Mems Gas Sensor And Their New Applications – A Review

N.Nandakumar[1], R.Thangavel[2], K.Shanmugasundaram[3], P.P.Sumi[4]
[1, 2, 3, 4] Department of Electronics
[1, 2, 3, 4] Sri Ramakrishna Mission Vidyalaya College of Arts and Science, Coimbatore, India.

Abstract- *The aim of this paper is to give an introduction to micro-electromechanical systems (MEMS) sensors and to consider a number of recent applications and commercialization, markets and product developments. Design/methodology/ approach – Following the first appearance and a brief historical background to MEMS sensors and their commercialization, the paper describes a selection of recent applications, with an accentuate on high volume applications. Various market figures are included to place these applications in a commercial circumstance. Sensors for both physical changes and gases are considered. The paper indicates that MEMS sensor applications proceed to grow in the consumer electronics, automotive and other industries, which consume many millions of sensors each year. New product growth reflects the requirement for smaller and lower-price sensors with improved performance and greater purposes. Markets for physical sensors dominate but MEMS technology is making advanced inroads in the gas sensing field. This article provides a timely review of a selection of current MEMS sensor applications, markets and product developments.*

Keywords- MEMS, Gas sensors, Sensors applications, IR Gas sensors

I. INTRODUCTION

Latterly industry and academic both are receiving increasing attention on gas sensing, as a typical application in intelligent systems. Gas sensing technology has become more importance because of its widespread and common applications in the following areas: medical applications, automotive industry, industrial production, indoor air quality supervision, environmental studies. Recent years, different researches have established various branches of gas sensing technology. In that there are three major areas that receive the most attention are investigation of different kinds of sensors, fabrication techniques and research about sensing principles. Gas pressure environment humidity gas type and concentration gas temperature gas sensor guideline, Micro/Nano level gas sensor, integrated with other IC's on the same chip MEMS sensor hub process control industries, life and working.

II. CURRENT APPLICATIONS OF GAS SENSOR

Monitoring of environmental, detection of fire, breathe tests for alcohol drinker, detection of poison gas, grading of agro products like coffee and spices, food process and storage, emissions monitoring for industrial, medical diagnosis.Figure 1 shows the various application of gas sensors.

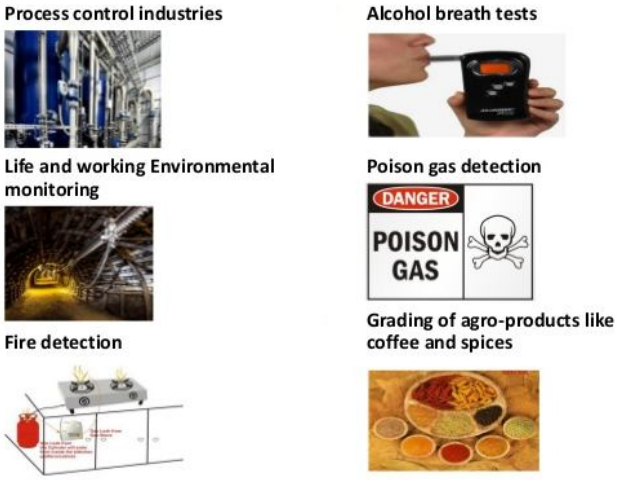

Figure 1. Current applications of gas sensor

III. FUTURE APPLICATIONS OF GAS SENSOR

Gas detecting for underwater, smart phone & wearable devices, detection of hazardous explosives. Figure 2 shoes the future application of gas sensor

