ELECTRONIC NOSE

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Outline

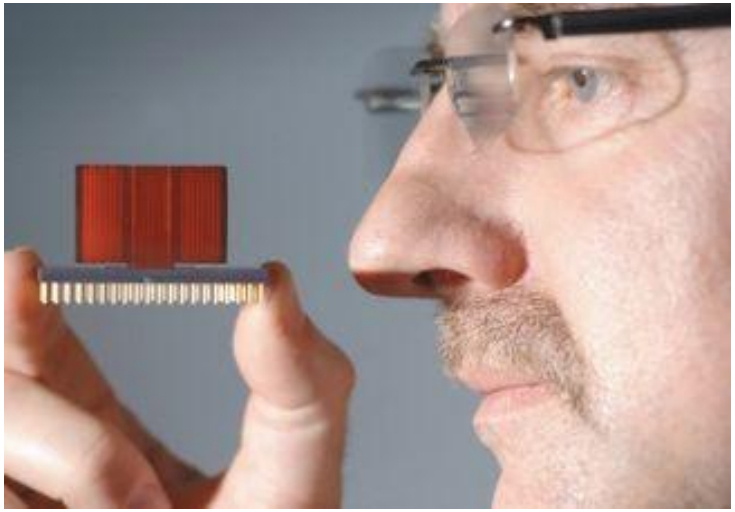
- Introduction
- Human nose
  - Smell in humans
- Why Electronic Nose?
- Way of Approaches/Methods
- Application
- Problems of Technology
- Q&A
- Reference

Introduction

- In the past, humans smell for many applications.
  - Disease Diagnosis
  - Good experience
  - Recognize something
- Challenges
  - Diseases are more and complicated.
  - A little different in many smells/long term
  - Only water-soluble substance

Introduction

- Electronic nose



- Target : to mimic human nose and solve the challenges above mentioned

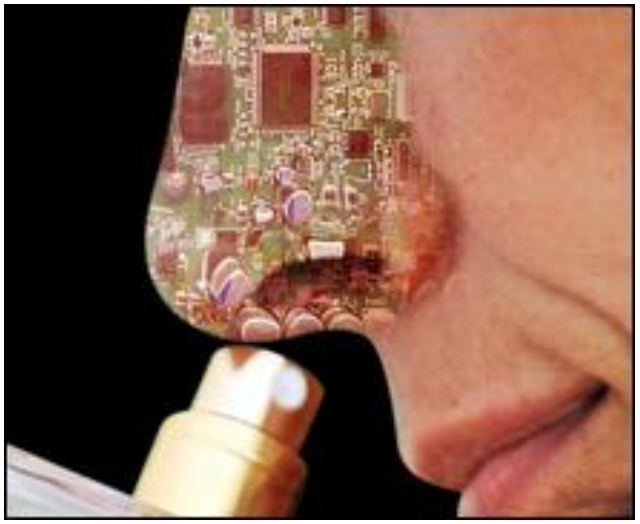
An example

- Oscar : a cat that can predict death

- How it can do that?

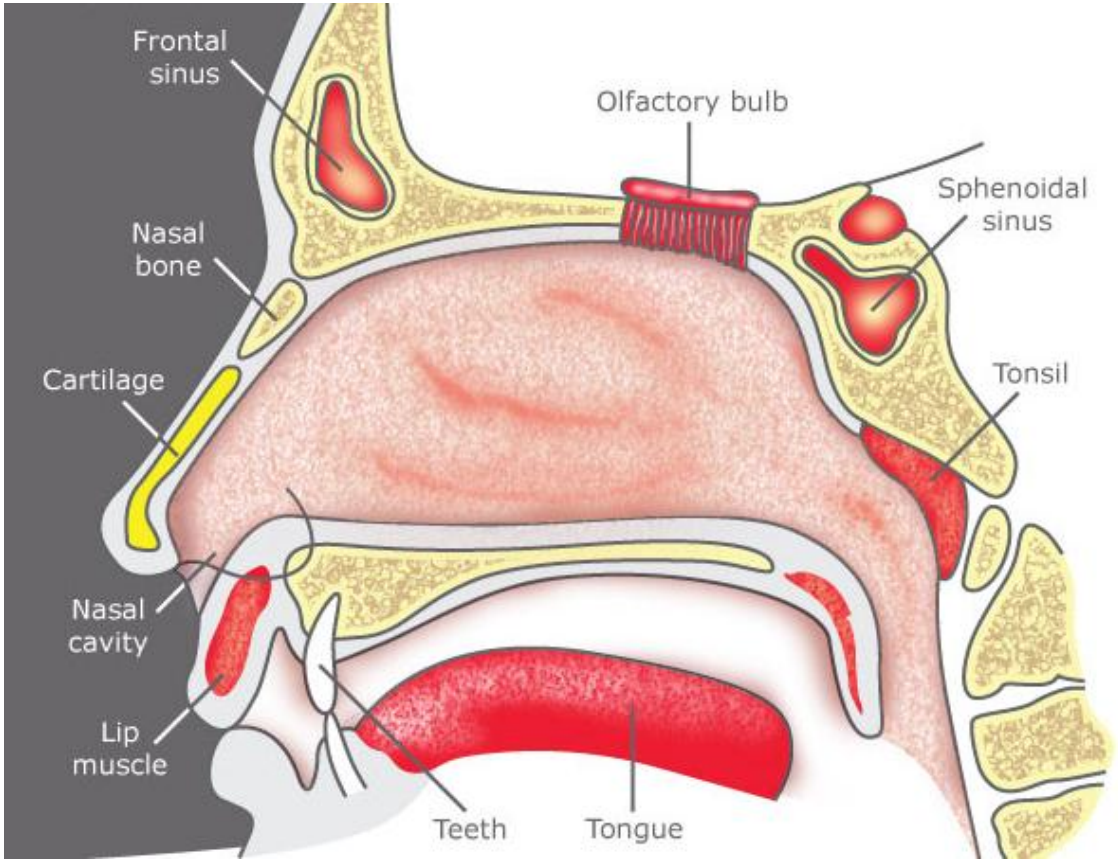
Why electronic nose?

