



Siargo Ltd.

# Digitize our perception

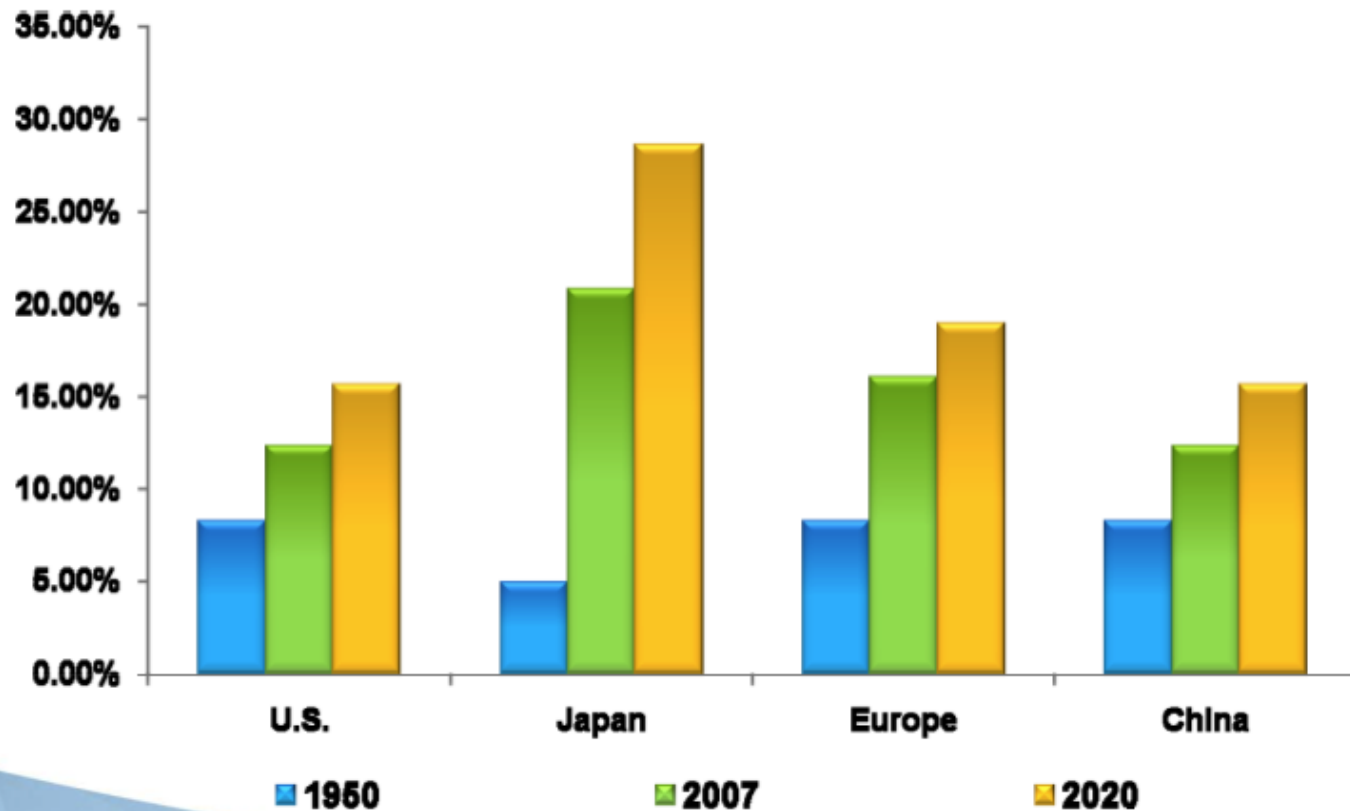
- Current applications and forward looking

