# Electronic-Nose system for breath analysis using chemical sensors array

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# Introduction


**Breath** Many acetone, isoprene, VOCs, and so from lung …

**Sweat** different bacterial or fungal infections

**Blood** Most VOCs from secreted cells

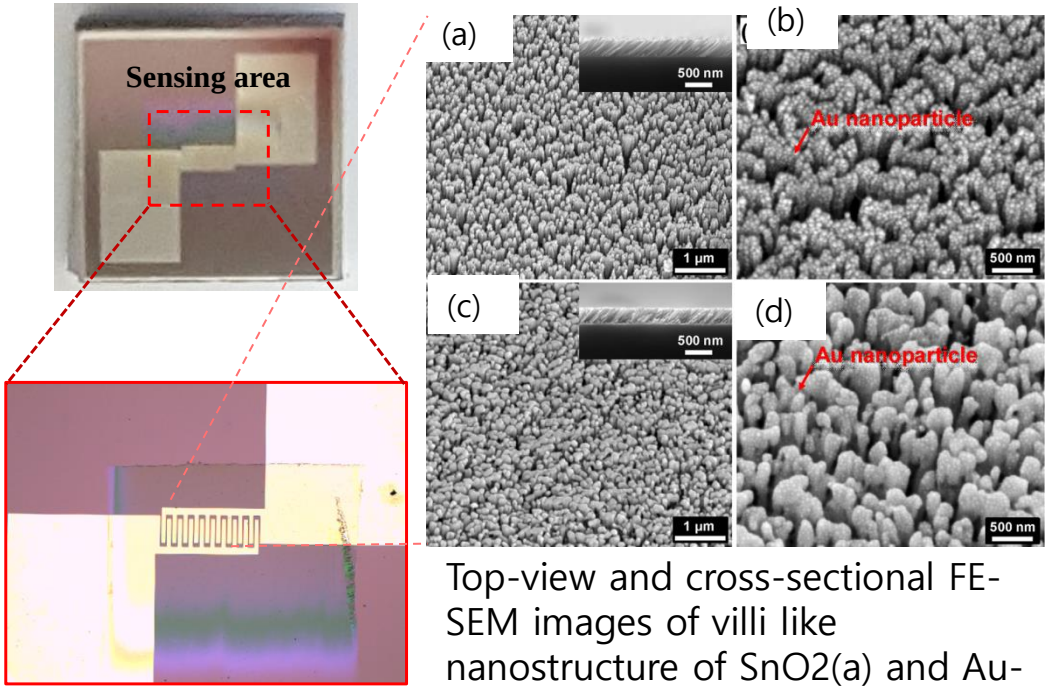
**Urine** Diabetics: acetone or ketones
Cancer: significant change in urine VOCs

# What are medical gas sensors for ?

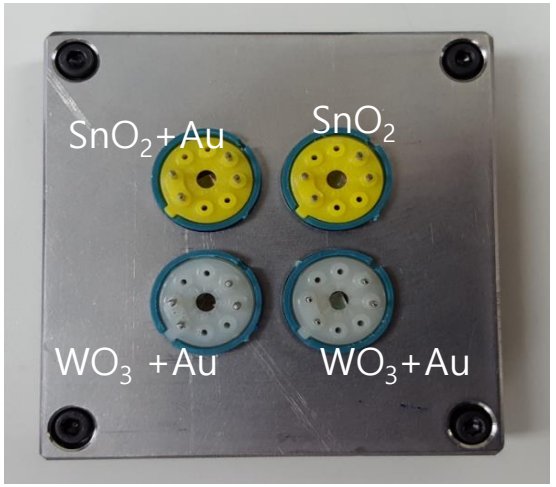
- Gases that become the markers of disease are very low concentration of ppb ~ several hundreds ppb.
- It is difficult to analyze the relationship of gases because there are hundreds of gases mixtures.