- Fast, reliable and real time technique.
- Differences between smells become obvious.
- Selections of smells



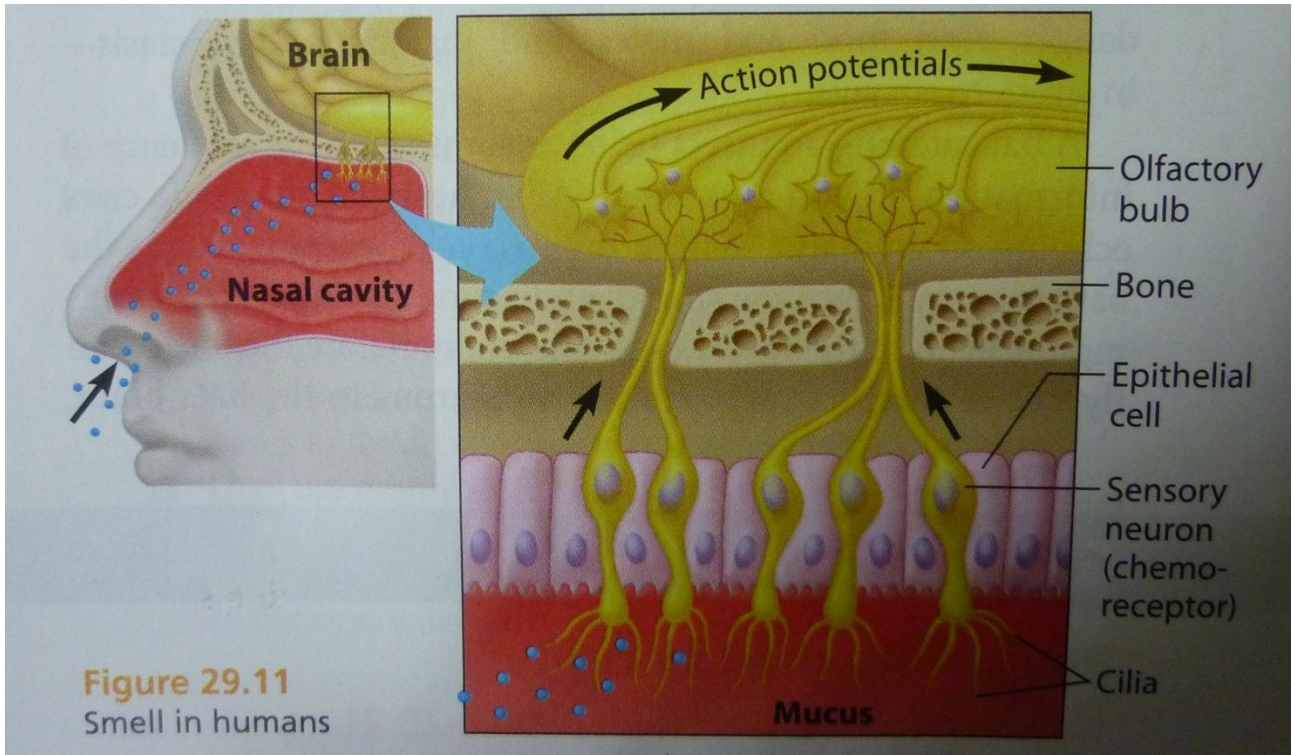
Human nose

- Simple structure



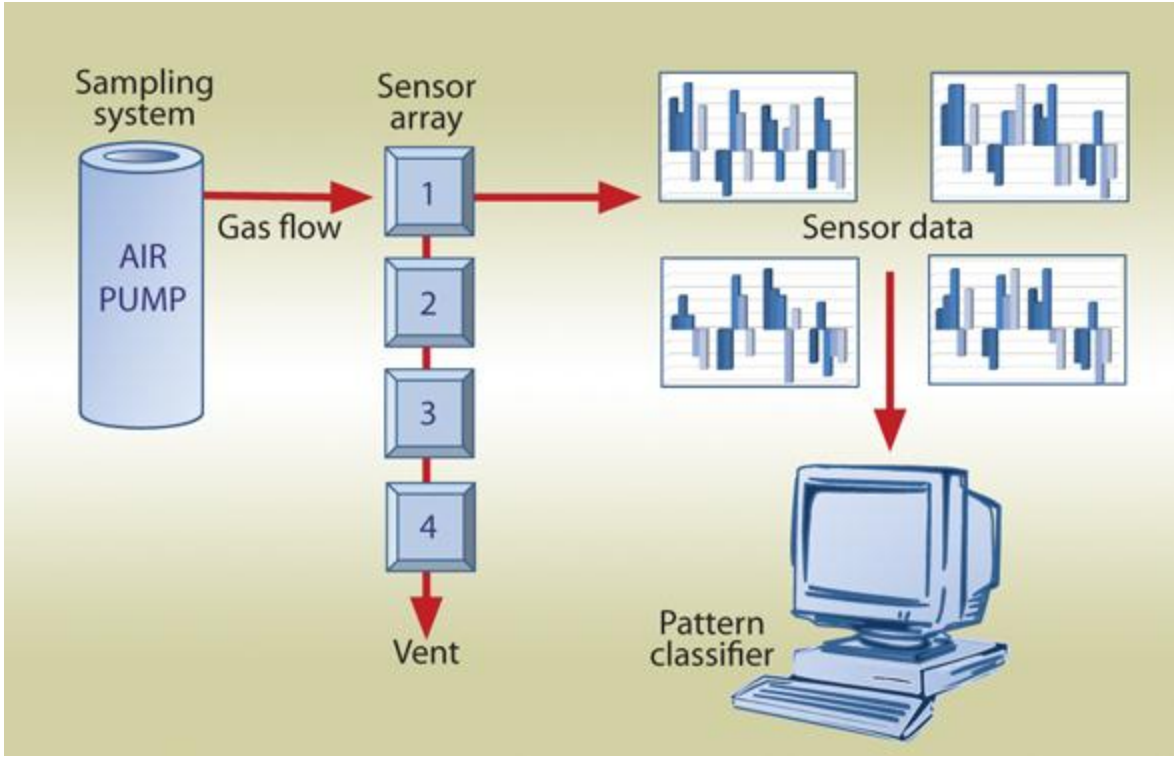
Smell in humans

- Odorous substance(water soluble) -> Cilia
- Sensory neuron(Chemoreceptor)
- Olfactory bulb -> Action potential



Three Basic Units of E-Nose

1. Sampling system
2. Sensor Array
3. Pattern Classifier



Approach & Principle

- Some Common Methods
  - Conductivity-Type
  - Piezoelectricity-Type
  - MOSFET-Type
  - Optical Fiber-Type
  - Spectrum-Type

Approach & Principle

- Conductivity-Type
  - Conducting Polymer
    - exposed to a vapor -> polymer swelling

