ALIGNED PARTICLE BASED SENSOR ELEMENTS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. patent application Ser. No. 09/201,999, filed Dec. 1, 1998, the disclosure of which is hereby incorporated by reference in its entirety for all purposes.

BACKGROUND OF THE INVENTION

[0002] Electronic noses are artificial sensory systems that are able to mimic chemical sensing. In some instances, electronic noses are arrays of sensors, which are able to generate electrical signals in response to analytes or vapors. For instance, it is possible to detect volatile materials by directly or indirectly measuring a response, such as a resistance, across each of the sensors in the array. Moreover, by providing different variables in each sensor of the array, such as the polymeric make-up of the sensors, it is possible to characterize various chemical materials according to the response of the array to that volatile material.

[0003] The potential applications of electronic noses are great. Examples of applications include, but are not limited to, environmental control, quality control, assessment of food and beverage products. For example, in relation to fish freshness, long chain carbonyl compounds, such as myristaldehyde, can be correlated with fresh fish, whereas short chain alcohols, dimethylsulfide and amines, which increase as a function of time, are characteristic of foul smelling fish.

[0004] U.S. Pat. No. 5,571,401, which issued to Lewis et al. (incorporated herein by reference), discloses sensor arrays useful for the detection of analytes. Each of these sensors comprise a resistor having a plurality of alternating nonconductive regions and conductive regions. As explained therein, gaps exist between the conductive regions and the nonconductive regions. In these sensors, the electrical path length and resistance of a given gap are not constant, but change as the nonconductive region absorbs, adsorbs or imbibes an analyte. The dynamic aggregate resistance provided by these gaps is, in part, a function of analyte permeation of the nonconductive regions.

[0005] The foregoing sensor is based on a conductive network in a nonconductive matrix. The swelling of the nonconductive matrix causes the conductive region to move apart changing the resistance of the sensor. The change in the resistance of the sensor can be correlated to the concentration of the vapor to be detected. The greater the resistance change for a given level of vapor, the lower the detection limit of the vapor being identified. It is thus advantageous to maximize the resistance change associated with the sensor elements.

[0006] One of the major challenges in sensor technology today is to enhance the signal-to-noise ratio (SIN) of a sensor element. By increasing the S/N of a sensor element, a lower detection limit is possible (i.e., the lower the concentration of analyte it is possible to detect). This is particularly useful in applications such as the detection of low concentrations of explosives, landmine detection or in medical applications such as in the detection of microorganism off-gases.

[0007] The response of the sensors upon exposure to vapor is dependent on various factors. One such factor is the percentage of connected paths that are broken. The number of connected paths prior to exposure to a vapor is related to the percolation threshold. The percolation threshold is defined as the particle volume fraction at which the conductivity of the resistor increases rapidly (i.e., an infinite number of conductive paths are formed and the lattice essentially transforms from an insulator to a conductor). At low volume loadings, there are few connected paths; whereas at high volume loadings there are many connected paths. However, at low volume loadings, there is greater sensor resistance. Unfortunately, there is concomitantly a high degree of noise at low volume loadings so that the signal to noise ratio is unsatisfactorily low.

[0008] In view of the foregoing, there is a need in the art to improve the signal to noise of vapor sensors while maintaining low volume loading. Low volume loading sensors result in more resistance and thereby a broader detection limit and greater dynamic range. The current invention fulfills this and other needs.

SUMMARY OF THE INVENTION

[0009] In certain aspects, the present invention provides a sensor array for detecting an analyte in a fluid, comprising: first and second sensors wherein the first sensor comprises a region of aligned conductive material; and wherein the sensor array is electrically connected to an electrical measuring apparatus. Preferably, the first and second sensors are first and second chemically sensitive resistors, each of the chemically sensitive resistors comprising: a plurality of alternating regions comprising a nonconductive region, such as an organic material, and an aligned conductive region. The aligned conductive region comprises an aligned conductive material compositionally different from the nonconductive region. Moreover, each sensor, such as a resistor, provides an electrical path through the nonconductive region and the aligned conductive region; and a first response such as an electrical resistance, when contacted with a first fluid comprising an analyte at a first concentration, and a second response when contacted with a second fluid comprising the analyte at a second different concentration.

[0010] In certain embodiments, the conductive region can be aligned using various processing techniques including, but are not limited to, exposure to an electric field, a thermal field, a magnetic field, an electromagnetic field, a photoelectric field, a light field, a mechanical field or combinations thereof

[0011] Various materials can form the aligned conductive region of the present invention. Such materials include, but are not limited to, conductive materials, semi-conductive materials, magnetic materials, photoresponsive materials and combinations thereof The aligned conductive materials are preferably embedded in an organic matrix, such as a polymeric matrix.

[0012] In another aspect, the present invention relates to a system for detecting an analyte in a fluid, the system comprising: a sensor array comprising first and second sensors wherein the first sensor comprises a region of aligned conducting material. Preferably, the first and second sensors are first and second chemically sensitive resistors, each chemically sensitive resistor comprising a plurality of alternating regions comprising a nonconductive region and an aligned conductive region. Preferably, the aligned con-