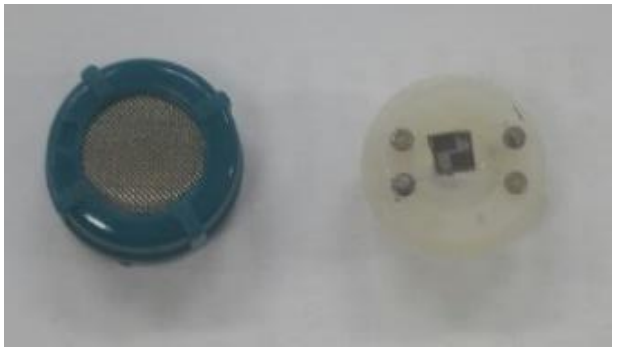
- **Proposed Method**
  - High sensitivity sensor
    ➔ **Nano materials with enhanced sensing area**
  - Improve selectivity
    ➔ Various sensor materials and catalyst
    ➔ Optimal sensors array configuration for disease marker
  - A **method for concentration** and supply of **disease marker gas** for exhalation.

# Sensor Array Configuration




Top-view and cross-sectional FE-SEM images of villi like nanostructure of SnO2(a) and Au-functionalized VLNS(b), VLNs of WO3(c) and Au-functionalized VLNW(d)
Source: Sensors and Actuators B 257 (2018) 295–302



**Provide by KIST**

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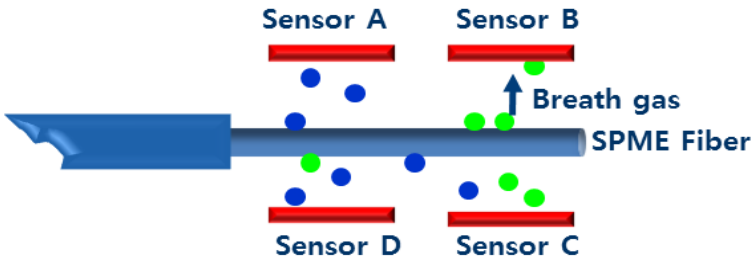
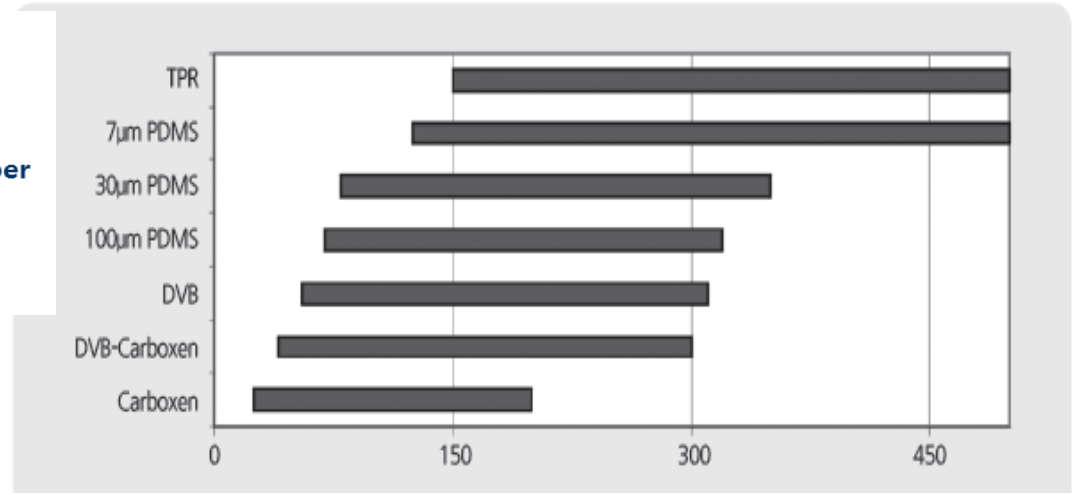
# Concentration of exhaled gas

