“Microwave Sterilization, Quartz Crystal Capacitive Sensor, Ultra-high Temperature Furnace”

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AGENDA

1. **Microwave Sterilization**
   (gas phase, liquid phase)
   Jumbo jet aircraft (Boeing)

2. **Quartz Crystal Capacitive Sensor (QCCS)**
   (VOC gas detection, Water molecules detection) **QCM ==> QCCS**

3. **Ultra-high Temperature Furnace**
   (ash, final dust treatment)
   Asbestos, PCB, Dioxin
   Waste treatment, Mineralization

1 Microwave Sterilization (gas phase, liquid phase)

- Sterilization of viruses contained in atmosphere, in water.

Jumbo jet aircraft (Boeing)

- Harmless treatment of VOC's and H_2S gas.

Drainpipe	⇨	Hydrogen sulfide (H_2S)

Microwave Sterilization System

As these viruses are airborne, a good air purification system is required at places where people gather, such as schools, offices, theaters, hospitals, restaurants and assembly halls.

Many sterilization processes have been studied worldwide.

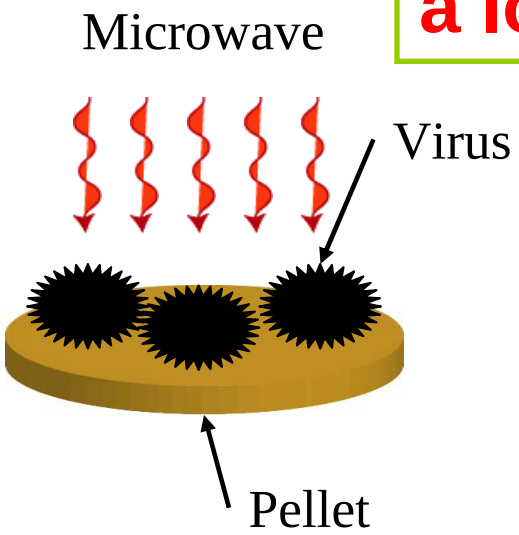
- Heat sterilization → Waste of energy
- Ozone gas sterilization → Difficulty to handle
- Plasma sterilization → Shadow effect
- UV light sterilization → Shadow effect

- Microwave sterilization
  - **Catalyst**
  - **Skin effect**

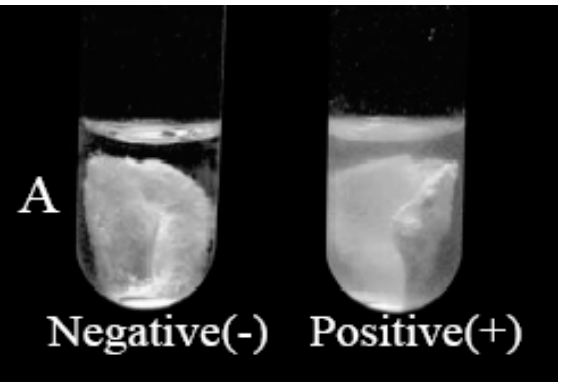
A material can be heated directly, rapidly and selectively, resulting in a reduction of power consumption ,compared with conventional electric furnace.

Microwave Sterilization System

Novel microwave sterilization system that can raise the temperature in very short time (5 sec) using a lower microwave power (50 W) .



- The *E. coli* (Escherichia coli) and *B. subtilis* (Bacillus subtilis) were loaded inside the pellet.
- The catalyst materials contained SiO2 - and/or Al2O3 - TiO2 that were coated with Pt and/or Ag. The pellets coated with micrometer size metal had a porous structure and a phase structure that maintained anatase in the system of SiO2 –TiO2.



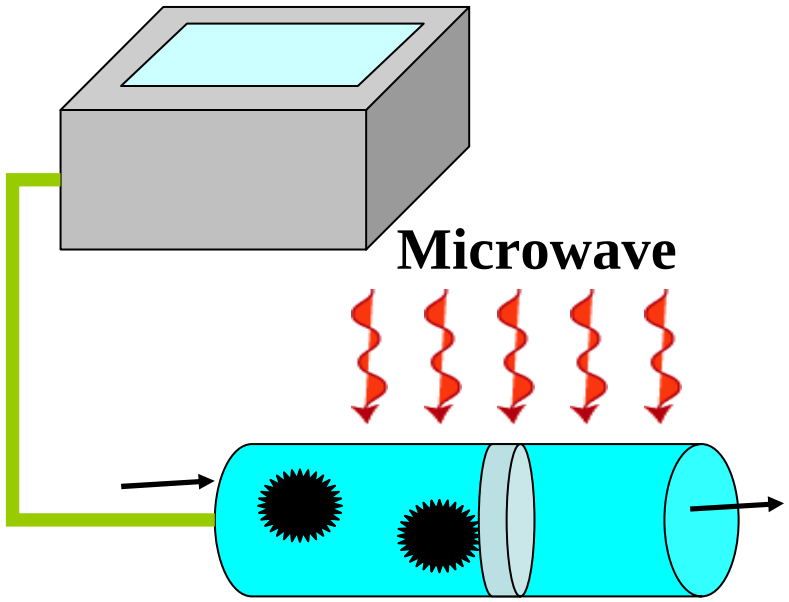
E. coli on the SiO_2 - TiO_2 coated with Ag completely sterilized within 5 s. E. coli on the Pt-coated Al_2O_3 - TiO2 pellet also sterilized within 5 s.

Jumbo jet aircraft (Boeing)

Microwave Sterilization in the water

Our developed system can sterilized virus in water (Ex. Legionella bacteria) rapidly.