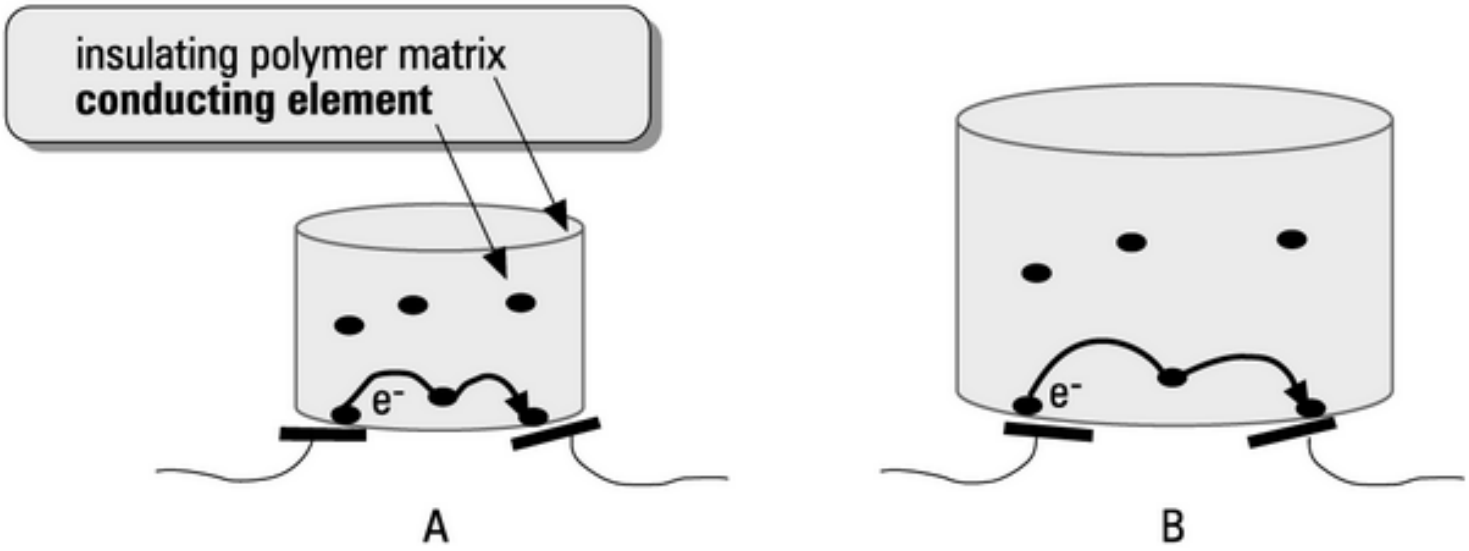
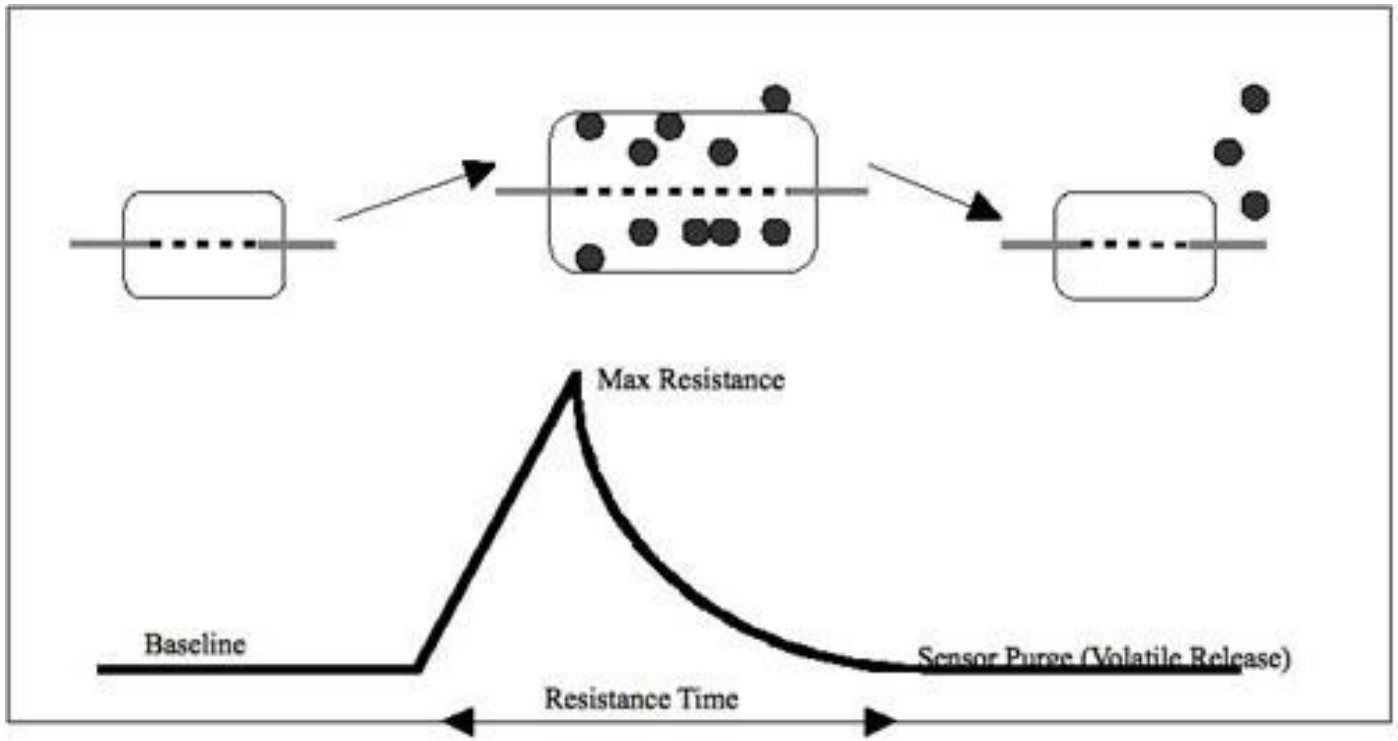


Figure 1Schematic of swelling-induced resistance change

Approach & Principle

- Conductivity-Type
  - Conducting Polymer
    - vapor increases the electrical resistance



Approach & Principle

- Conductivity-Type
  - Conducting Polymer
    - get the pattern from sensor array!

      -> vapor selective polymer makes sensor array have different patterns corresponding to the vapor!