January 20, 2015



# The demands

## Aging Population % of Population Over Age 65

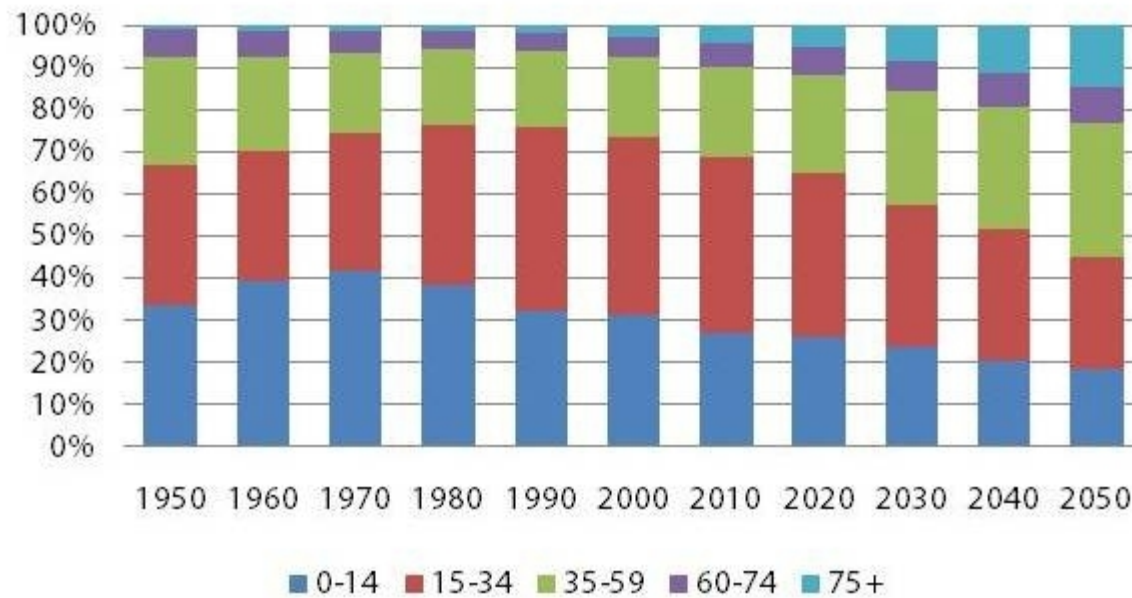


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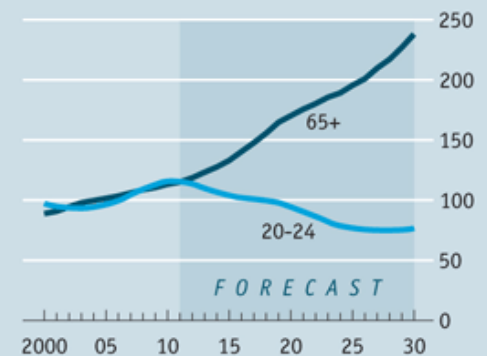
# The demands: China

### China's Shifting Population Structure



### The burden of ageing

China's population by age group, m



Source: The Brookings Institution

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## The demands

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### By 2020, age 65+

- over 170M in China
- over 30M in US
- over 40M in Japan
- over 120M in Europe
- => even with 2% have medical demands, the system may crash
- Preventive medical is the key and urgently requested



