ization techniques include, 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 The techniques employed to align the particles depends in part on the particle composition.

[0022] Suitable particles for use in the present invention include particles with a permanent magnetic dipole including, but not limited to, iron, nickel or cobalt require the use of a magnetic field for polarization to occur. Particles such as carbon black, coke, C_{60}, and the like, TiO_2, $BaTiO_3$, In_2O_3, SnO_2, $Na_xPt_3O_4$, conducting polymers, metals such as platinum, copper, gold, silver etc., polarize with application of an electric field. In some embodiments, the conductive material is a conducting polymer, or an insulating polymer with conductive fillers. Suitable conductive polymers are disclosed in U.S. Pat. No. 5,571,401, which issued Nov. 5, 1996, and WO 99/31494, which published on Jun. 24, 1999. As disclosed in WO 99/31494, the sensors taught therein comprise substituted polythiophenes. One polymer is poly (3,3"-dihexyl-2-2":5',2"-terthiophene). In a preferred embodiment, the conductive particle is carbon black.

[0023] In an equally preferred embodiment, the conductive material can be a particle, such as a gold nanoparticle, with a capping ligand shell. A preferred nanoparticle is disclosed in WO 99/27357, entitled "Materials, Method and Apparatus for Detection and Monitoring Chemical Species," published Jun. 3, 1999. Examples of colloidal nanoparticles for use in accordance with the present invention are described in the literature (see, Templeton et al. *J. Am. Chem. Soc.* (1 998) 120 :1906-1911; Lee et al., *Isr. J Chem.* (1997) 37: 213-223 (1997); Hostetler et al. *LANGMUIR* (1998) 14:17-30; Ingram et al., *J. Am. Chem. Soc.,* (1997) 119 :9175-9178; Hostetler et al., *J. Am Chem. Soc.* (1996) 118 :4212-4213; Henglein J Phys. Chem. (1993) 97 :5457-5471; Zeiri, *J. Phys. Chem.* (1992) 96:5908-5917; Leff et al., *LANGMUIR* (1996)4723-4730. Moreover, particles such as copper phthalocyanine and phenothiazine polarize when illuminated. All of these polarization techniques can be used to generate sensors of the present invention.

[0024] Polarization processing, such as magnetic field processing, involves exposure to various polarization mechanisms having different directions and optionally, different strengths. For example, during fabrication of the present sensors, exposure to a magnetic field can optionally be in one direction, such as in the x-, y- or z-direction; in two directions, such as x- and y-directions, x-and z-directions or y- and z-directions; or in three directions, such as x-, y- and z-directions. In a preferred embodiment, the polarization processing is along the same axis as the vapor measurement. For instance, if the vapor measurement is along the z-direction, particle alignment will be along the z-direction. In an equally preferred embodiment, the direction of expansion of the alternating regions is along the same axis as the vapor measurement. As used herein, the x-, y-, and z-axes have their traditional meaning, i.e., the x and y axes are in the plane of the sensor substrate and the z axis is perpendicular to the x and y origins.

[0025] In addition to magnetic field processing, sensor fabrication of the present invention can include other modes of polarization. For example, photosensitive conductive material will be exposed to optical radiation, such as visible, infrared or ultraviolet light. Electrosensitive conductive material involves exposure to electric fields having different directions and different strengths.

[0026] As previously discussed, enhancing the response of the sensor can be accomplished by confining the direction of expansion of the alternating regions to be along the axis of measurement or, preferably, along the axis of the particle alignment For instance, a polymer can have a 2% volume expansion on exposure to a certain vapor concentration. If this swelling can be isolated to one dimension, then the linear expansion can be as high as 8% causing a much larger change in resistance than would occur without confinement.

[0027] Aligning the conductive region e.g., material or particles, in a nonconducting matrix during deposition causes an increase in the number of conductive paths which in turn, results in a very low base resistance. As discussed earlier, the formation of a conductive path is related to the percolation threshold of the material. The percolation threshold varies from material to material depending on factors, such as particle size, shape and composition. Alignment of the conductive region will cause percolation to occur at a much lower volume loading. Thus, sensors containing aligned conductive regions will give a larger signal when exposed to a vapor compared to a sensor without aligned regions. As the nonconductive region, such as an organic polymer, swells, disruption of the particle chains occurs and a lowering in the conductivity or an increase in the resistance occurs. As the polymer desorbs, the particles return to their minimum energy state that corresponds to particle alignment.

[0028] Non-sensor alignment of particles are known. For instance, U.S. Pat. No. 4,177,228 issued to Prolss, entitled "Method of Production of a Micro-Porous Membrane for Filtration Plants," discloses the alignment of particles by various techniques. Likewise, U.S. Pat. No. 5,742,223, issued to Simenddinger, entitled "Laminar Non-linear Device with Magnetically Aligned Particles," discloses composites with magnetically and electrically conductive particles. In addition, U.S. Pat. No. 4,838,347, issued to Dentini, entitled "Thermal Conductor Assembly," discloses a polymer field with thermally conducting magnetically aligned particles. Furthermore, U.S. Pat. No. 5,104,210, issued to Tokas, entitled "Light Control Films and Method of Making," discloses composites of magnetically alignable particles.

[0029] In certain aspects, the present invention relates to conductive regions capable of alignment including, but not limited to, conductive, semi-conductive, magnetic and photoresponsive particles embedded in a nonconductive region, such as an organic matrix, For instance, in one embodiment, particles suitable for use, while preferably spherical, are not limited by their shape and can even be in the form of flakes. Suitable particulate materials that are magnetic include, but are not limited to, metals such as, nickel, cobalt and iron and their magnetic alloys. Other suitable magnetic particles include, but are not limited to, oxides and intermetallic compounds as are known in the art. Composite materials can also be used. These material include, but are not limited to, nickel coated with copper, or magnetically thermally conducting ceramics (see, U.S. Pat. No. 4,838,347, incorporated herein by reference). Additional magnetic particles include, but are not limited to, alloys containing nickel, iron, cobalt