases is with pellistor sensor technology. Pellistors detect a rise of temperature in a gas on combustion. Typical pellistor construction has a coil of fine platinum (Pt) wire embedded in a refractory bead that is loaded with a catalyst, usually palladium (Pd). The Pt wire heats the catalyst to its operating temperature. The Pt wire also detects any extra heat produced if gas burns on the catalyst, by a change in its resistance as the catalyst temperature increases. However, as the Pt wire is very fine (10–50 μm in diameter) pellistors are fragile. The power consumption of the device is high (120–500 mW) and they also have to be individually produced.

Recently micromachined 'hotplate' planar sensor structures, where a supported thin etched SiO_2 or SiN membrane carries a Pt track on one side and a catalyst layer on the other, have been fabricated. The technology has resulted in smaller structures, less power use and should allow parallel production on the wafer level. However, due to the poor performace of the catalyst layer, reliable devices have not been achieved.

Now, scientists at the University of Southampton have produced a micromachined pellistor structure that has low power consumption and a controllable catalyst structure (P. N. Bartlett and S. Guerin, *Anal. Chem.*, 2003, 75, (1), 126–132). Nanostructured Pd films were electrochemically deposited (e) from the hexagonal (H_1) lyotropic liquid crystalline phase of a nonionic surfactant, octaethyleneglycol monohexadecyl ether, onto micromachined Si hotplate structures. $(NH_4)_2PdCl_4$ served as the source of Pd. The electrodeposited nanostructured Pd catalyst layer can be formed into metal or alloy powders and films with regular nanoarchitecture. The H_1-e Pd films have high surface areas (~ 28 $m^2 g^{-1}$) and are effective and stable catalysts for the detection of methane in air on heating to 500ºC. The response of the H_1-e Pd-coated planar pellistors was linearly proportional to a concentration of 0 to 2.5% methane in air with sensitivity of ~ 35 mV/% methane and good stability. Pd adhesion to the structure is excellent. The detection limit for devices is < 0.125% methane in air.

There is optimism that practical commercial devices can be achieved from this technology.