- Hot spring
- Circulating water

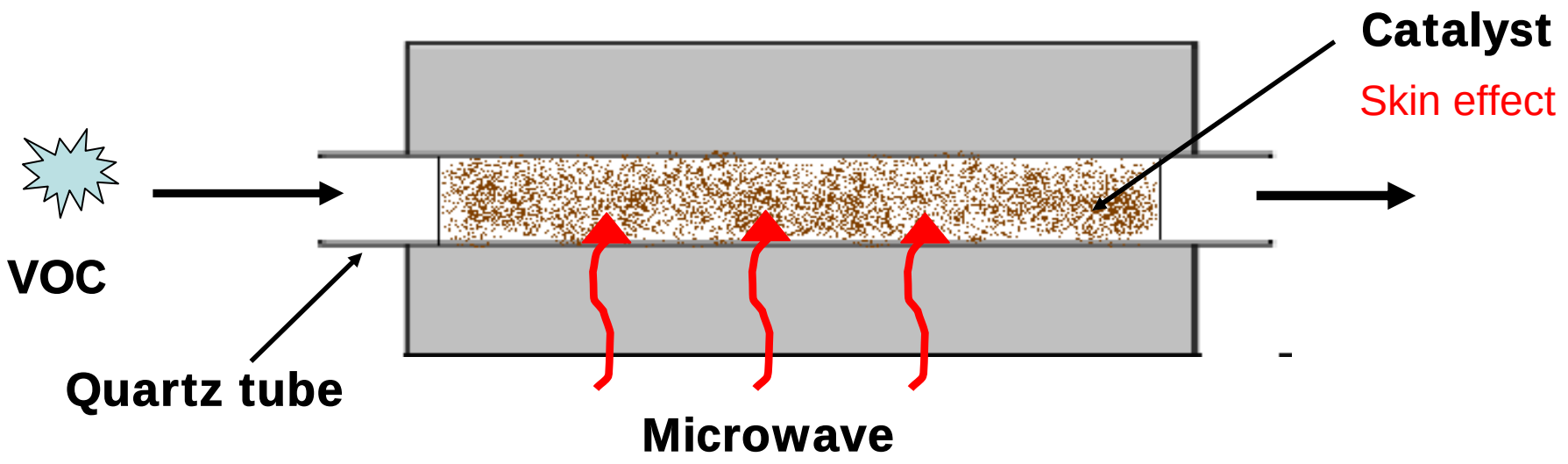


Microwave assisted catalytic decomposition of hydrogen sulfide (H_2S) and TCE

- **The microwave heating could greatly reduce the reaction temperature, accelerate the TCE decomposition speed and improve the TCE decomposition ratio compared with conventional heating.**

Drainpipe, Bad smell, Building

Our system can resolve TCE and H_2S completely!



How to use our microwave system

■ Microwave Sterilization System

For air conditioner in the hospital, **airplane**, and home.

⇒To prevent infections of SARS and Bird Flu.

■ Microwave Dissociation and System for VOC

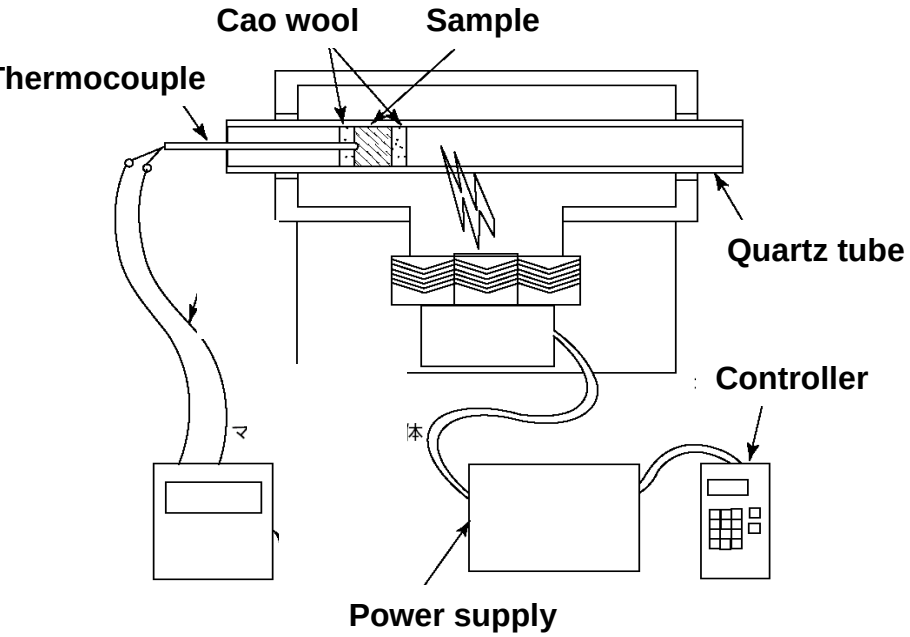
Using for odor eliminating in the food and paper-making factory

⇒For odor eliminating and emission reduction of toxic substances.

Harmless!

Drainpipe, Bad smell, Building

Thermocouple sensing system which is useable under the microwave irradiation



Aronceramics+carbon

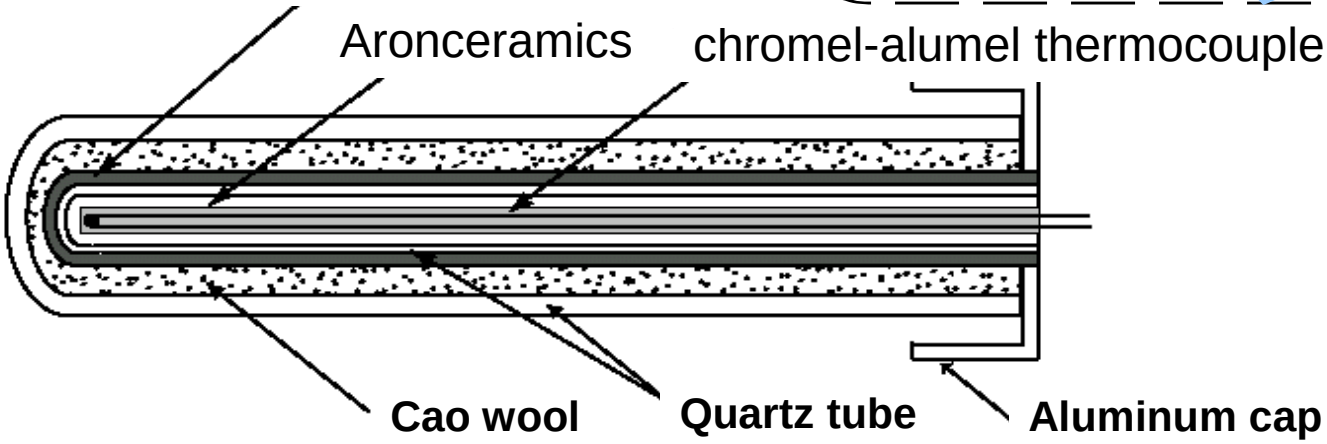
Developed Thermocouple

Microwave

Microwave cause a noise.