## SPME fiber



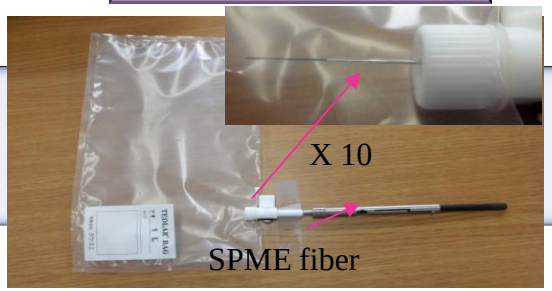




| | | |
|---|---|---|
| 7μm | PDMS | Nonpolar volatile sample MW125~600 Larger molecular weight |
| 30μm | PDMS | Nonpolar volatile sample MW85~600 Larger molecular weight |
| 100μm | PDMS | Nonpolar volatile sample MW60~275 lower molecular weight |
| 85μm | Polyacrylate | Polarity volatile sample MW 80~300 |
| 65μm | PDMS/DVB | Bipolar volatile sample, Amine Alcohol MW 80~300 |
| 65μm | Carboxen/DVB | Polarity sample, Alcohol MW 40~275 |

# Process of exhaled breath measurement

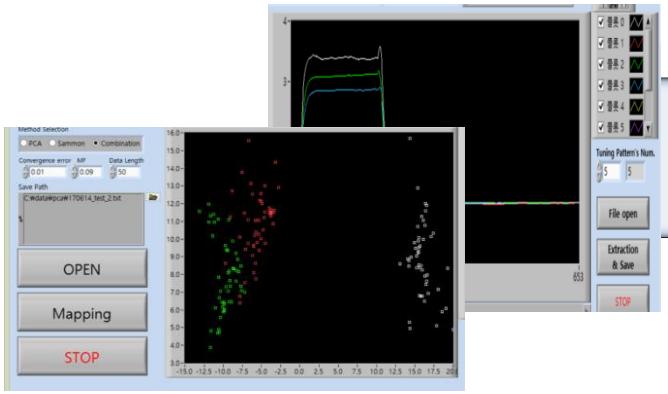