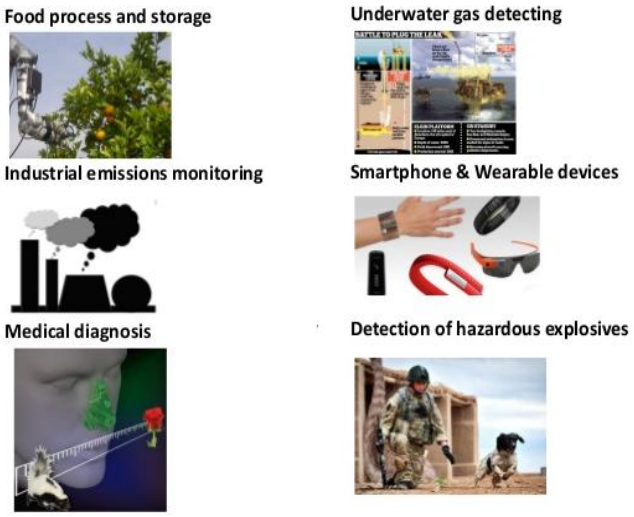

Figure 2. Future application of gas sensor

IV. IMPROVEMENTS OF NEW GENERATION MEMS GAS SENSOR

Structure on chip to support multiple-gas detection, highest Sensitivity, lowest power consumption, smallest size, lower cost, less material required, easier mass production, less manufacturing cost. Market requirement and development trend of gas sensors year of 2014-2021. Market potential need forecast of gas detection in many applications lifetime and application comparison of many gas sensor IR, MOS,Infra-red sensor, Chem FET, Metal Oxide Semiconductor, chemical Field-Effect Transistor IR Million USD Infra-Red (IR) gas sensors are cover all types of applications with longer life time. Need for new generation MEMS gas sensor are reliable and stable gas sensing for safety purpose, high performance on sensing and accuracy. Feature size for CMOS integration requirement good selective on different gases detection, safety battle to plug the leak environment struggle to avoid volkswagen incident on 2015 HVAC control and monitor to struggle to create safe human environment. Personal mobile/wearable analysis for some special protection. Best solution - on-chip-platform sensor smaller size and lower cost sensitivity, selectivity, less power consumption, The trend of MEMS hub chip immerged out which is integrated with CMOS and supported by new software. MEMS level gas sensors will cause power consuming decreased and sensitivity, selective increased significantly by different sensors united. The total price will be dropped down by mature mass production finally. On-Chip-Photonics gas sensor non-dispersive IR Electrochemical Size 1.5 mm × 2.0 mm × 0.9 mm ~ cm3 1 mm × 1 mm x Xmm price below USD 10 above USD 50 above USD 50 type multi-gas detection single gas detection, single gas detection sensitivity < 100 ppb < 50 ppm up to 100 ppb response time: < 5 s < 30 s < 5 s significant stability very stable significant output drift overtime, drift down 2% per month environmental dependency environmental independent ambience and temperature dependent ambience and temperature dependent power consumption < 30 mW 120 ~ 600 mW < 30 mW others CMOS compatible, ultra- compact size, and good selectivity high selectivity, but big package size simple, low cost, but very poor selectivity. On-Chip-Platform gas sensor – superior performance. Tech details of new generation MEMS gas sensor - wafer level and package level MEMS gas sensor, new generation MEMS gas sensor 3D packaging technology, MEMS universal platform (Wafer Level) , IC integration, New MEMS IR sensor – future development direction thermal- conduct electro chemical metal oxide IR sensor size sensitivity high, low power consumption lifetime new IR MEMS sensor price. Multi-gas detection on a single-chip various sensors RH, temperature, humidity… Broad-band tunable filter, switch, MMI … light source: LED, laser chip, black- body, SLED… detector: Thermopile, PD. CO2, CO, NO2, CH4, Hydrocarbons, VOCs… high sensitive sensing block technology MEMS + Photonic => New MEMS IR gas sensor (wafer level).

V. WORKING PRINCIPLE OF NEW MEMS IR GAS SENSOR

Gas sample Si3N4 .LED generate the IR. The feature size and power will be reduced down significantly. IR ray can be tuneable as the range of wavelength to detect the target gases. IR ray has less loss by waveguide design and will be propagation by absorbing the target gas. The photo detector sensitive materials can detect the spectrum of evanescent wave on feedback of dark current. The current signal will be converted into digital that to be transmitted for system.