Shielded thermocouple

Useable under microwave irradiation



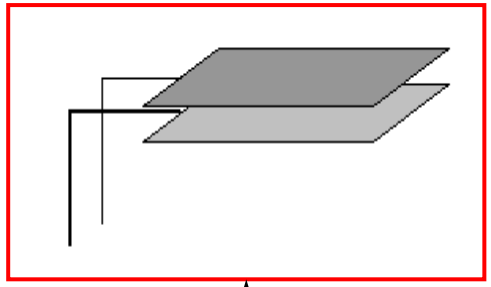
2 Quartz Crystal Capacitive Sensor (QCCS)

- **VOC concentration detection**
- **Water molecules detection.**

Quartz Crystal Microbalance (QCM) —developed→ **QCCS**

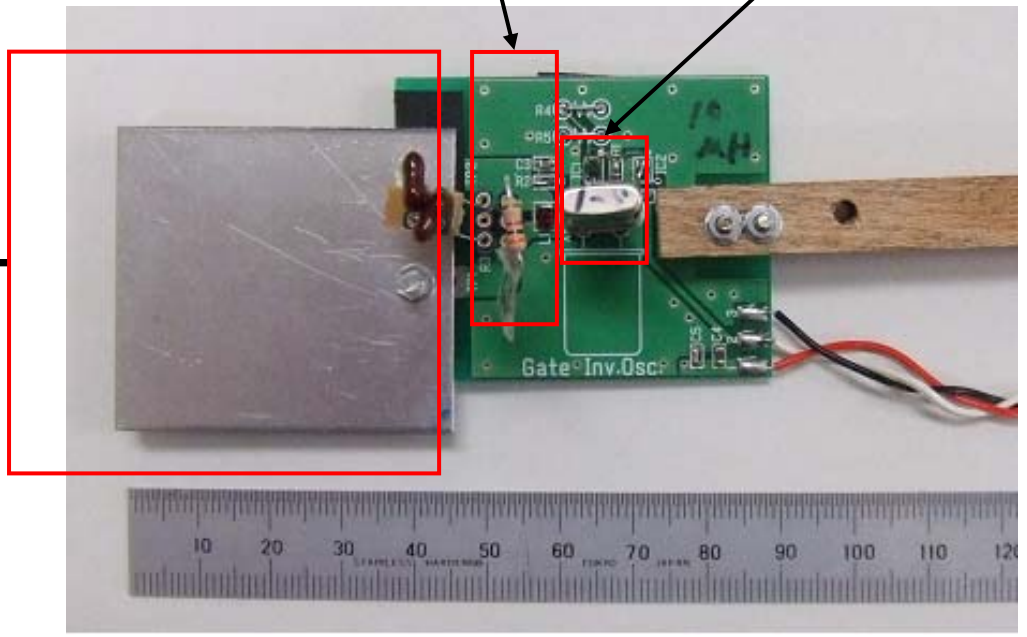
What is “Quartz Crystal Capacitive Sensor (QCCS)”?

Parallel plate capacitor



LC Resonance circuit

Quartz crystal（5MHz or 10MHz）

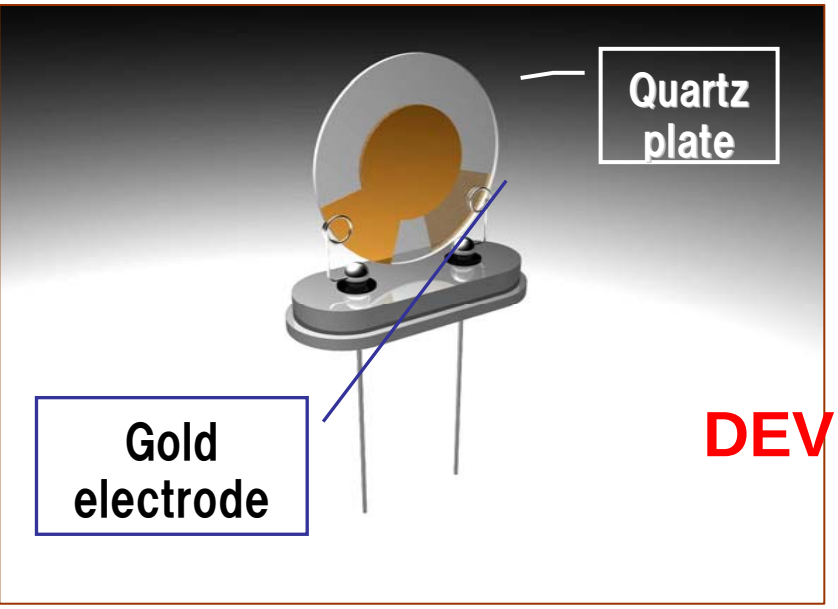


QCCS

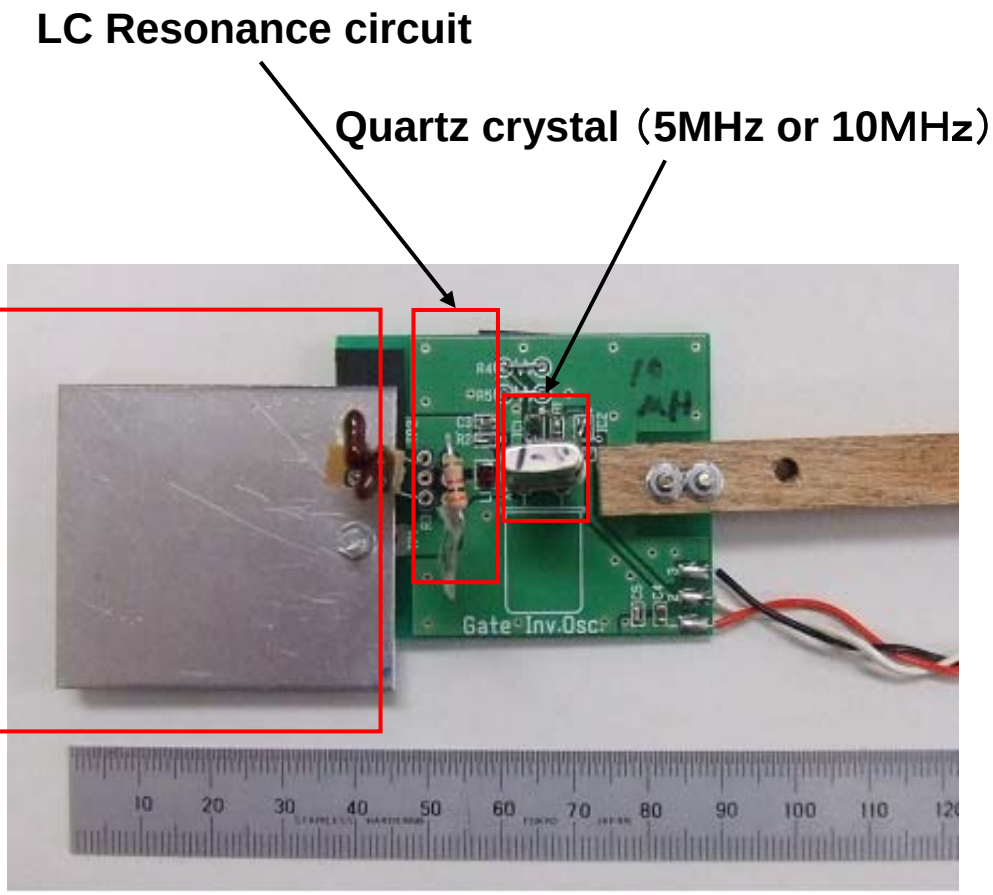
Quartz Crystal Capacitive Sensor : QCCS

A quartz crystal capacitive sensor (QCCS) consists of a parallel plate capacitor, an AT-cut quartz crystal, an LC resonance circuit, and a custom-made oscillating circuit.