**Breath collection**

**Sampling by SPME**

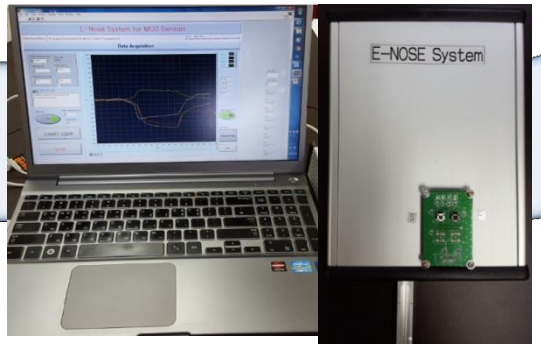



**Breath Delivery**

**Analysis**




**Breath Test**

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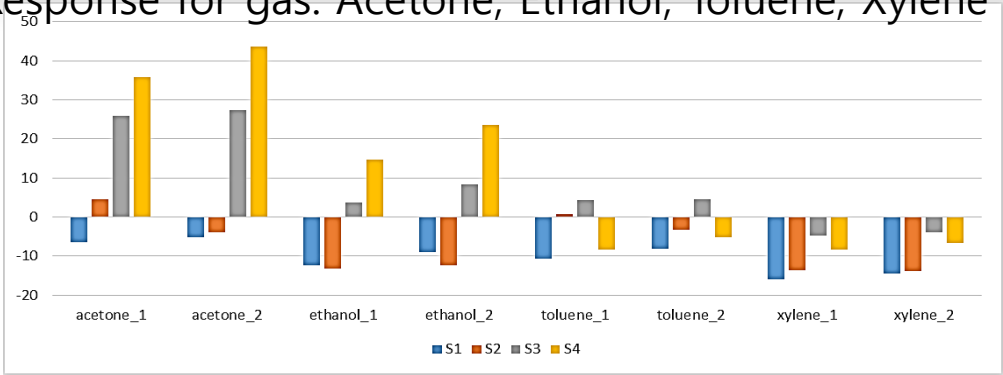
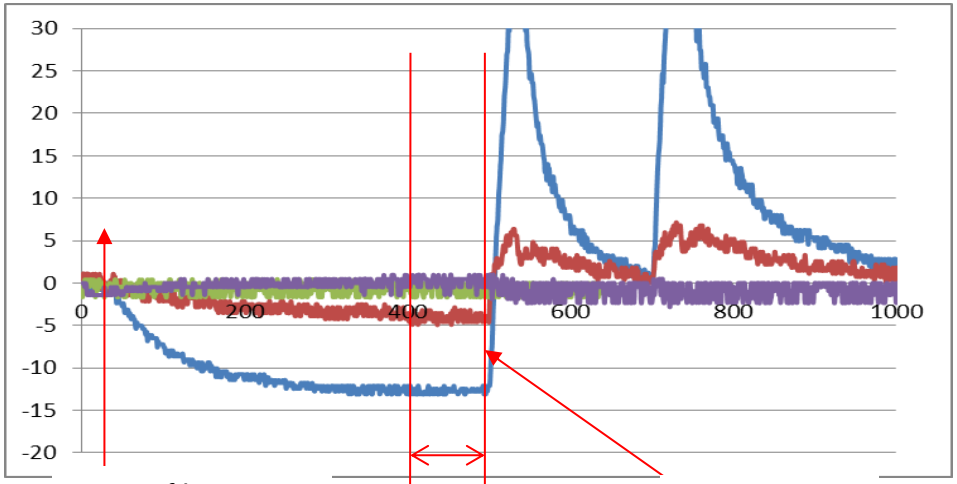
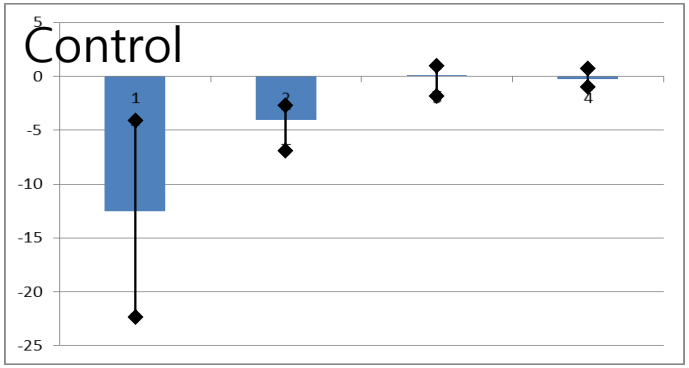
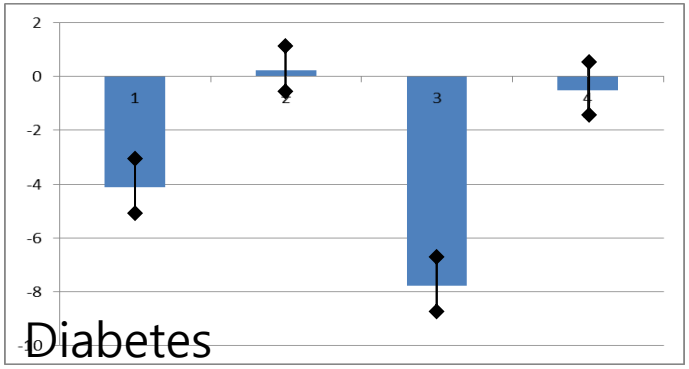
# Result of exhaled breath

Response for gas: Acetone, Ethanol, Toluene, Xylene




Control : 20 person
Diabetes: 18 person
*Patient and control group were diagnosed as diabetes and healthy person by doctor 's diagnosis.*