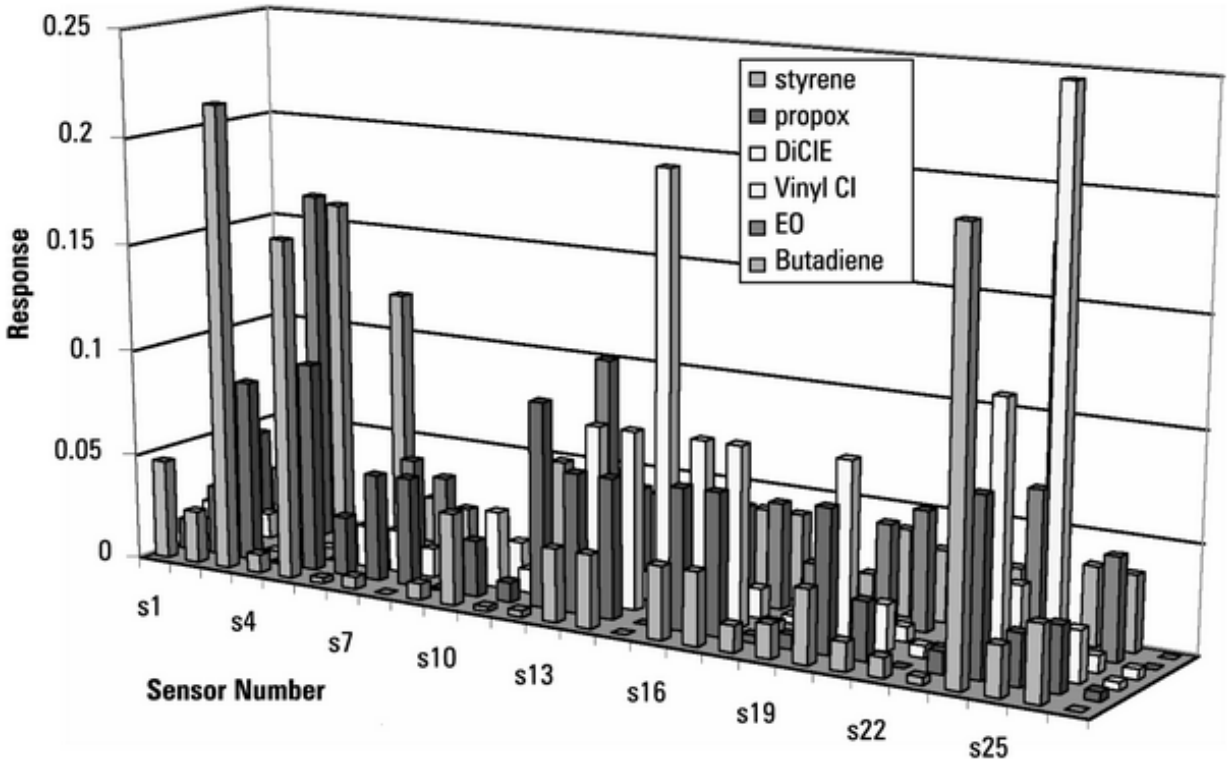
    - Clean

      -> recovery

Approach & Principle

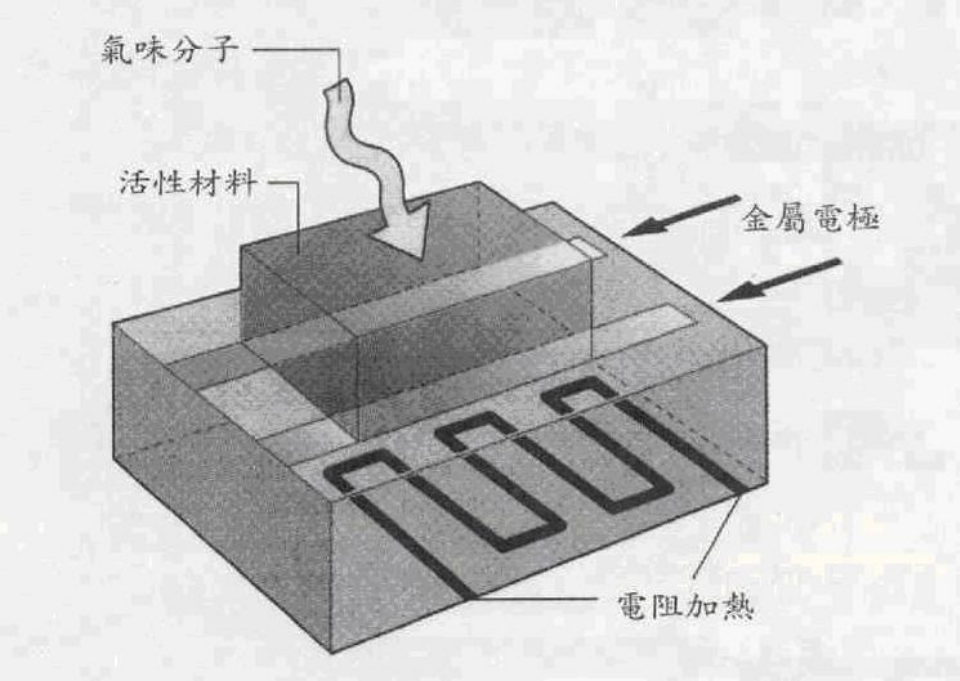
- Conductivity-Type
  - Conducting Polymer

    Pattern is like a fingerprint of the vapor



Approach & Principle

- Conductivity-Type
  - Metal Oxide
    - Principle is just like conducting polymer
    - Only work at 200~400 Celsius degree



Approach & Principle

- Conductivity-Type
  - Conducting Polymer
    - Pros:

      1) resolution higher than metal oxide (room Temp.)