Quartz Crystal Microbalance (QCM) VS (QCCS)"?



DEVELOPED



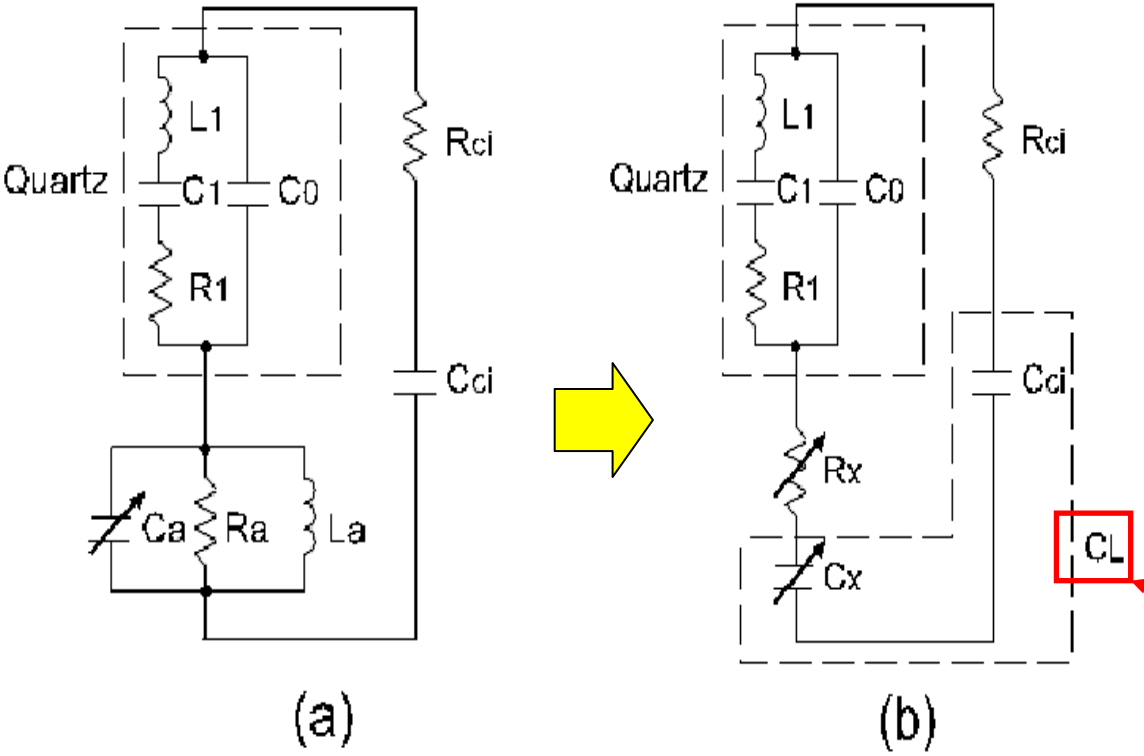
QCM

- Bare Quartz Crystal
- Low stability

QCCS

- Shielded Quartz Crystal
- High stability and sensitivity

Procedure of simulation



Equivalent circuit schematic of QCCS

D_L: Calculated frequency deviation of QCCS

$$D_L = \frac{1}{2\gamma} \times \frac{1}{1+\frac{C_L}{C_0}} \qquad (1)$$

where

$$\frac{1}{C_L} = \frac{1}{C_x} + \frac{1}{C_{ci}} \qquad \gamma = \frac{C_0}{C_1}$$

$$C_x = -\frac{1}{\omega \cdot Q_a R_a \left(1-\frac{\omega^2}{\omega_a^2}\right)} - \frac{Q_a}{\omega \cdot R_a}\left(1-\frac{\omega^2}{\omega_a^2}\right)$$

$$\omega_a^2 = \frac{1}{L_a C_a} \qquad Q_a = \frac{R_a}{\omega \cdot L_a}$$

Result of simulation (Organic vapor sensing)

