Journal of Physical Chemistry & Biophysics
ISSN: 2161-0398

Gole and Laminack, J Phys Chem Biophys 2016, 6:3
http://dx.doi.org/10.4172/2161-0398.1000217

Review Article Open Access

New Generation Devices for Gas (Liquid) Sensing

Gole JL[1,2]* and Laminack W[1]

[1]School of Physics, Georgia Institute of Technology, Atlanta, Georgia 30332, USA
[2]School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, Georgia 30332, USA

Abstract

We present a short review and novel approach for the construction of conductometric sensors demonstrating considerably higher sensitivities than traditional metal oxide sensors. Sensor platforms do not require film-based technology, operate at room temperature, and can be obtained without the use of time consuming self-assembly processes. A combined nanopore coated micro-porous array, is deposited with nanostructure directing acidic metal oxide island sites which vary in their Lewis acidity, decorate the micropores, and control an electron transduction process. The interaction of analytes with these island sites varies in a predictable manner and can be modified through *in-situ* functionalization of their Lewis acidity through formation of the oxynittrides or oxysulfides. Microporesallow rapid Fickian diffusion of the analytes to the active nanostructured island sites whose reversible interaction with the analyte dominates the sensor response. We require only that the island sites be deposited at sufficiently low concentration so as not to interact electronically with each other. Highly accurate repeat placement of the nanostructured island depositions is not required. The nanoporous walls of the microarray act as a phase match for the deposition of a diversity of nanostructures that are selected for deposition from a variety of solution-based sources and the forgiving deposition process requires a minimum of energy consumption and time. Comparisons to a variety of metal oxide systems are considered. Observed sensitivities and the sensor system reversibility can be predicted from the recently developing IHSAB model.

Keywords: Sensors; Directing nanostructure; Metal-oxide; Island sites; Acid/base theory; IHSAB principle; Extrinsic semiconductors

Introduction

Because the requirements for the detection, monitoring, and transformation of environmental constituents are increasing at a significant rate developing sensor interfaces must be sensitive to low level exposures and have fast response times [1]. As concerns about the impact of gases on health and environmental concerns increase, the reliable detection of several gases over a range of temperatures has become a priority. Included in this group, NO_x associated with air pollution, combustion, and respiratory disease [2,3] is critical. NO is the primary monitor of an asthmatic attack and can also provide rapidly accessed noninvasive disease [4] detection. NH_3, which plays an especially important role in urban environments [5,6], also is produced albeit at much lower levels, during an asthma attack. SO_x and H_2S [7-9] as well as NO_x play an important role in automotive and industrial exhaust, acid rain, photochemical smog, and corrosion [3] and natural gas venting.. PH_3 is an extremely toxic gas used for fumigation in agriculture and is a byproduct in the production of methamphetamines [10,11]. Advances in gas sensor technology used to monitor these exemplary gases have been driven by sensitivity, selectivity, stability, response time, and durability. Here, we review a new solid-state device technology which detects analytes by measuring an electrical property of a detection interface and from this measurement we can evaluate an interacting gas. Conductometric gas sensors can be made to consist of a sensitive interface layer decorated by nanostructure island sites. The nanostructure decorated interfaces that can be easily constructed, do not demand complex self-assembly, are much easier to implement and reproduce than film depositions, and require far fewer starting materials. These attributes suggest enhanced energy efficiency both in the transduction mechanism and in the simplicity of a design involving minimal manufacturing time. Metal oxide sensors have been the most commonly used solid-state sensor. These sensors [12,13] use the metal oxides of tungsten (WO_3), nickel (NiO), copper (Cu_xO), aluminum (Al_2O_3), titanium (TiO_2), tin (SnO_x), or zirconium (ZrO_2). The most commonly cited types of oxide sensors in the literature are based off thin films (<1 micrometer). However, in some cases thick films are used, doped with noble metals or various nanoshapes designed to effect grain boundaries [13-20]. These metal oxide sensors must be heated to elevated temperatures that range from 100 to 600°C depending on the analyte [13,21-23]. For effective monitoring of a given analyte, the temperature must be precisely controlled. The necessary heating results in is a significant power drain on the system. The required temperature ranges means that these configurations can be greatly affected by an impinging combustion or flue gas, severely impeding the correct identification of the gaseous species in the flow. The figure compares the typical metal oxide configuration to the potential configuration for PSi sensors, which maybe heat sunk (Figure 1). The required temperature control of typical metal oxide sensors and the necessity to generate the sensing interface from film technology are two key problems that can be overcome with the technology that we summarize below. We describe a conductometric gas sensor that can be made to consist of an easily designed sensitive hybrid nano/microporous interface transformed through the introduction of select nanostructures. This hybrid structure facilitates rapid Fickian [24,25] diffusion into a microporous framework whose nanoporous wall covering serves to provide a phase match for the selectively deposited nanostructures. In contrast to both thin and thick films, which may respond in minutes [26] due to slow diffusion, the current structure, with which analyte interaction is diffusion dominated, allows a response in less than two seconds [27].

