Chemiresistor Patents and Abstracts

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- SD-6976, Ho, C.K., R.C. Hughes, and M.W. Jenkins, Waterproof microsensor for in-situ monitoring of volatile compounds, filed 5/22/02.
- SD-6894, Ho, C.K., Method for characterizing subsurface volatile contaminants, filed 10/24/02. U.S. Patent 7,003,405 granted 2/21/06.
- SD-7095, Ho, C.K., Circular chemiresistors for microchemical sensors, filed 1/23/03. U.S. Patent 7,189,360 granted 3/13/07.
- SD-7097, Ho, C.K., Automated monitoring and remediation system for volatile subsurface contaminants using in-situ sensors, filed 10/24/02.
- SD-7307, Ho, C.K., Portable vapor diffusion coefficient meter, filed 10/24/02. U.S. Patent 7,229,593 granted 6/12/07.
- SD-7372, Ho, C.K., Confined cavity chemiresistors for microchemical sensors, filed 1/23/03.
- SD-7373, Ho, C.K., Multi-pin chemiresistors for microchemical sensors, filed 1/23/03. U.S. Patent 7,179,421 granted 2/20/07.
- SD-7542: Ho, C.K. and A.S. Kooser, Chemical and biological detection using imprinted chemiresistor sensors, filed 2/27/04

SD-6976: Waterproof microsensor for in-situ monitoring of volatile compounds

An in-situ, real-time waterproof microsensor that detects and quantitatively characterizes volatile organic and inorganic compounds in soil or groundwater. The microsensor uses an array of polymer-based microsensor elements (e.g., chemiresistors, SAW devices, MEMS microcantilever mass devices) packaged in a compact, rugged, and waterproof housing that is designed to protect the microsensor from harsh subsurface environments, including high humidity and completely water-saturated conditions. The housing can use a selective, gas permeable membrane to pass only VOCs of particular interest, while excluding water or other liquids. The microsensor can use an array of multiple polymer-based sensors (e.g., chemiresistors), a thin-film gas preconcentrator module, an on-board temperature sensor and heating element, and an on-board ASIC, to control the microsensor's temperature, perform resistance measurements, and condition the data. Pattern recognition techniques, such as VERI, can be used to identify multiple VOC's.

SD-6894.1: Method for characterizing subsurface volatile contaminants
(U.S. Patent 7,003,405 granted 2/21/06)

An inverse analysis method for characterizing diffusion of vapor from an underground source of volatile contaminant using data taken by an *in-situ* sensor. The method uses one-dimensional solutions to the diffusion equation in Cartesian, cylindrical, or spherical coordinates for isotropic and homogenous media. If the effective vapor diffusion coefficient is known, then the distance from the source to the *in-situ* sensor can be estimated by comparing the shape of the predicted time-dependent vapor concentration response curve to the measured response curve. Alternatively, if the source distance is

known, then the effective vapor diffusion coefficient can be estimated using the same inverse analysis method. A triangulation technique can be used with multiple sensors to locate the source in two or three dimensions. The *in-situ* sensor can contain one or more chemiresistor elements housed in a waterproof enclosure with a gas permeable membrane.

SD-7095: Circular chemiresistors for microchemical sensors

A circular chemiresistor for use in microchemical sensors. A pair of electrodes is fabricated on an electrically insulating substrate. The pattern of electrodes is arranged in a circle-filling geometry, such as a concentric, dual-track spiral design or a circular interdigitated design. A drop of a chemically sensitive polymer (i.e., chemiresistive ink) is deposited on the insulating substrate, which spreads out into a thin, circular disk contacting the pair of electrodes. This circularly-shaped electrode geometry maximizes the contact area between the pair of electrodes and the polymer deposit, which provides a lower and more stable baseline resistance than with existing linear-trace designs. The circularly-shaped electrode pattern also serves to minimize batch-to-batch variations in the baseline resistance due to non-uniform distributions of conductive particles in the chemiresistive polymer film.

SD-7097.1: Automated monitoring and remediation system for volatile subsurface contaminants using in-situ sensors

A system and method for using an *in-situ* sensor to provide automated feedback control of active remediation systems for removing vapors from an underground source of volatile contaminants. The remediation system uses a vacuum pump to extract vapors from an extraction well, and/or an air compressor for injecting air via an injection well to force vapors towards the extraction well. The automated remediation system can turn off one or both of the pumps when the vapor concentration measured by the *in-situ* sensor drops below a non-productive low threshold level. Subsequently, when the vapor concentration rebounds to sufficiently high, productive level, the system can turn on the pumps and continue the remediation process. The system can also be used as an automated sentinel at sites where contamination is probable. The *in-situ* sensor can contain one or more chemiresistor elements housed in a waterproof enclosure with a gas permeable membrane.

SD-7307: Portable vapor diffusion coefficient meter

An apparatus for measuring the effective vapor diffusion coefficient of a test vapor diffusing through a sample of porous media contained within a test chamber. A chemical sensor measures the time-varying concentration of vapor that has diffused a known distance through the porous media. A data processor contained within the apparatus compares the measured sensor data with analytical predictions of the response curve based on the transient diffusion equation using Fick's Law, iterating on the choice of an effective vapor diffusion coefficient until the difference between the predicted and measured curves is minimized. Optionally, a purge fluid can forced through the porous

media, permitting the apparatus to also measure a gas-phase permeability. The apparatus can be made lightweight, self-powered, and portable for use in the field.

SD-7372: Confined cavity chemiresistors for microchemical sensors

A confined cavity chemiresistor for use in microchemical sensors. A pair of conductive lines is fabricated on an electrically insulating substrate, which has a recessed, open cavity. The distal end of each conductive line rests inside of the cavity. A chemically sensitive polymer that swells when exposed to vapors of a volatile chemical is deposited within the cavity on the substrate, contacting the conductive lines inside of the cavity. The cavity confines the outer perimeter of the deposited film, which can be circular. The pair of conductive lines can be arranged in a dual-track, concentric, spiral design, or a dual-track, circular interdigitated design. The cavity can also be created by attaching a polymer seal ring or gasket to the surface of the substrate. The chemiresistor can be fabricated from LTCC or HTCC co-fired ceramic material.

SD-7373: Multi-pin chemiresistors for microchemical sensors

A multi-pin chemiresistor for use in microchemical sensors. A pair of free-standing, bare wires is supported by an electrically insulating support, and are oriented parallel to each other and spaced closely together. A free-standing film of a chemically sensitive polymer that swells when exposed to vapors of a volatile chemical is formed in-between the pair of closely-spaced wires by capillary action. Similar in construction to a thermocouple, this "chemicouple" is relatively inexpensive and easy to fabricate by dipping the pair of bare wires into a bath of well-mixed chemiresistor ink. Also, a chemiresistor "stick" is formed by dipping an electrically insulating rod with two or more linear or spiral-wrapped electrical traces into the bath of well-mixed chemiresistor ink, which deposits a uniform coating of the chemically sensitive polymer on the rod and the electrical traces. These "sticks" can be easily removed and replaced from a multi-chemiresistor plug.

SD-7542: Chemical and biological detection using imprinted chemiresistor sensors

Molecular imprinted chemiresistor devices and methods for their application to detect chemical and biological substances in fluids are described. Imprinting, according the invention, can include substances other than molecules, as well.