      2) work in room temperature
    - Cons:

      1) hard to fabricate, cost time

      2) sensitive to humidity

      3) clean -> longer recovery time

Approach & Principle

- Conductivity-Type
  - Metal Oxide
    - Pros:

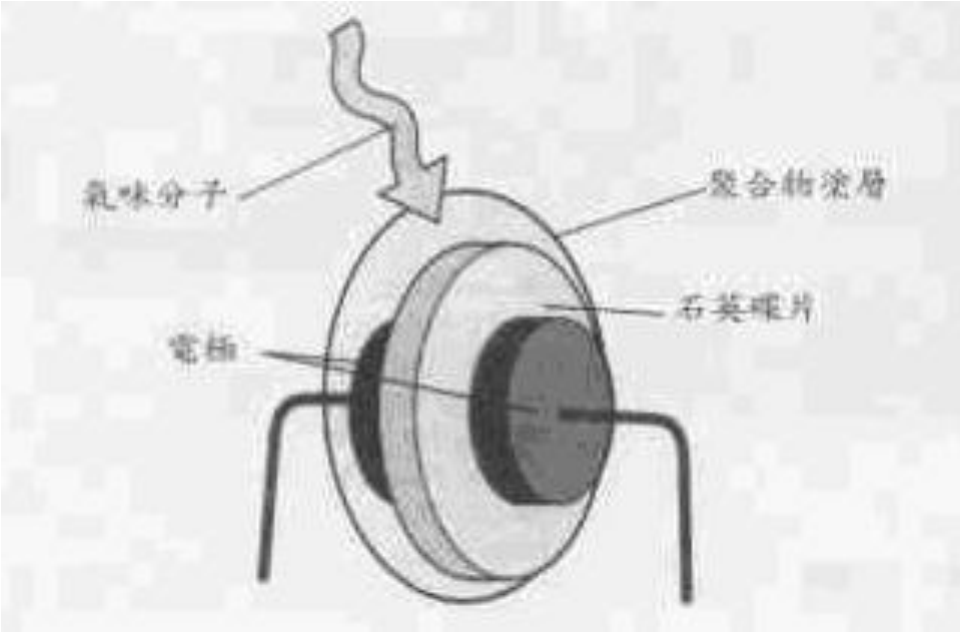
      1) wide range and mostly used

      2) lower cost (commercialized)
    - Cons:

      1) high work temperature (worse resolution)

Approach & Principle

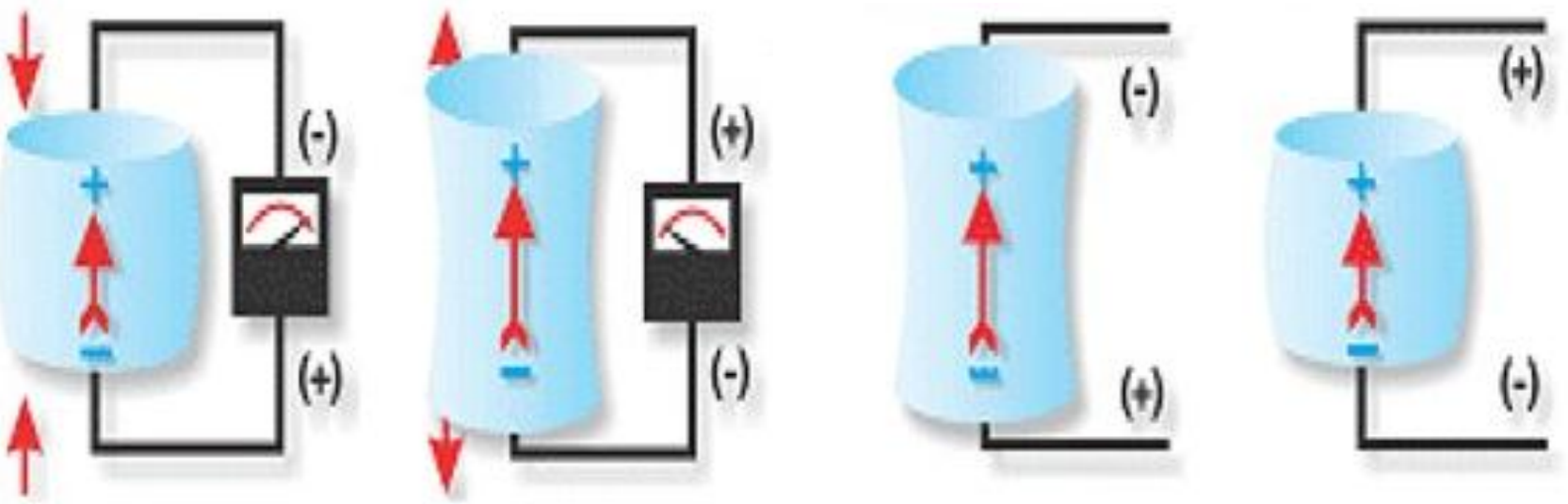
- Piezoelectricity-Type
  - Quartz Crystal Microbalance (QCM)
  - Piezoelectricity effect & Sauerbrey equation



Approach & Principle

- Piezoelectricity-Type
  - Quartz Crystal Microbalance (QCM)

Piezoelectricity effect



POSITIVE REVERSE

Approach & Principle

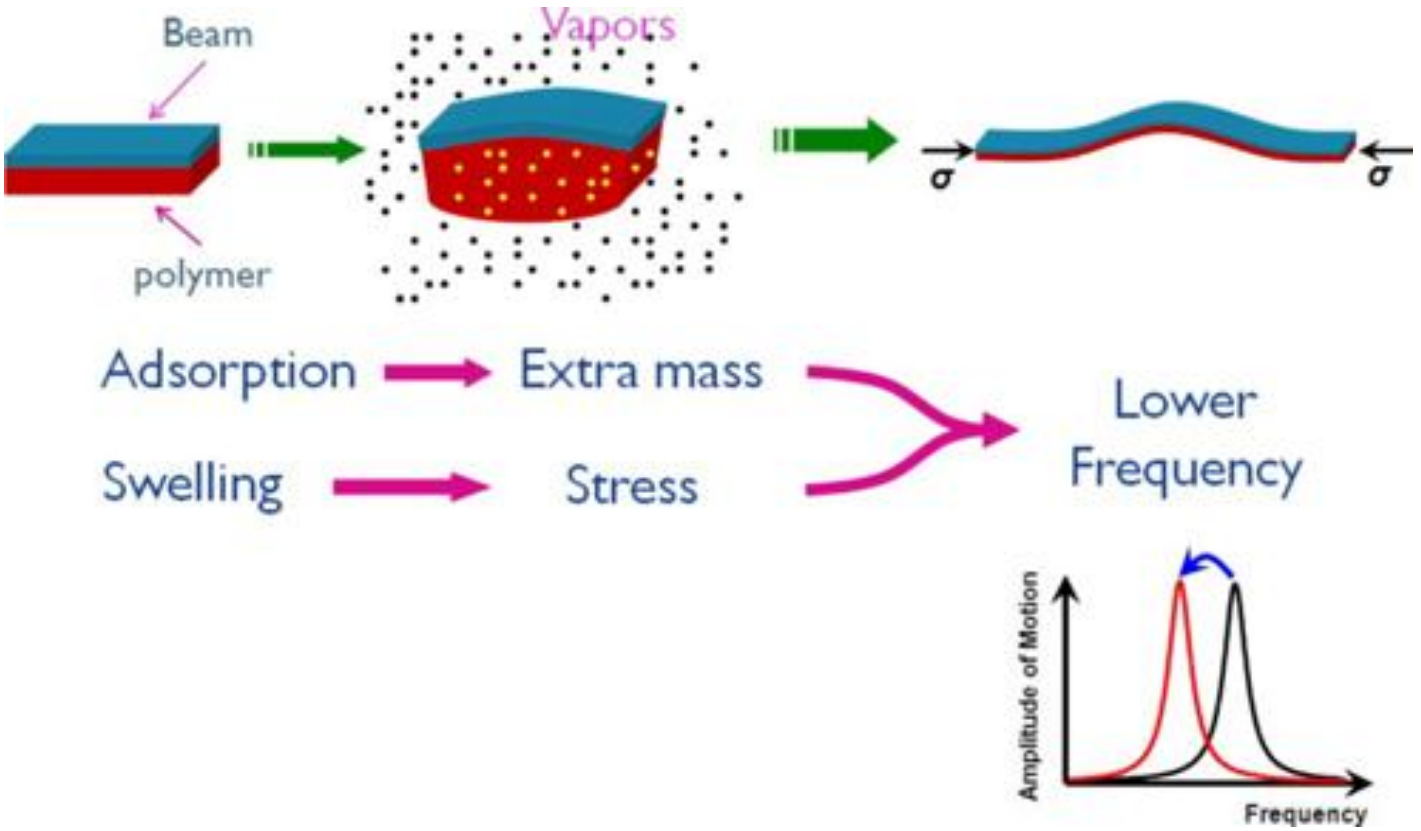
- Piezoelectricity-Type
  - Quartz Crystal Microbalance (QCM)
  - Sauerbrey equation