***Corresponding author:** Gole JL, School of Physics and School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, Georgia 30332, USA, Tel: +14048944029; E-mail: James.Gole@physics.gatech.edu

Received April 05, 2016; **Accepted** May 06, 2016; **Published** May 12, 2016

Citation: Gole JL, Laminack W (2016) New Generation Devices for Gas (Liquid) Sensing. J Phys Chem Biophys 6: 217. doi:10.4172/2161-0398.1000217

Technology Summary

We are developing a wholly -new approach to chemical sensor technology which can lead to a significant improvement in the operation of gas sensors, sensor arrays, catalysts, and micro-reactors. Interfaces formulated with novel, rational, and inexpensively implemented concept are tailored to desired specifications and operative across a wide temperature and pressure range with application to mixed analyte environments. A patented etch process creating a nanopore covered microporous array forms an easily modified simple MEMS/NEMS platform on which metal oxide island oxide island sites are deposited in a forgiving process to form distinct electronically independent detection centers. The nanoporous coating prevents sintering of these island centers at elevated temperatures. The concentration of detection centers can be made to produce an optimum matrix of enhanced sensor responses superior to that based on surface coating techniques. The novel sensor core concept forces nanostructure island site directing analyte- interface physisorption (rather than chemisorption) at a doped and metal oxide decorated semiconductor interface and provides a sensitive means of transferring electrons that are easily detected. Figure 1 depicts the current interface as well [24] as the deposition of the pore wall structure Figure 2.

Conceptual approach

The technology to define the sensors is based on science that combines the basic tenants of acid/base chemistry and semiconductor physics to tailor novel gas-solid and liquid-solid interfaces. The acid/base chemistry is combined with and defined by the recently developed Inverse Hard/Soft Acid/Base principle. This core sensor concept is based on building nanostructure directing physisorption rather than chemisorption at a doped semiconductor interface. Understanding the character of an analyte on an extrinsic semiconductor interface (p or n-type) provides a sensitive and controllable means of transferring electrons that are easily detected by monitoring the resistivity (conductivity) of the semiconductor. This approach is relatively simple to follow and implement [25].

Details of device fabrication

The sensor preparation is oriented to electrochemical etching to create micro-channels to facilitate the diffusion of analytes into detection interfaces. The etch procedure simultaneously forms nano-thin films on the inner walls of the micro-channels (Figure 1). These inner walls provide a phase matching layer, which is used to insure efficient trapping of the deposited nanoparticles and exclude their sintering with enhanced temperature. The deposited nanoparticles are chosen to achieve a targeted chemistry with the analytes. Electrical contact pads (Figure 1) enable simple resistivity measurements for device readout. Initial matrix array elements that enable multi-analyte detection have been created with combinations of nanoparticles, initially tested, and made operational. The manner of fabrication leads to an ability to develop cost effective, rugged devices [25].