$$D_L = \frac{1}{2\gamma} \times \frac{1}{1 + \frac{C_L}{C_0}} \quad (1)$$

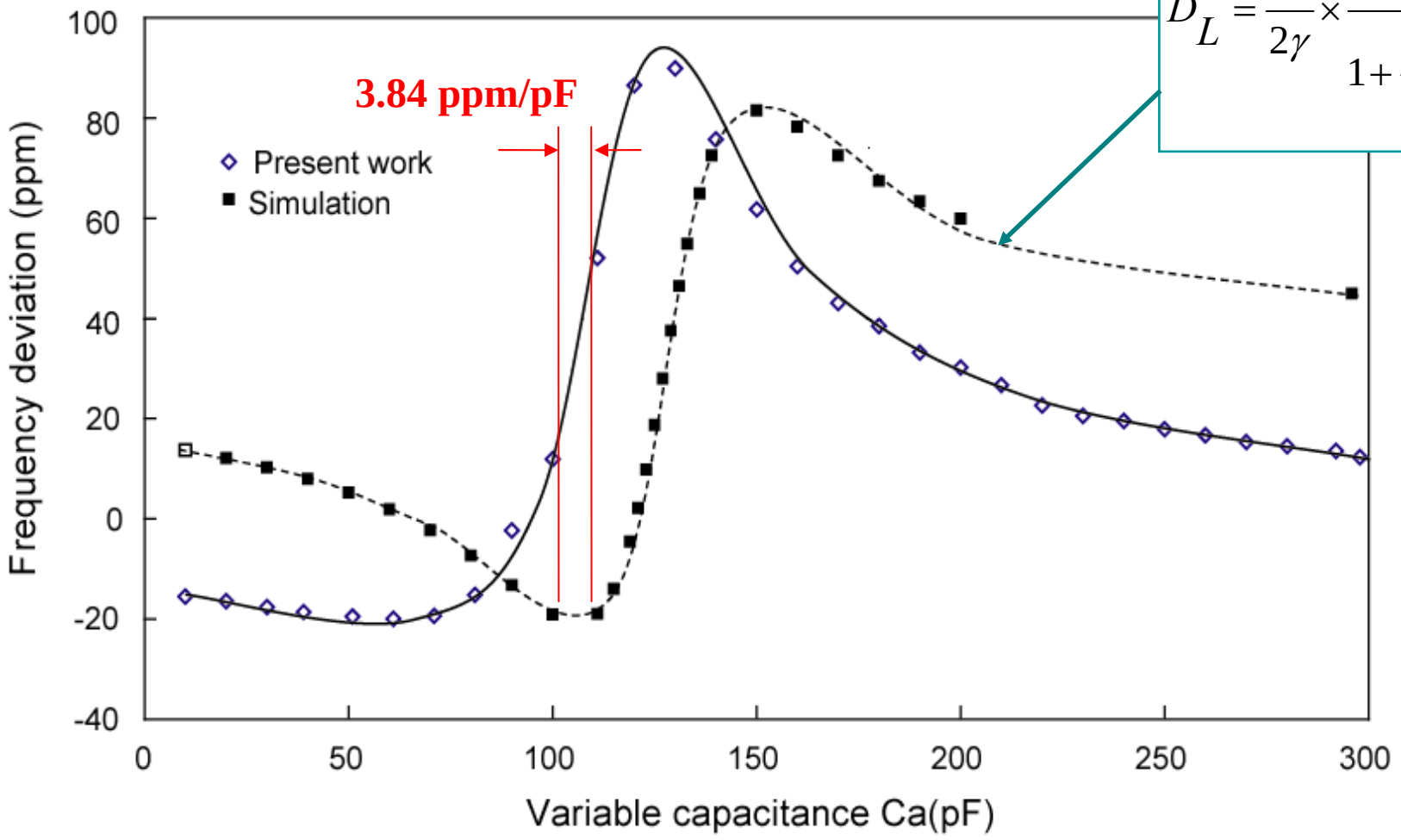


Fig. 4 **Relationship between frequency deviation and variable capacitance for the organic vapor sensing**

Experimental procedure (Organic vapor sensing)

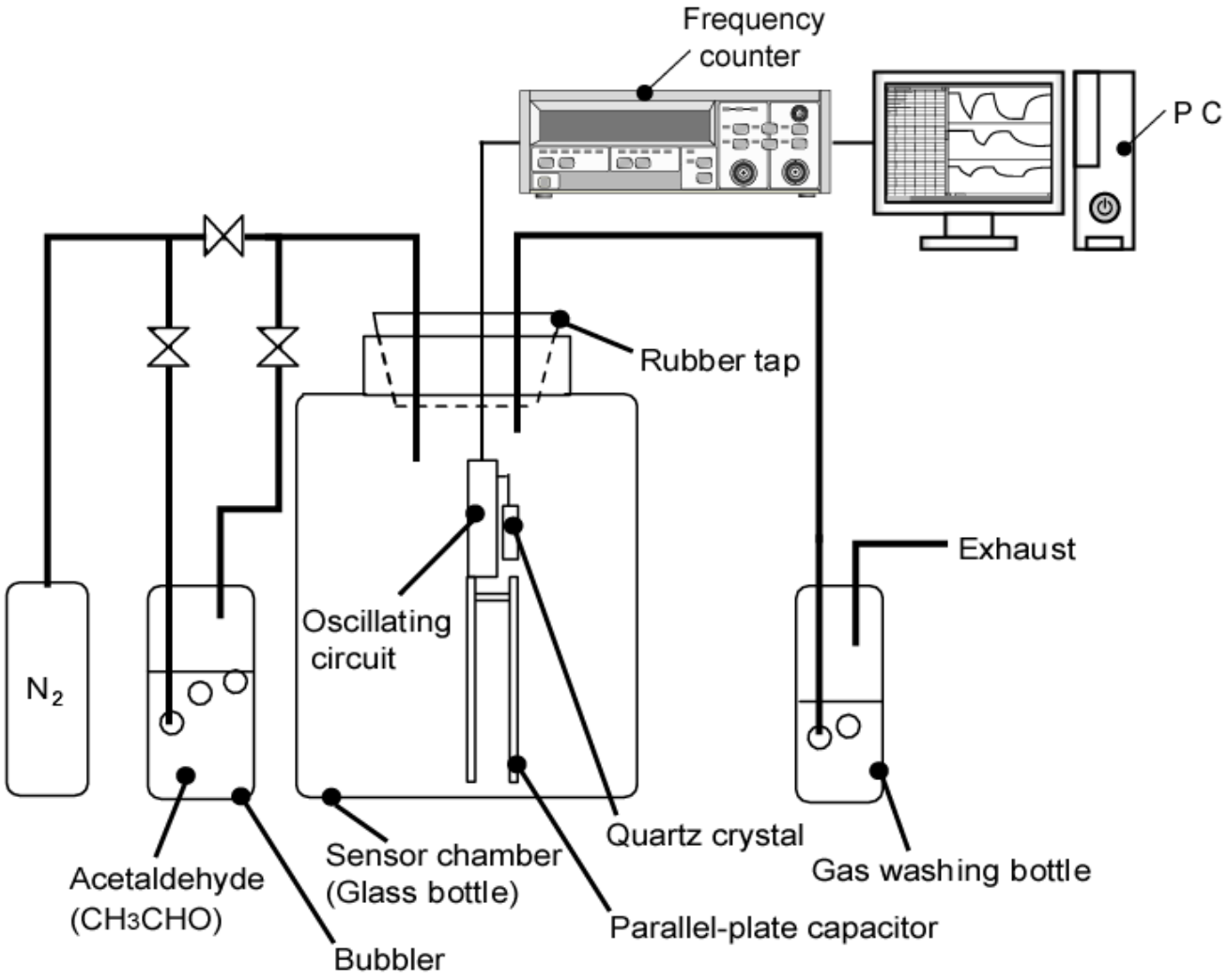


Fig. 4 **Schematic diagram of sensor system for acetaldehyde detection.**

Experimental result (Organic vapor sensing)