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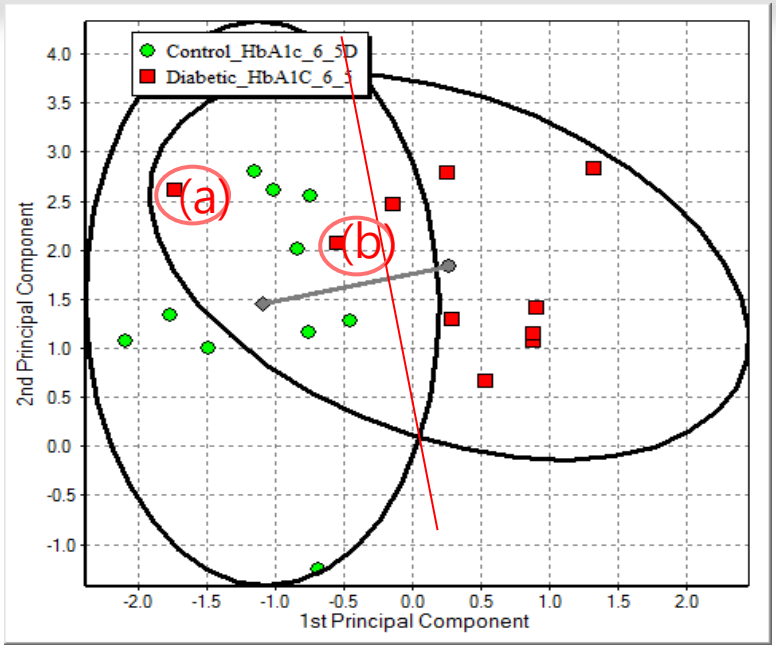
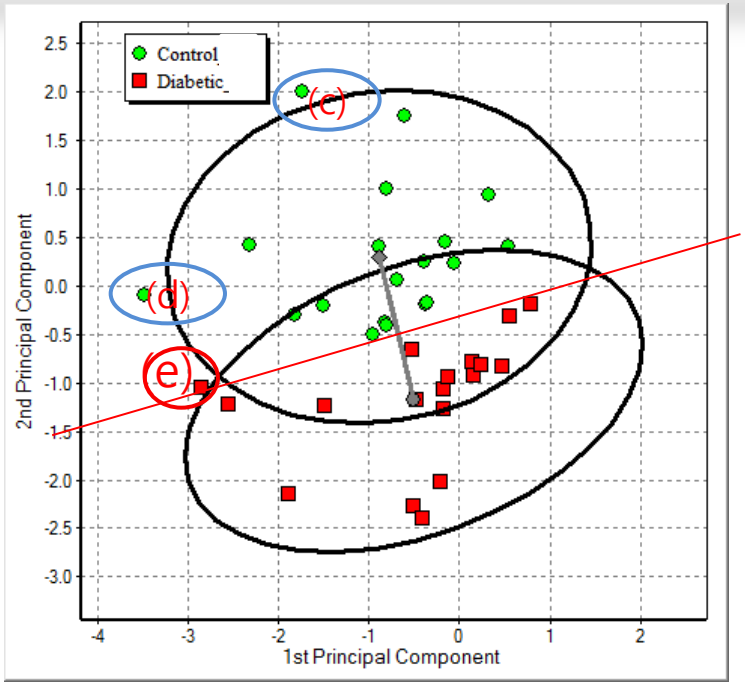
# Result of PCA




- PCA results of normal subjects less than 6.5% and diabetic patients with HbA1C greater than 6.5%

  (a): HbA1C : 8.2%, Glucose: **112**mg/dl
  (b): HbA1C : 7.2%, Glucose: 151mg/dl




- PCA results of normal and diabetic patients

  (c): HbA1C : 5.3%, Glucose: 97mg/dl
  (d): HbA1C : 4.9%, Glucose: 87mg/dl
  (e): HbA1C : 6.1%, Glucose: 108mg/dl

# Summary

1. We implemented an e-nose system for measuring exhalation gas using nanostructured $SnO_2$ and $WO_3$ sensors and sensors made by adding catalysts. The breath of the healthy person and the diabetic patient was collected with a tedlar bag, adsorbed on the SPME fiber, and the exhalation gas was supplied to the e-nose system and analyze.
    a. Since HbA1C was diagnosed as diabetic when it was 6.5% or more, PCA analysis of breathing of diabetic patients with 6.5% or more and healthy person below 6.4% was successful. However, separation of the two was difficult. One of the subjects was low in glucose and the other was presumed to be the cause of the drug, but the exact cause of the disease was unknown.
    b. The total number of patients was 18 in healthy 20 patients, and all of them were generally well performed by PCA analysis. However, the patient group and the normal group are scattered
2. Additional studies for diabetes monitoring
    a. Development of a simple mechanism or method for supplying expiring gas to the sensors
    b. Analysis of exact exhalation markers for diseases