Technology Features

The sensors are selective to the environmentally deleterious gases H_2S, SO_2, NO_x, and NH_3 in the presence of the BTEX gases (benzene, toluene, xylene) and CO [7-9]. The relative sensitivity/selectivity exceeds 1000/1 vs. a current industry standard of 20/1. Since the sensor is formed from nanoparticule island sites on nanopore covered microporous channels, this allows rapid diffusion, while preventing sintering of these highly active sites at elevated temperatures, greatly improving response times (~ 2 sec). The nanostructures are readily

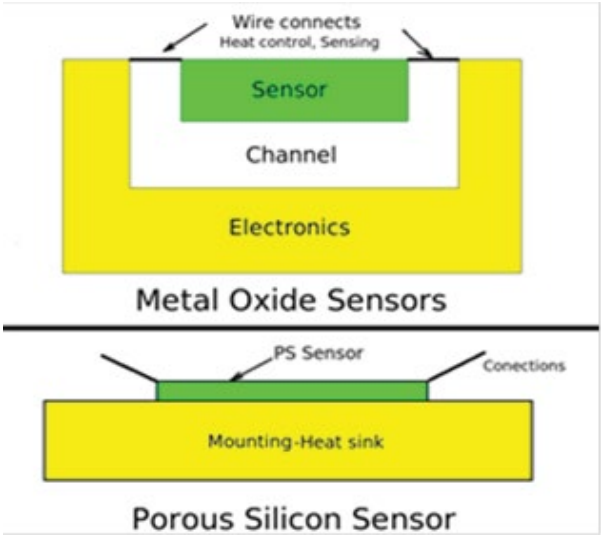

Figure 1: Comparison of a metal oxide (usually SnO_2 or WO_3) elevated temperature (150-500°C) heat controlled sensors separated from their electronics by a channel with a heat sunk. PS sensor operating at room temperature and capable of operation to temperatures of at least 100°C.

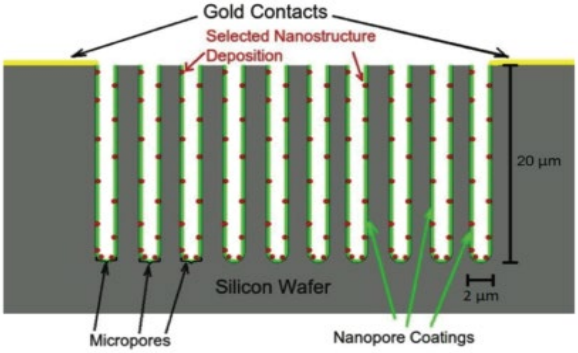

Figure 2a: Schematic configuration of PSi sensor.

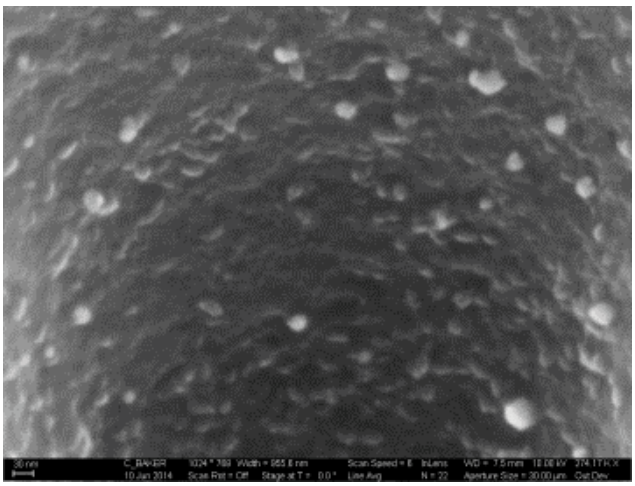

Figure 2b: Closeup of nanostructure (white) decorated micropore.

functionalized (nitridation, sulfidation) allowing the tuning of response across a broad range of acidity and basicity and analyte interactions [25]. In addition, the sensor platforms are capable of operation under extremely small magnetic field control [27]. The devices have the potential for adaptation to solar pumped sensing, micro-reactor, and solar assisted micro-reactors to achieve difficult but important chemical transformations, extending the development of basic heterogeneous catalyst sites and potential acid/base pairing combinations [28]. The technology has now been applied to the characterization of volatile liquids including the alcohols, acetone, chloroform, additional polar and nonpolar solvents, and more complex liquids including isoprene. The nature of liquid sensing has been completely reevaluated [29]. The responsiveness of PS sensor systems is superior to other metal oxide systems. The PS sensors operate at room temperature, are easily constructed with simple deposition techniques (vs. spray pyrolysis, magneton sputtering, and other film coating techniques) and are much easier to fabricate and use than nanorod or nanowire configured systems [25]. A short comparative table is given (Table 1).

