

# Inkjetted arrays of gold-nanocluster chemiresistors for end-of-service-life indicators in respiratory cartridges

**Jeremy Greenblatt<sup>a\*</sup>, Jay L. Snyder<sup>b</sup>, Gary K. Fedder<sup>c</sup>**

<sup>a</sup> IIBR, P.O.Box 19, Ness Ziona 70450, Israel, <sup>b</sup> NPPTL, NIOSH, Pittsburgh, PA 15236, USA, <sup>c</sup> ICES, CMU, Pittsburgh PA15213, USA

Monolayer-protected gold nanocluster chemiresistor arrays, formed by ink-jetting onto 200  $\mu\text{m}$  "spiral" gold electrodes, were explored for use as respirator cartridge end-of-service-life indicators. Inkjetting was performed in a computer controlled home-built drop-on-demand system based on a 30  $\mu\text{m}$  orifice piezoelectric dispenser and featuring drops of 10-40 pl. Inkjetting was chosen for coating because the final sensors had to be as small as possible and carry a big enough array. Our final array was made of 6 transducers on a 2.5 mm by 2.5 mm chip, bonded to a TO5 header. Three matched pairs of spiral electrodes were connected electrically in half-bridge circuits. After coating and thermal annealing, one transducer of each matched pair was capped to prevent contact with the environment, conferring temperature compensation.

An earlier parametric study was performed on an 18 transducer 2.5 mm by 5 mm Si chip, featuring "spiral" electrode gaps of 3, 4, 6, 9 and 12  $\mu\text{m}$  and 75 nm Gold/Ti, 4  $\mu\text{m}$  wide electrodes. We have studied the influence of coating thickness and electrode gap-width on noise and sensitivity towards toluene (hydrophobic), 2-propanol (hydrophilic) and relative humidity, for fresh and aged coatings. The most important finding of this study was an unusual and unexpected gap width dependence of the response to relative humidity greater than 70%. This gap-width dependence vanished upon aging. A possible mechanism of the response and its implications will be discussed.

A gap width of 3 microns was chosen for the final product as it has shown the least variance in humidity response. The overall sensitivity of the inkjetted sensors to a large variety of solvents was comparable to those produced on larger interdigitated transducers using spray or spin coating. Breakthrough of 500 ppm of toluene in a carbon cartridge simulator was demonstrated.