$$\Delta f = -\frac{2f_0^2}{A\sqrt{\rho_q \mu_q}}\Delta m$$

  - →mass deposited on the surface cause resonance frequency shift (~1kHz, 10~30MHz for quartz resonance freq.)
  - → also can calculate concentration

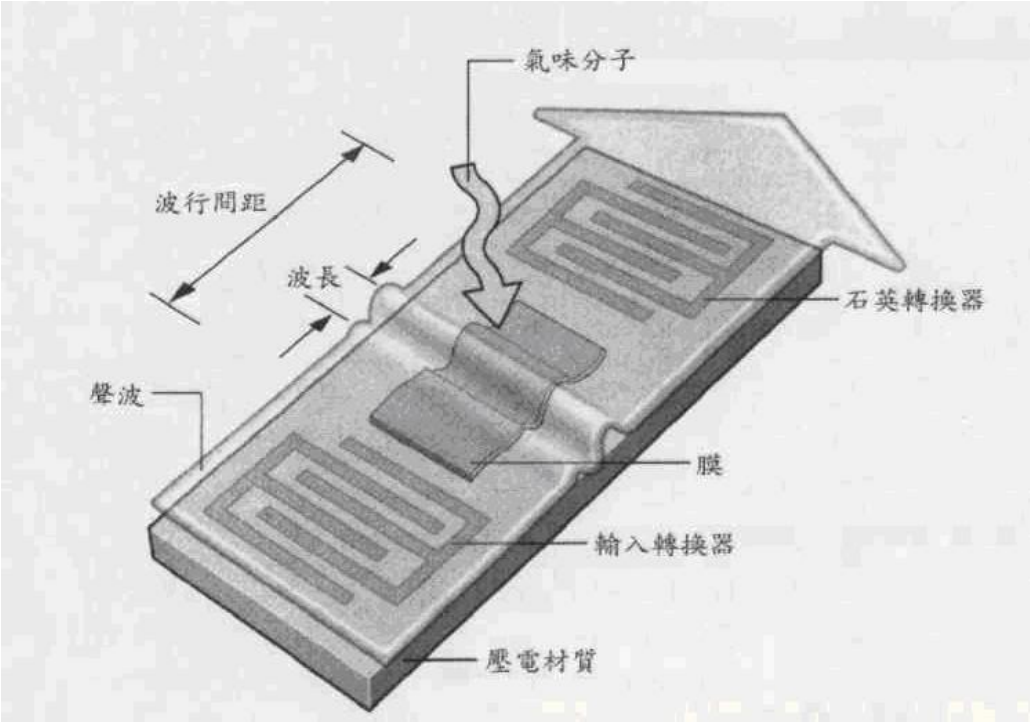
Approach & Principle

- Piezoelectricity-Type
  - Quartz Crystal Microbalance (QCM)



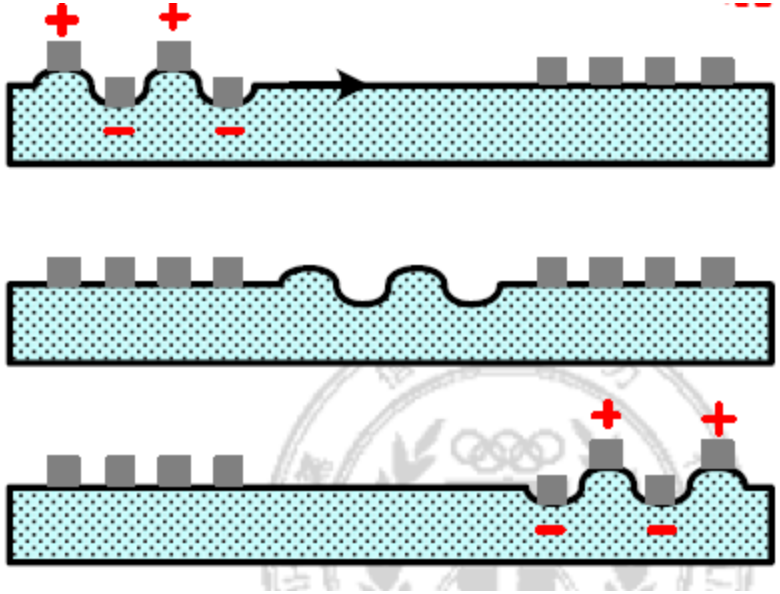
Approach & Principle

- Piezoelectricity-Type
  - Surface Acoustic Wave (SAW)
  - piezoelectricity effect & mass loading effect



Approach & Principle

- Piezoelectricity-Type
  - Surface Acoustic Wave (SAW)
  - Input transducer (reverse piezoelectricity effect)
    - ~> surface wave (Rayleigh wave)
    - ~> output transducer (pieoelectircity effect)