Comparisons to currently utilized sensors

Test devices have been built and characterized providing not only complementarity with, but also a significant superiority to

Gas	Gas Concentration Lower Exposure Limit (LEL)	Response sensitivity	Operating Temperature	Material	Method	Authors
H_2S	1 ppm	5900[a]	200°C	Ag (8 nm)-doped SnO_2	DC magnetron sputtering (SnO_2); Ag film coating	Jin et al. [30]
H_2S	3 ppm; 1 ppm LEL	40%[b]; unreported	74°C	Ag-doped SnO_2	Polymeric sol-gel	Gong et al. [31]
H_2S	2.5 ppm	~85%[b]	400°C	SnO_2	Spray pyrolysis	Griessler et al. [32]
H_2S	0.5 ppm	~1.4[a]	300°C	SnO_2	Flame spray pyrolysis (FSP) (nanopowders); Spin coating (sensor)	Liewhiran et al. [33]
H_2S	10 ppm	~1.45[a]	300°C	CuO	Heating in open-air high purity copper foils (nanowires)	Shao et al. [34]
H_2S*	1 ppm 0.5 ppm	~ 5[e] ~ 4	25°C 25-100°C	PS untreated Nanostructure decorated PS	Nanopore covered µ-pores	Lewis et al. [35] Baker et. al
SO_2	50 ppm	~40%[b]	300°C	SnO_2	Spray pyrolysis	Griessler et al. [32]
SO_2	20 ppm	~3.8[a]	300°C	SnO_2	FSP (nanopowders) Spin coating (sensor)	Liewhiran et al [33]
SO_2	5 ppm	~45%[b]	350°C	0.15 wt% V_2O_5/SnO_2	Simultaneous precipitation technique (nanopowder); painting (sensor)	Das et al. [36]
SO_2*	1 ppm	~ 5[e]	25°C	PS untreated	Nanopore covered µ- pores	Lewis et al. [35]
CO	50 ppm	8[a]	350°C	0.2 wt% Pt/SnO_2	FSP (nanopowders); Thermophoresis (sensor)	Mädler et al. [37]
CO	500 ppm	N/A[c]	200 - 400°C	SnO_2	FSP (nanopowders); Drop coating (sensor)	Sahm et al. [38]
CO	10 ppm	N/A	150°C	CuO	Soft chemistry (nanospheres); Thick film screen printing (sensor)	Hübner et al. [39]
CO *	1 ppm	~ 3[e]	25°C	PS, SnO_2 treated	Sn electroless solution	DeBoer et al. [40]
NO_2	5000 ppb	20[a]	220°C	SnO_2	FSP (nanopowders); Drop coating	Sahm et al. [38]
NO_2*	<500 ppb	~ 10[e]	25°C	PS, TiO_2 treated	TiO_2 nanoparticle solution doped nanopore covered µ-pores	Laminack et al. [39]
NH_3	100 ppm	3.1[a]	200°C	CuO	Heating in open-air high purity copper foils (nanowires)	Shao et al. [34]
NH_3*	<500 ppb	~ 50[e]	25°C	PS, Au_xO treated	Au electroless solution	Ozdemir et al. [41]
PH_3*	<500 ppb	~ 10[e]	25°C	PS, Au_xO treated	Au electroless solution	Ozdemir et al. [38,42] Laminack et al. [43]
H_2S	50 ppb	N/A	25-200°C	ZnO	Nanorods	Wang et al. [44]
H_2S	1 ppm	N/A	RT[d]	In_2O_3	Nanowires 2-3 min response	Zeng et al. [45]
NH_3	10 ppb	N/A	RT	$W_{18}O_{49}$	Ultrathin (5 nm) Nanowire bundles	Zhao et al. [46]
NH_3	100 ppb	N/A	300°C	SnO_2	Coupling SnO_2 nanowire to MEMS microhotplate	Meier et al. [47]
CO	100 ppb (Quote <5 ppm)	N/A	300°C	SnO_2	Single nanowire	Hernández-Ramírez et al. [48]