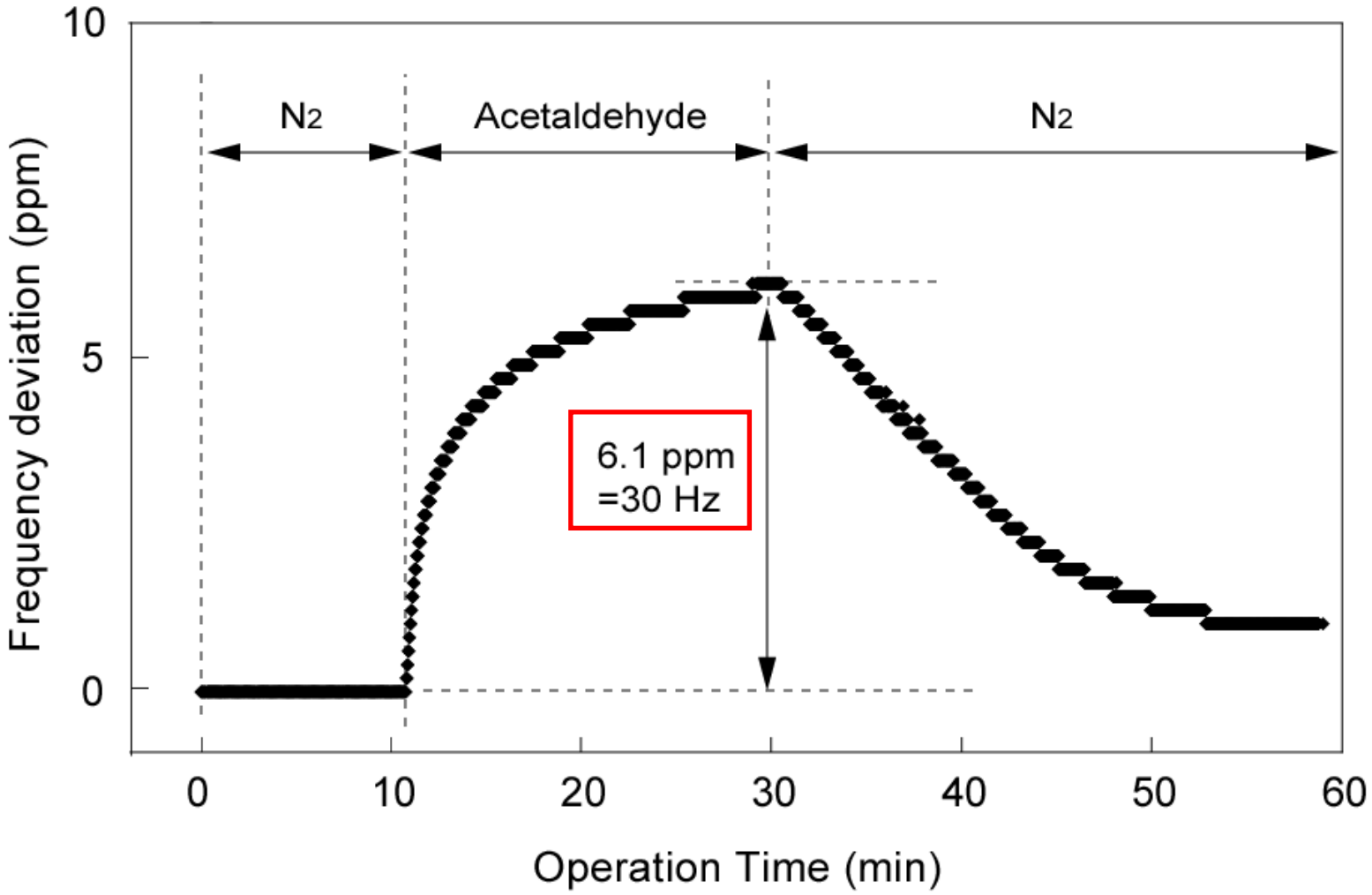


Fig. 5 **Relationship between frequency deviation and operation time.**

Result of simulation (Measuring of water content)

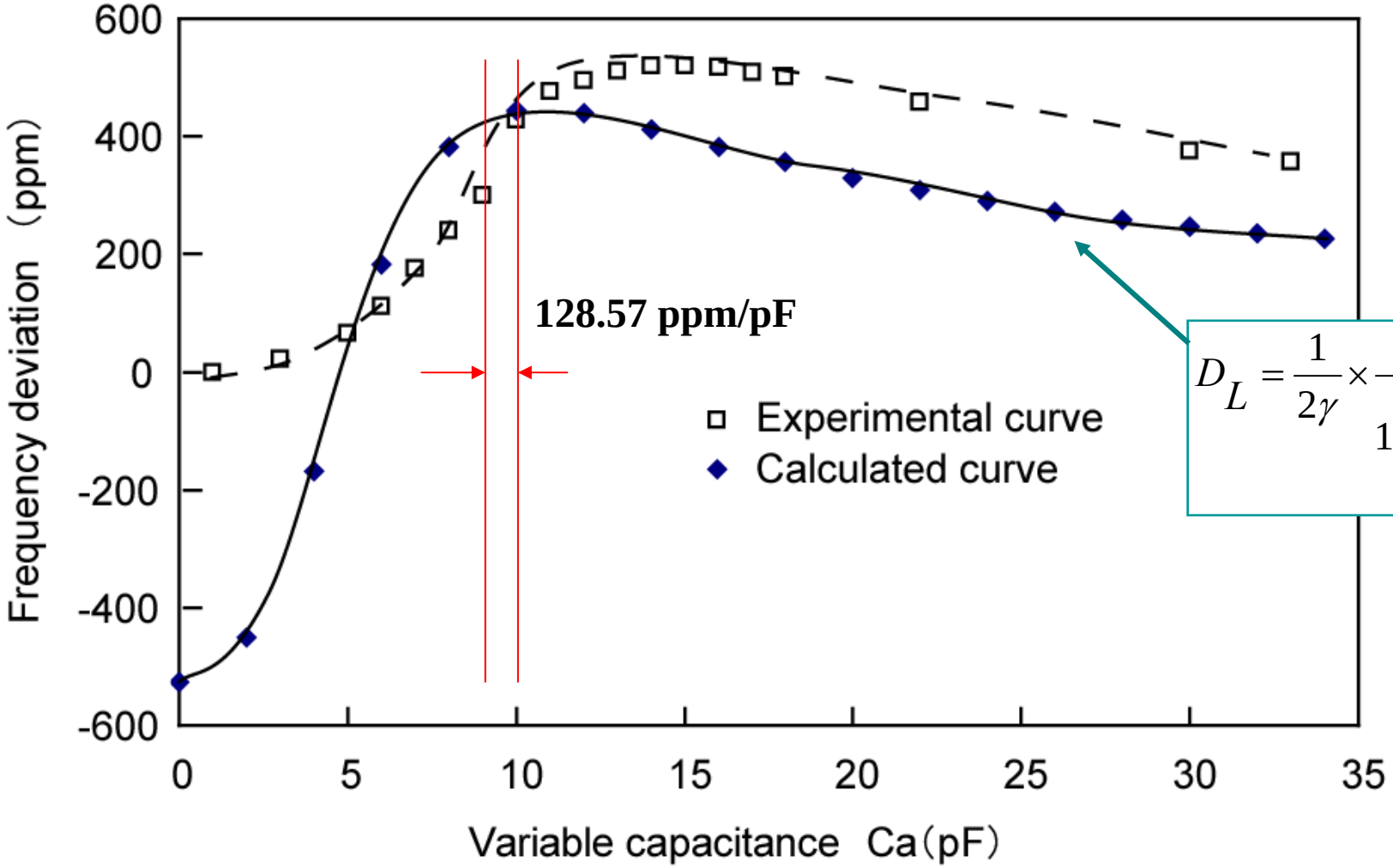


Fig. 6 **Relationship between frequency deviation and variable capacitance for the organic vapor sensing**