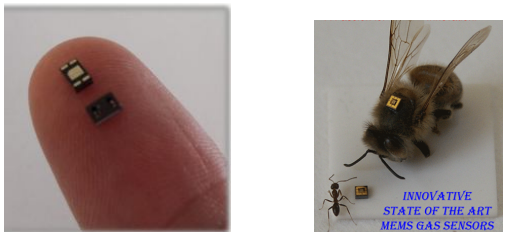

Figure 3. New generation MEMS gas sensor

System on chip design with new MEMS IR gas sensor separate sensors with system (CMOS) One chip integrated with humidity, temperature, RF sensors & IC system. 3D advanced packaging (wafer level) on new MEMS IR gas sensor novel wafer level IR sensor packaging with hermetically sealed Si Cap wafer solder ball TSI or TGI substrate with getter layer silicon filter/lens silicon cap IR sensor wire polymeric die attach vacuum wafer level hermetic seal passive components passives terminal TO-5 and FR4

substrate silicon filter/lens metal cap IR sensor wire polymeric die attach inert/vacuum environment solder seal ring solder attach sealant conventional IR gas sensor module, cheaper cap materials (silicon), miniaturized feature size, better process-ability, lower price (wafer level packaging) reliability increased(by hermetic vacuum seal) packaging as back end technology is to make all chips including CMOS soldered on the same print board assembly which works for devices. Figure 3 shows new generation MEMS gas sensor.

VI. ADVANTAGES OF NEW MEMS IR GAS SENSORS

Gas sensor size scaled down to 1mm Sensitivity is below 50PPb multi gases sensing covered from toxic gases, combustion gases, even VOC. Price will be dropped down to 10 dollars in next several years.

VII. FUTURE POSSIBILITIES & CHALLENGES IN GAS SENSOR

Nano-scopic devices of less than 100nm (NEMS), new material (e.g. Graphene, CNTs, etc.) smaller size, special configuration requirements (e.g. crucial environmental conditions, military applications, etc), Integration with IoT customized design. smaller size - from MEMS to NEMS, nanoelectromechanical systems (NEMS) is aimed to scale down sensor size to below 100nm level. An advantage to integrate with CMOS which is less than 15nm and compatible with existing CMOS line for mass production in the future. Graphene is a single or few atomic layer(s) of carbon, possessing exotic properties such as ultra-high carrier mobility, high thermal conductivity, ultrahigh stiffness and strength. New material - graphene graphene reduces the baseline stabilization time to a few seconds, greatly reduces cross-sensitivity and enhances selectivity of gases. Enables ultra-low power consumption for portable handheld devices, reduce the size. special configuration requirements, gas detection under crucial environment, deep sea gas sensing, outer space application , integration with IoT, industry automation with gas sensing, smart building gas sensing customized design, immature material technology, high R&D cost, lack in manufacturing technology, lack in back-compatibility, unwillingness to switch potential challenges.

VIII. CONCLUSION

New generation MEMS gas sensor with following improvements: smaller size, lower cost, faster response, better sensitivity, longer life time, new materials such as graphene and customized design will be available to be integrated with MEMS gas sensor in the future. New generation MEMS gas sensor technology enables wider opportunities and application in various industries.

REFERENCES

[1] http://www.slideshare.net/Funk98/mems- gas-sensor-and-their-new-applications

[2] Chia-Jung Lu, William H. Steinecker,Wei- Cheng Tian,Michael C. Oborny, “First- generation hybrid MEMS gas chromatograph” Lab Chip., (2005)

[3] Jian Zhen Ou, C.K.Yao Asaf Rotbart Jane G. Muir Peter R. Gibson Kourosh Kalantar-Zadeh "Human intestinal gas measurement systems: in vitro fermentation and gas capsules" Trends in Biotechnology., Volume 33, Issue 4, April 2015, Pages 208-213 (2015)

[4] G Velasco and J -P Schnell "Gas sensors and their applications in the automotive industry" Journal of Physics E: Scientific Instruments., Volume 16

[5] Xiao Liu 1, Sitian Cheng 1, Hong Liu 1, Sha Hu 1, Daqiang Zhang 2 and Huansheng Ning“A Survey on Gas Sensing Technology" Sensors., 2012, 12(7), 9635-9665; (2012)