# What is preventive medical?

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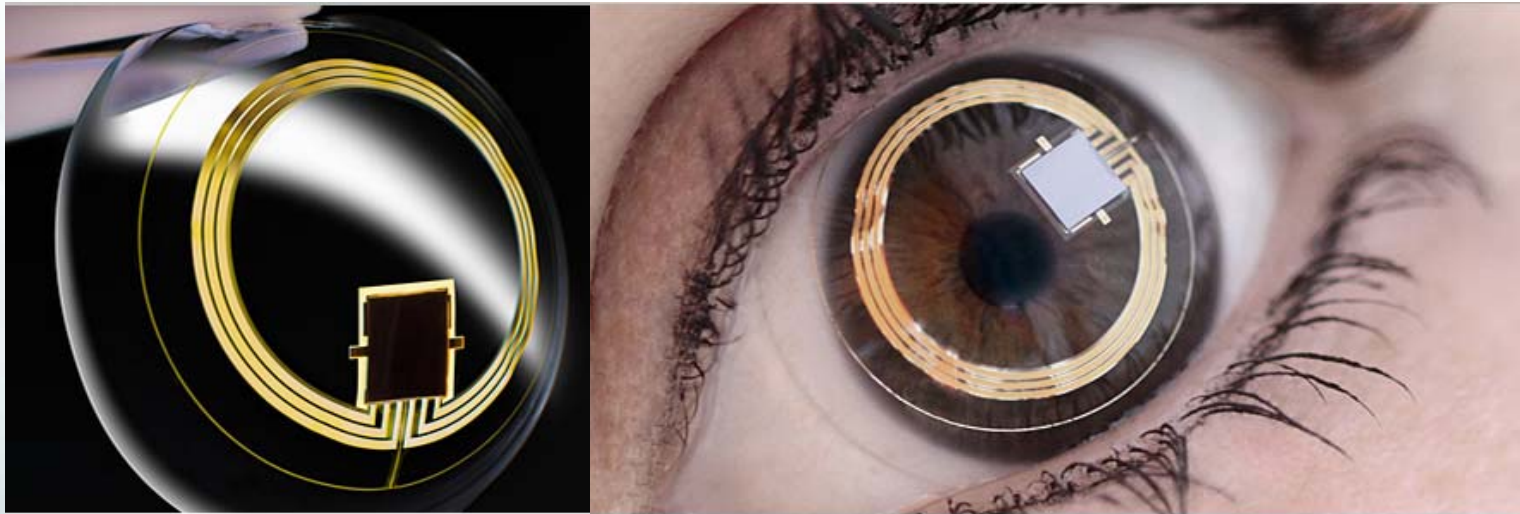
- Identify disease at its infant stage
- Noninvasive or nondestructive
- Easy to use
- Connected

=> Can MEMS provide a pathway?



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## Current examples – MEMS pressure sensor for glaucoma



A disposable contact lens with a MEMS strain-gage pressure sensor element, an embedded loop antenna (golden rings), and an ASIC microprocessor (2mmx2mm chip). Measure corneal curvature changes in response to IOP.

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# Current examples

## - smart pill: micro-endoscope

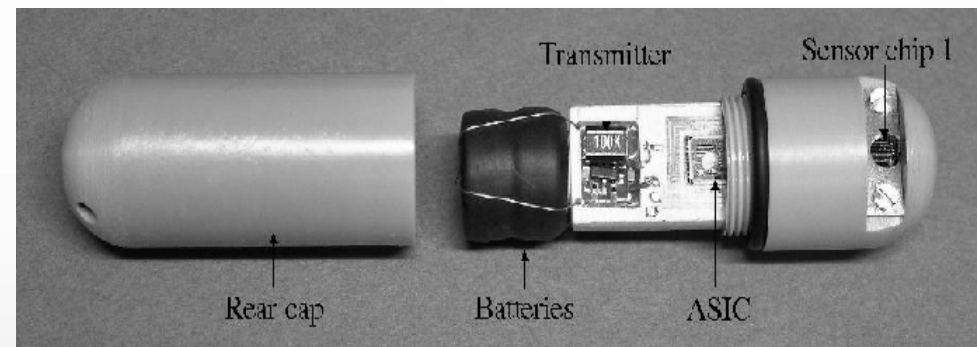


### Components of lab on a pill

- Digital camera (CMOS Technology)
- Light source
- Battery
- Radio transmitter
- MEMS Sensors



Source: Given Imaging



- ✓ Requires no sedation
- ✓ Can show a view of the entire small intestine
- ✓ Can aid in early detection of colon cancer

35mm

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# Current examples – smart patch for diabetes care

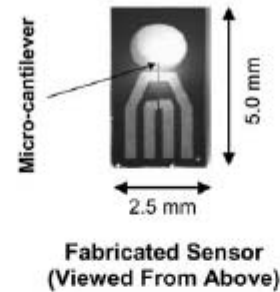
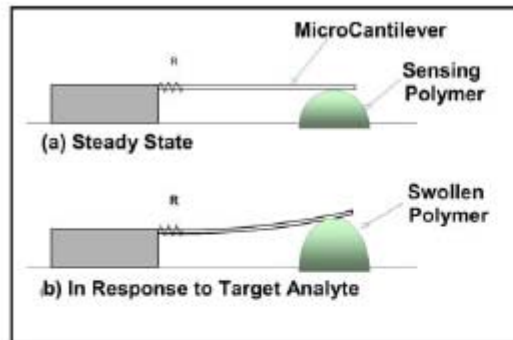


based on a MEMS integrated and ultra-precise disposable pump-chip technology, offering unmet safety and accuracy levels.