Approach & Principle

- Piezoelectricity-Type
  - Surface Acoustic Wave (SAW)

$$\frac{\Delta v}{v_o} = -\frac{\omega v_o \rho_s}{4}\left(\frac{v^2_{xo}}{\omega P} + \frac{v^2_{yo}}{\omega P} + \frac{v^2_{zo}}{\omega P}\right)$$

→ Wave velocity change depends on particle concentration on suface

→ calculate velocity and hence concentration

Approach & Principle

- Piezoelectricity-Type
  - Quartz Crystal Microbalance (QCM)
    - Pros:

      1)S/N ratio is higher than SAW

      2)easy to fabricate
    - Cons:

      1)narrow frequency range

      2)larger space than SAW

Approach & Principle

- Piezoelectricity-Type
  - Surface Acoustic Wave (SAW)
    - Pros:

      1)fabricate in photolithography (planet structure)

      2)cost down in bulk

      3)wider frequency range (~hundred MHz)

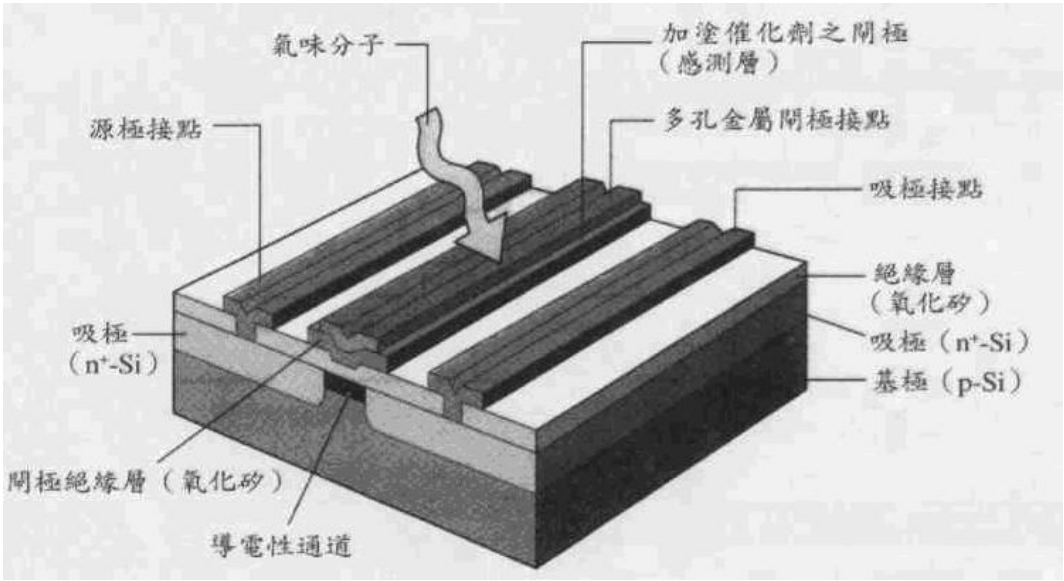
      4) sensitive due to energy concentrating near to surface
    - Cons:

      1)bad S/N ratio than QCM

      2)harder than QCM to fabricate

Approach & Principle

- 金氧半場效電晶體（MOSFET）型氣味感測裝置
  - Gate塗上一層金屬催化劑，易揮發的有機化合物受其催化而帶電
  - 於感測層上的電荷可改變V_{GS}，並對電流I_D產生影響



Approach & Principle

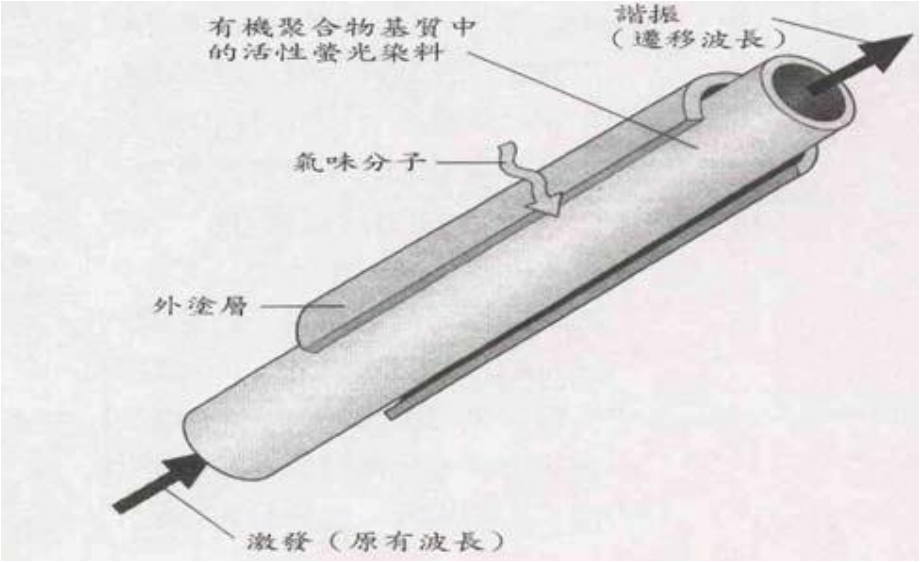
- 金氧半場效電晶體（MOSFET）型氣味感測裝置
  - 優點：1)與微電子電路相連
    2)易於大量製造
  - 缺點：1)催化反應會產生氣體生成物
    2)設計氣體進出口，結構複雜

Approach & Principle

- 光纖維感測器(Optical Fiber-Type)
  - 四周及兩端均塗有一薄層含螢光染料的化學活性材料的玻璃纖維
  - 該活性材料定置於有機聚合物的基層中，當外來的一束窄頻帶光脈衝沿玻璃纖維傳遞，螢光染料極性改變
  - 發出轉移的螢光放射譜線，從其譜線即可檢測到易揮發有機化合物的存在，並加以測定