Experimental procedure
(Measuring of water content)

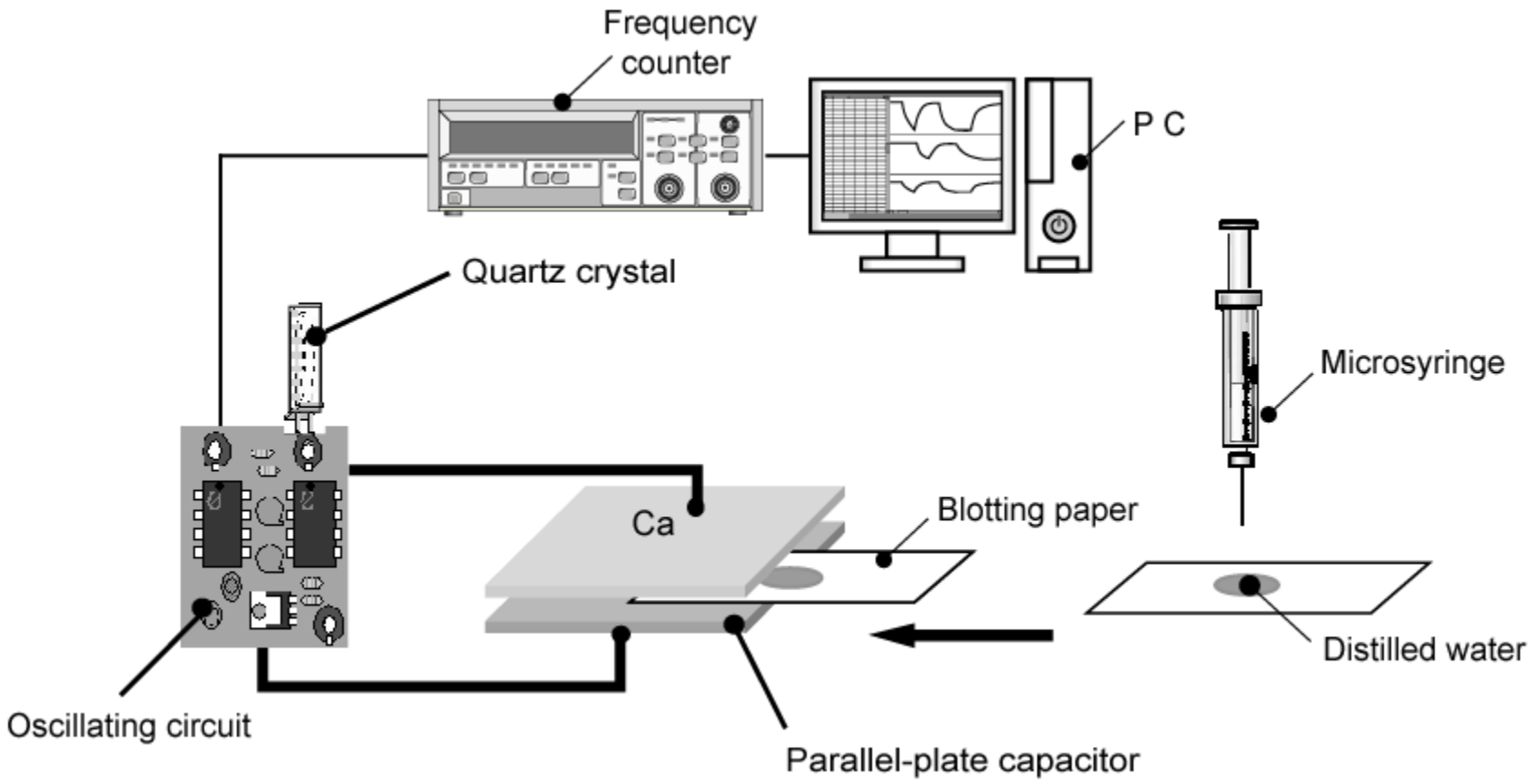


Fig. 7 **Schematic diagram of sensor system for measuring of water content.**

Experimental result (Measuring of water content)