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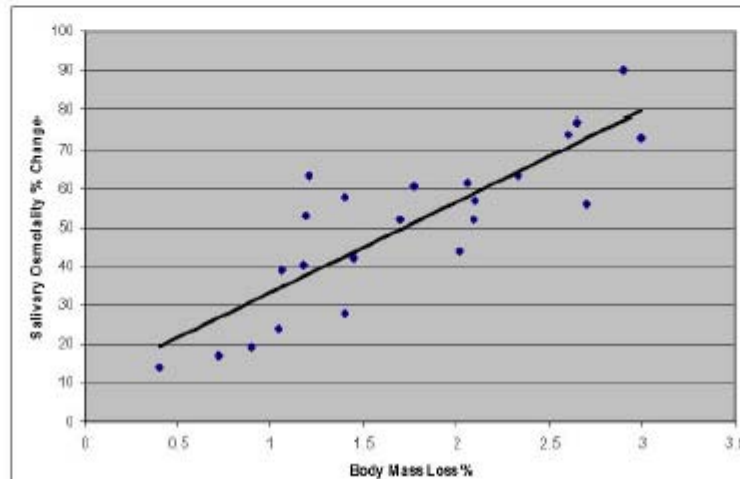


# Current examples – body dehydration monitor



Disposable sensor and reader for home or lab use

Principle of Operation (Side View)



Source: Cantimer, Menlo Park, CA

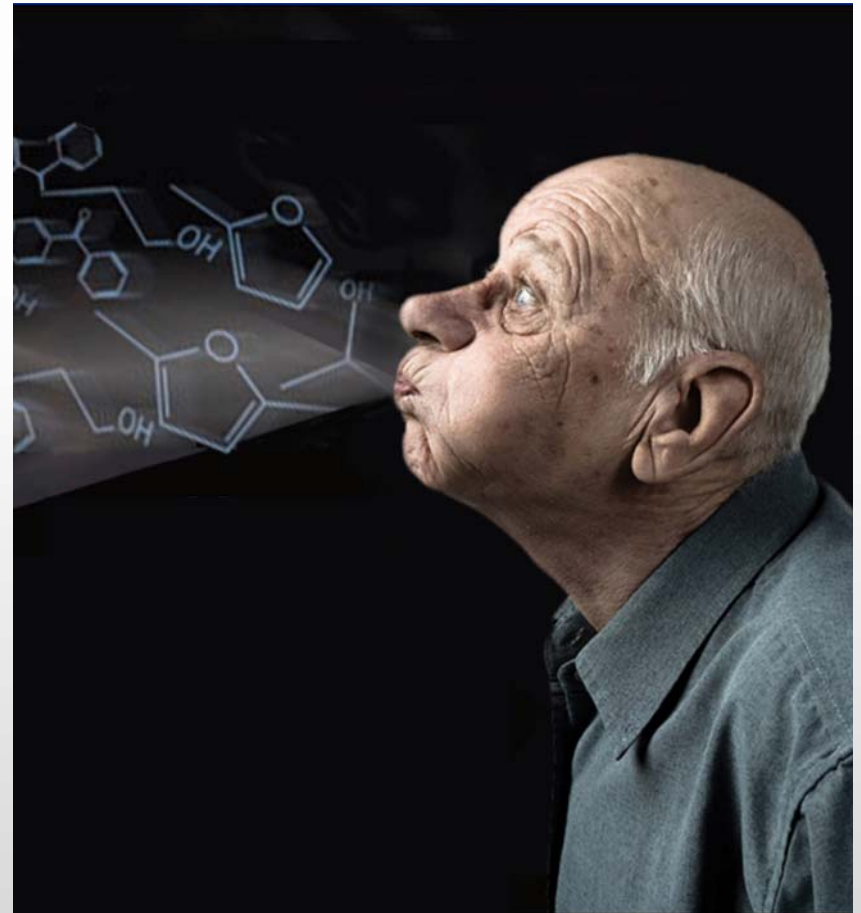
Body dehydration status monitor

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# Respiratory: challenges to digitize