Approach & Principle

- 光纖維感測器(Optical Fiber-Type)
  - 電子鼻光學感測器 — 由不同螢光染料混合物所組成陣列

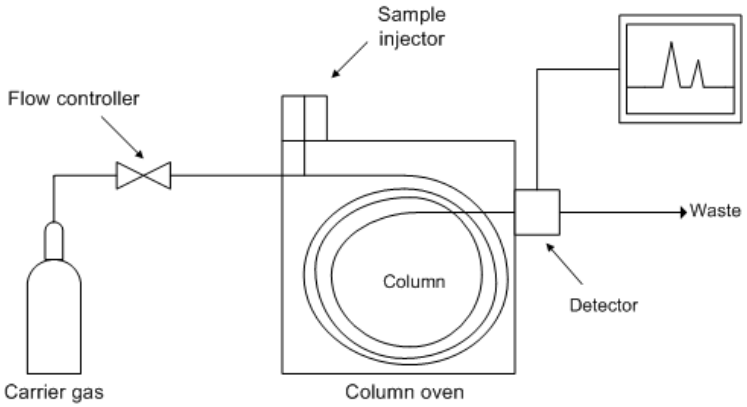


Approach & Principle

- 光纖維感測器(Optical Fiber-Type)
  - 優點：1) 便宜、容易製造、選擇性廣
    2) 螢光染料可用以識別抗體抗原的結合
    3) 感測器陣列的靈敏度高(ppb)
    4) 抗噪能力強
  - 缺點：1) 控制系統不易製造、成本較高
    2) 螢光染料壽命較短

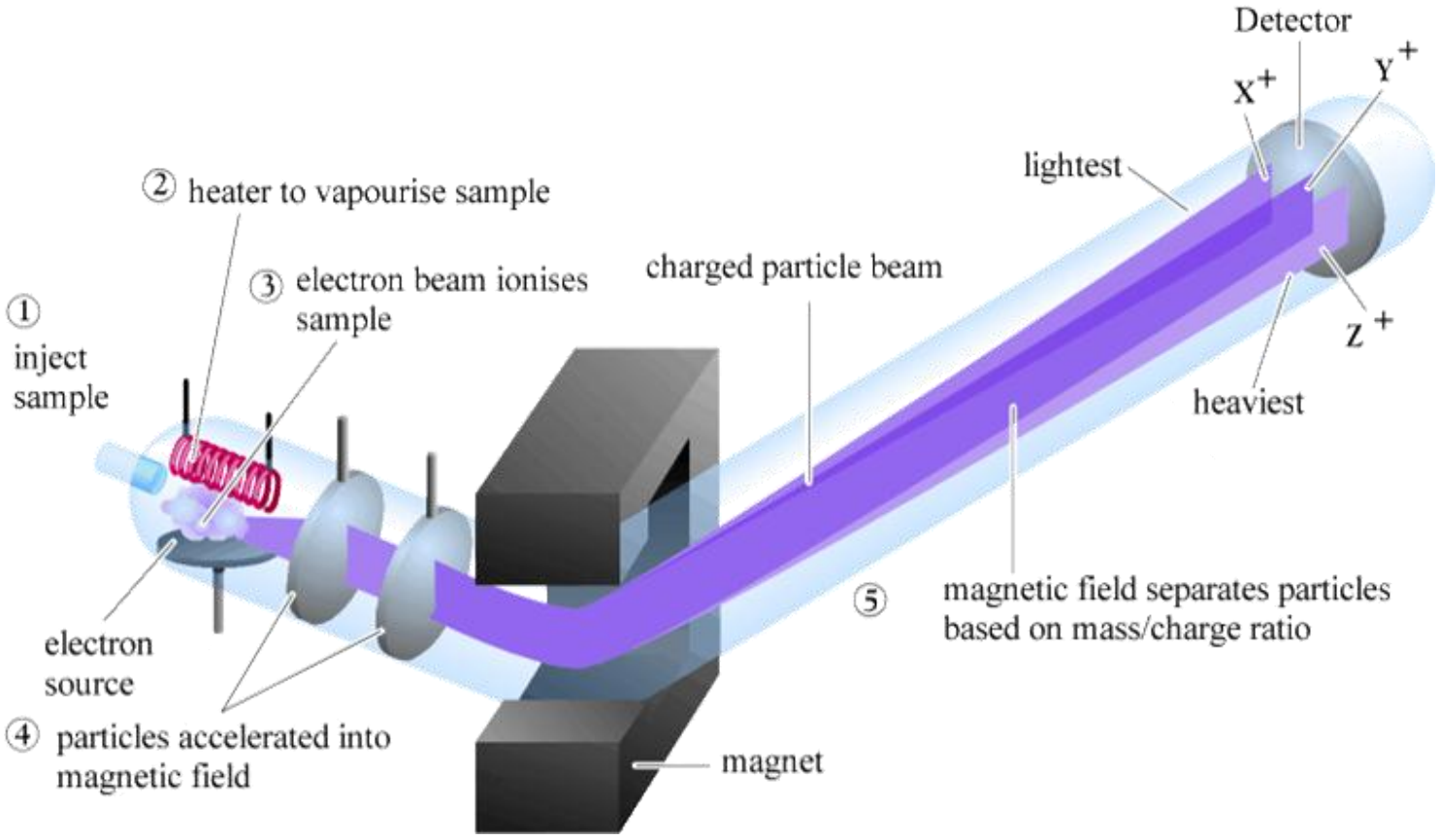
Approach & Principle

- Some other approaches of molecule determination
  - Gas chromatography
  - Mass spectrometry



Approach & Principle

- How mass spectrometry works



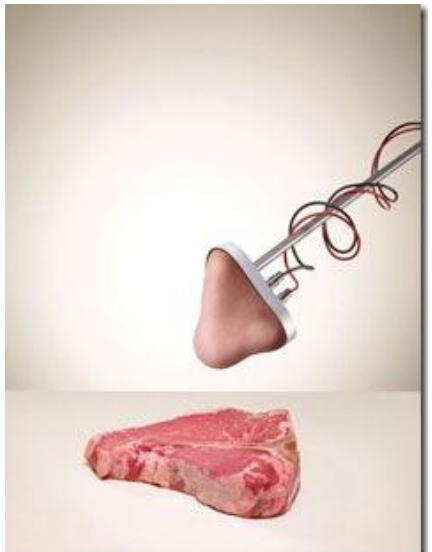
What's the disadvantage?

- Cost lots of time and works
- Huge instruments that are not portable

- We need small size device and real time system

Application

- Measuring air quality
- Diagnosis of some diseases
- Checking reality of something
- Safety check at Custom
- Exploring the unknown



Conclusion

- The mimicry of human nose
- The basic operation principal of human nose
- The 4 approaches used in electronic nose
  - Conductivity-Type
  - Piezoelectricity-Type
  - MOSFET-Type
  - Optical Fiber-Type
- Applications
- A noninvasive approach for diagnosis
- A fast and easy way of detection
- Defect – smells that don't include in library


Thank
You
for Listening
to Our
Presentation


ANY QUESTION?

Q&A

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