Sensitivity=$(R_{air}-R_{gas})/R_{air} \times 100\%$
Sensitivity=R_{air}/R_{gas}
N/A=Not Available
RT=Room temperature
From $\Delta = \frac{\Delta R(\text{deposited}) / R_0(\text{deposited})}{\Delta R(\text{untreated}) / R_0(\text{deposited})}$

Table 1: Lower exposure limit of various gas sensor materials and methods.

alternate technologies. They operate in an unsaturated mode over wide temperature and pressure ranges. Pulsed mode operation ensures low energy consumption and high analyte selectivity. Extensive Diffusion/Absorption/Desorption Modeling based on a non-empirical approach that permits predictive analytical modeling of Mixed Gas interactions and Interface modifications has been developed [30]. In contrast to optical systems, the sensors have minimal alignment requirements. There is no need for high Q cavities such as those used for Fabry-Perot devices.

Summary

The simple design allows the sensors to operate in saturated or unsaturated mode over wide temperature ranges with insensitivity to temperature drift. When the sensors are heat-sunk, the configuration allows reliable performance at a surface temperature ≈ 100°C, even in elevated temperature environments (e.g., combustion or flue gas) in sharp contrast to typical metal oxide sensors. The PSi sensor design allows for rapid response (≈ 2 s), high sensitivity (near-ppb), and reversibility to the gas response. Ease of modification with a diversity of clearly mapped and readily generated gas-selective nanostructured materials, provides a range of sensitivities for a broad range of gases as well as being formatable for sensor arrays (response matrix). Energy-efficient-low power requirements (microwatts- less than watch battery), and sensitivity-weak physisorptive processes produce a conductmetric response with $\Delta G \leq 2$ Kcal/mole. Low energy magnetic field, signal enhancement can be achieved with transition metal nanostructures deposited to a semiconductor surface. Contaminated sensors are readily rejuvenated using an HF technique. Does not require film-based technology or lengthy self-assembly. Nanostructure island sites provide faster response, greater sensitivity. Pulsed mode operation ensures low analyte consumption and high analyte selectivity, as well as the ability to rapidly assess false positive signals using FFT techniques. Ready use for the development of solar pumped sensors Liquid phase organic solvent detection as a function of moderate temperatures has also been demonstrated.