- Research has identified that the following diseases can be traced in respiratory
- Stomach cancer
- Lung cancer
- Intestine cancer
- and others



# Respiratory: challenges to digitize



- Breath is an excellent sample for non-invasive diagnostics.
  - Dogs are trained to detect medical problems, such as low sugar level in diabetics or cancer, due to their extreme smell sensitivity.
- What can be smelled with chemical sensors:
  - Cancer
  - Cholesterol
  - Asthma
  - Lipid peroxidation
  - Metabolism
  - Neonatal jaundice, intestinal distress
  - Cystic fibrosis/bronchitis
  - Periodontal disease
  - Infectious disease (flu)
  - Etc.



Source: Dr. J. Stetter, SRI

# Respiratory: challenges to digitize

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**Over 300 compounds**

**Trace Concentrations**

**Sampling Issues**

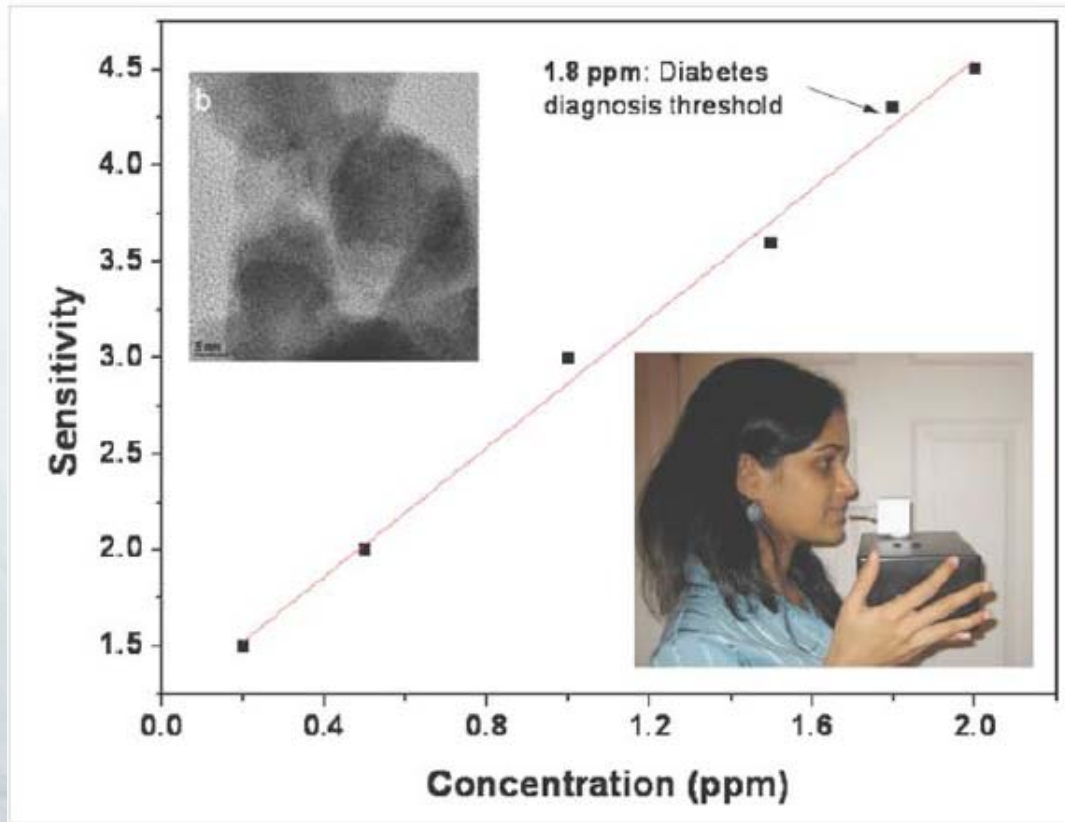
# Respiratory: challenges to digitize



Biomarkers	Physiological origin	Related diseases	Physiological ranges in human breath
Ethane	Lipid peroxidation	Oxidative stress	1-11 ppb
Pentane	Lipid peroxidation	Oxidative stress	Less than ethane
Isoprene	Cholesterol biosynthesis	Cholesterol metabolic disorder	55-121 ppb; 12-580 ppb;
Acetone	Decarboxylation of acetoacetate and acetyl-CoA	Diabetes mellitus, ketonemia	293-870 ppb; 1.2-1880 ppb
Ethanol	Alcohol ingestion	Alcohol poisoning	27-153 ppb; 13-1000 ppb
Methanol	Degradation of natural pectin from plants; ingestion	Methanol intoxication	160-2000 ppb
NH <sub>3</sub>	Metabolic product of amino acid deamination	Uremia, kidney impairment	422-2389 ppb; 200-1750 ppb
CO	Inhalation from Incomplete burning of carbon containing fuels, e.g. smoking	Lung diseases	<6 ppm
NO	L-arginine oxidation	Asthma, lung diseases	1-9 ppb, lower respiratory; 0.2-1 ppm upper respiratory; 1-30 ppm, nasal level.