References

1. Korotcenkov G, Porous CB (2010) Semiconductors: Advanced Material for Gas Sensor Applications. Critical Reviews in Solid State and Materials Sciences 35: 1-37.
2. Eranna G, Joshi B, Runthala D, Gupta R (2004) Oxide Materials for Development of Integrated Gas Sensors - A Comprehensive Review. Critical Reviews in Solid State and Materials Sciences 29: 111-188.
3. Ozdemir S, Gole J (2007) The potential of porous silicon gas sensors. Current Opinion in Solid State and Materials Science 11: 92-100.
4. Zeidler MR, Kleerup EC, Tashkin DP (2004) Exhaled nitric oxide in the assessment of asthma. Curr Opin Pulm Med 10: 31-36.
5. Teague G (2016) Personal communication.
6. Gomzi M (1999) Indoor air and respiratory health in preadolescent children. Atmospheric Environment 33: 4091-4086.
7. Air Quality and the Selective Detection of Ammonia in the Presence of Carbon Monoxide, Toluene, Benzene, and Xylene, William Laminack, Caitlin Baker, and James Gole, Air Quality, Atmosphere, and Health.
8. Baker C, Laminack W, Gole JL (2015) Sensitive and Selective Detection of H2S and Application in the presence of toluene, benzene, and xylene. Sensors and Actuators, B Chemical pp: 28-34.
9. Selective Detection of Inorganics NOx, SO_2, and H_2S in the presence of volatile BTEX contaminants, toluene, benzene, and xylene Caitlin Baker, William Laminack, and James L. Gole, Air Quality, Atmosphere and Health.
10. Berck B (1968) Sorption of phosphine by cereal products. J Agric Food Chem 16: 419-425.
11. Burgess JL (2001) Phosphine exposure from a methamphetamine laboratory investigation. J Toxicol Clin Toxicol 39: 165-168.
12. Barsan N, Schweizer-Berberich M, Gopel W (1999) Fundamental and practical aspects in the design of nanoscaled SnO_2 gas sensors: a status report. Fresenius' journal of analytical chemistry 365: 287-304.
13. Comini E (2006) Metal oxide nano-crystals for gas sensing. Anal Chim Acta 568: 28-40.
14. LeGorea LJ, Lada RJ, Moulzolfa SC, Vetelinoa JF, Fredericka BG, et al. (2002) Defects and morphology of tungsten trioxide thin films. Thin Solid Films 406: 79-86.
15. Rani S, Roy SC, Bhatnagar M (2007) Effect of Fe doping on the gas sensing properties of nano-crystalline SnO_2 thin films. Sensors and Actuators B: Chemical. 122: 204-210.
16. Jiménez I, Arbiol J, Dezanneau G, Cornet A, Morante JR (2003) Crystalline structure, defects and gas sensor response to NO2 and H2S of tungsten trioxide nanopowders. Sensors and Actuators B: Chemical 93: 475-485.
17. Moulzolf SC, Ding S, Lad RD (2001) Stoichiometry and microstructure effects on tungsten oxide chemiresistive films. Sensors and Actuators B: Chemical 77: 375-382.
18. Ponce M, Aldao C, Castro M (2003) Influence of particle size on the conductance of SnO2 thick films. Journal of the European Ceramic Society 23: 2105-2111.
19. Rothschild A, Komem Y (2004) The effect of grain size on the sensitivity of nanocrystalline metal-oxide gas sensors. Journal of Applied Physics 95: 6374-6380.
20. Yoon DH, Choi GM (1997) Microstructure and CO gas sensing properties of porous ZnO produced by starch addition. Sensors and Actuators B: Chemical 45: 251-257.
21. Morrison SR (1987) Selectivity in semiconductor gas sensors. Sensors and Actuators. 12: 425-440.
22. Watson J (1994) The stannic oxide gas sensor. Sensor Review 14: 20-23.
23. Yamazoe N, Shimanoe K, Aswal DK, Gupta SK (2007) Overview of gas sensor technology. Nova Science Publishers Inc., New York, USA.
24. Kottke PA, Federov AG, Gole JL (2009) Multiscale Mass Transport in Porous Silicon Gas Sensors. Modern Aspects of Electrochemistry 43: 139-168.
25. Gole JL, Laminack W (2012) General Approach to Design and Modeling of Nanostructure Modified Semiconductor and Nanowire Interfaces for Sensor and Microreactor Applications, In: Korotcenkov G (eds.), Chemical Sensors: Simulation and Modeling, Solid State Sensors, Momentum Press, New York, 3: 87-136.
26. Schechter I, Ben-Chorin M, Kux A (1995) Gas Sensing Properties of Porous Silicon. Analytical Chemistry 67: 3727-3732.
27. Baker C, Laminack W, Tune T, Gole JL (2014) Magnetically Induced Enhancement of Reversibly Responding Conductometric Sensors. Jour of Applied Physics 115: 164312.
28. Laminack W, Gole JL (2013) Light Enhanced Electron Transduction and Amplified Sensing at a Nanostructure Modified Semiconductor Interface, Advanced Functional Materials 23: 5916-5924.
29. Baker CV, Gole JL (2016) Detection of Liquid Organic Solvents on Nanostructure Decorated Porous Silicon Interfaces. ACS Sensors 1: 235-242.
30. Jin C, Yamazaki T, Ito K, Kikuta T, Nakatani N (2006) H_2S sensing property of porous SnO_2 sputtered films coated with various doping films. Vacuum 80: 723-725.
31. Gong J, Chen Q, Lian M, Liu N, Stevenson R, et al. (2006) Micromachined nanocrystalline silver doped SnO_2 H_2S sensor. Sensor and Actuators B: Chemical. 114: 32-39.
32. Griessler C, Brunet E, Maier T, Steinhauer S, Köck A, et al. (2011) Tin oxide nanosensors for highly sensitive toxic gas detection and their 3D system integration. Microelectronic Engineering 88: 1779-1781.
33. Liewhiran C, Tamaekong N, Wisitsora-at A, Phanichphant S (2012) The Monitoring of H2S and SO_2 Noxious Gases from Industrial Environment with Sensors Based on Flame-Spray-Made SNO_2 Nanoparticles. Engineering Journal 16 123-134.

34. Shao F, Hernándes-Ramírez F, Prades JD, Fábrega C, Andreu T, et al. (2014) Copper (II) oxide nanowires for p-type conductometric NH_3 sensing. Applied Surface Science 311: 177-181.

35. Lewis S, Gole JL (2015) Unpublished results.

36. Das S, Chakraborty S, Parkash O, Kumar D, Bandyopadhyay S, et al. (2008) Vanadium doped tin dioxide as a novel sulfur dioxide sensor. Talanta 75: 385-389.

37. Mädler L, Roessler A, Pratsinis SE, Sahm T, Gurlo A, et al. (2006) Direct formation of highly porous gas-sensing films by in situ thermophoretic deposition of flame-made Pt/SnO_2 nanoparticles. Sensors and Actuators B: Chemical 114: 283-295.

38. Sahm T, Mädler L, Gurlo A, Barsan N, Pratsinis SE, et al. (2004) Flame spray synthesis of tin dioxide nanoparticles for gas sensing. Sensors and Actuators B: Chemical 98: 148-153.

39. Hübner M, Simion CE, Tomescu-Stanoiu A, Pokhrel S, Bârsan N, et al. (2011) Influence of humidity on CO sensing with p-type CuO thick film gas sensors. Sensors and Actuators B: Chemical. 153: 347-353.

40. Gole JL, Lewis SC, DeBoer JR, Hesketh PJ (2005) Sensitive, selective, and analytical improvements to a porous silicon gas sensor. Sensors and Actuators B. 110: 54-65.

41. Ozdemir S, Gole JL (2008) Porous Silicon Gas Sensors for Room Temperature Detection of Ammonia and Phosphine. ECS Transactions. 16: 379-385.

42. Ozdemir S, Gole JL (2010) A phosphine detection matrix using nanostructure modified porous silicon gas sensors. Sensors and Actuators B 151: 274-280.

43. Laminack W, Gole JL (2014) A Variable Response Phosphine Sensing Matrix Based on Nanostructure Treated p, and n-type Porous Silicon Interfaces. IEEE Sensors. 14: 2731-2738.

44. Wang C, Chu X, Wu M (2006) Detection of H_2S down to ppb levels at room temperature using sensors based on ZnO nanorods. Sensors and Actuators B: Chemical. 113: 320-323.

45. Zeng Z, Wang K, Zhang Z, Chen J, Zhou W (2009) The detection of H2S at room temperature by using individual indium oxide nanowire transistors. Nanotechnology. 20: 045503.

46. Zhao YM, Zhu YQ (2009) Room temperature ammonia sensing properties of W18O49 nanowires. Sensors and Actuators B: Chemical. 137: 27-31.

47. Meier DC, Semancik S, Button B, Strelcov E, Kolmakov A (2007) Coupling nanowire chemiresistors with MEMS microhotplate gas sensing platforms. Applied Physics Letters 91: 063118.

48. Hernández-Ramírez F, Tarancón A, Casals O, Arbiol J, Romano-Rodríguez A, et al. (2007) High response and stability in CO and humidity measures using a single SnO2 nanowire, Sensors and Actuators B: Chemical. 121: 3-17.

Citation: Gole JL, Laminack W (2016) New Generation Devices for Gas (Liquid) Sensing. J Phys Chem Biophys 6: 217. doi:10.4172/2161-0398.1000217