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# Respiratory: challenges to digitize



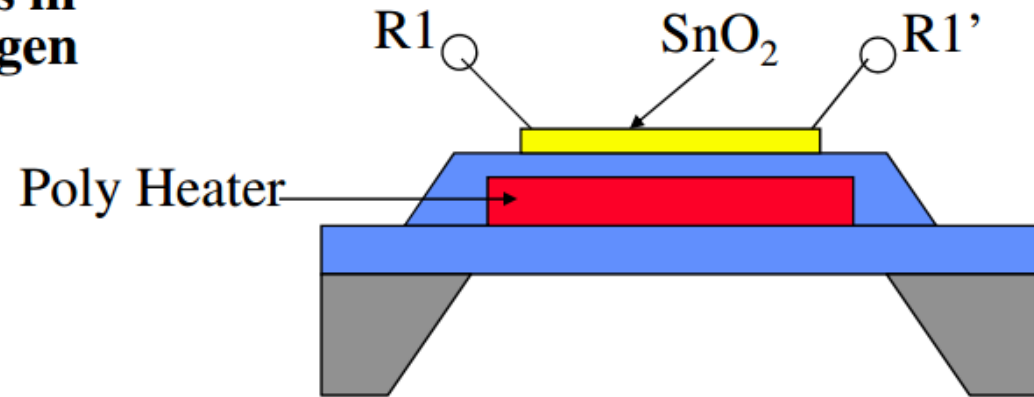
MEMS metal oxide gas sensor enables the sensitivity and response time

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# Respiratory: challenges to digitize



## Resistance changes in presence of Hydrogen



The metal oxide ( $\text{SnO}_2$ ,  $\text{TiO}_2$ ,  $\text{In}_2\text{O}_3$ ,  $\text{ZnO}$ ,  $\text{WO}$  etc.) will react with adsorbed ambient oxygen to form an electron trap ( $\text{O}^-$ ) on the surface **increasing** the resistance  $R1-R1'$ . When combustible gases are present ( $\text{H}_2$  for example) the hydrogen reacts at the surface to reverse the effect of the adsorbed oxygen **reducing** the resistance. The heater keeps the film at a fixed but elevated temperature ( $250\text{ }^\circ\text{C}$ )

# Challenges for digitization

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- **Packaging, packaging, packaging**
  - MEMS chip often needs ASIC
  - Electrical interconnect
  - Mechanical stress management
  - Small form factor
  - Hermeticity (for both MEMS function and biocompatibility)
- **Sterilization**
  - Gamma, e-beam (damaging to electronics and some plastics)
  - Ethylene oxide (can be absorbed by plastics)
  - Steam 121-134C (creates problems with material CTE mismatch, glass transition temperature)





# Summary

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- The huge market demands speed up the development of MEMS sensors for digital medical applications
- Gas sensors will be a new fighting grounds for the market, and many players already jump started
- Eliminating of the cross-talking and increase of the accuracy and sensitivity will be the key to success