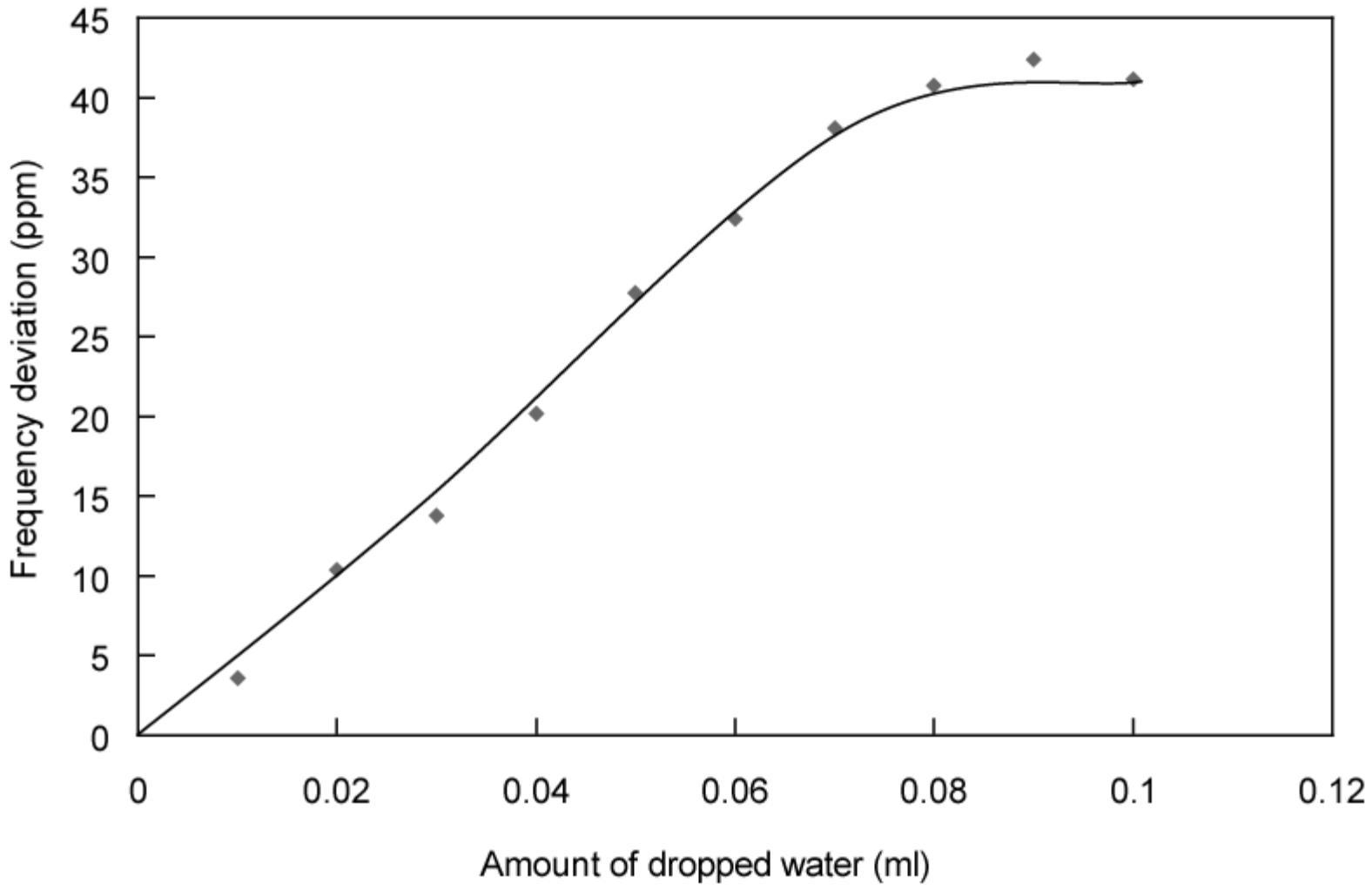


Fig. 8 **Relationship between frequency deviation and operation time.**

3 Ultra-high Temperature Furnace (ash, final dust treatment)

- Resource of burn out ash.
  - **Asbestos**
  - **PCB**
  - **detoxifying treatment**

Normal operating temperature : 1800˚C

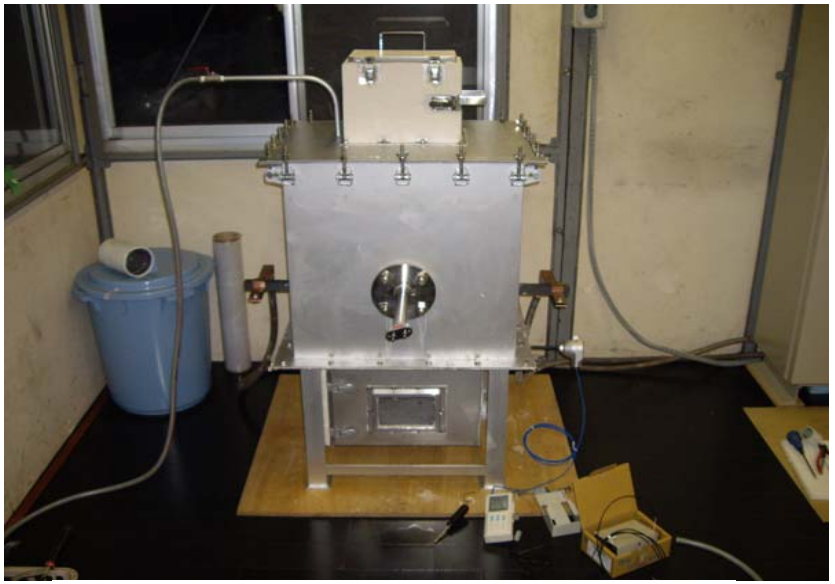
Ultra-high Temperature Furnace

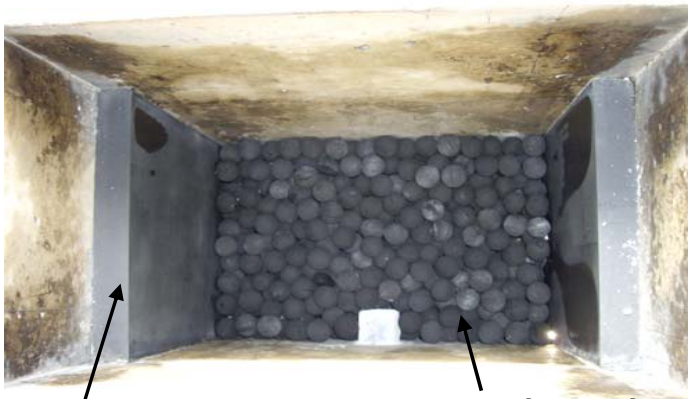
Ash contains heavy metal. There is a possibility that the ash contaminates the soil in a refuse landfill.

Developed furnace can melt the ash at ultra high temperature (1,800 ˚C) and render it harmless completely.

After ash is melted, Glass slag is obtained.
It doesn't contains toxic substances.

Furthermore we obtained amount of flammable gas and hydrogen gas
when the ash is melted.





Carbon electrode

Heating elements
(Carbon ball)

Temperature Control System by B_4C/C Thermocouple

- B_4C/C Thermocouple was consisted of a graphite tube and a B_4C rod connected to one another by a conical fitting.

This system can control the temperature directly in the furnace at 2,200 ˚C!!

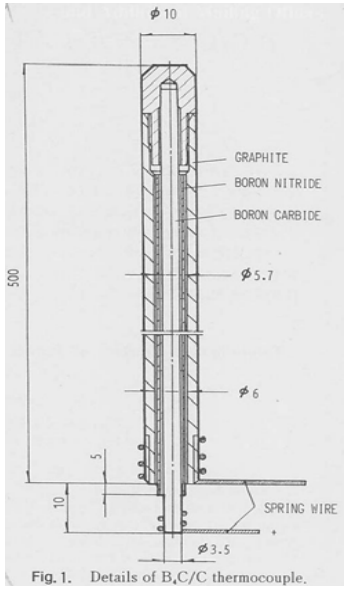


Fig. 1. Details of B_4C/C thermocouple.

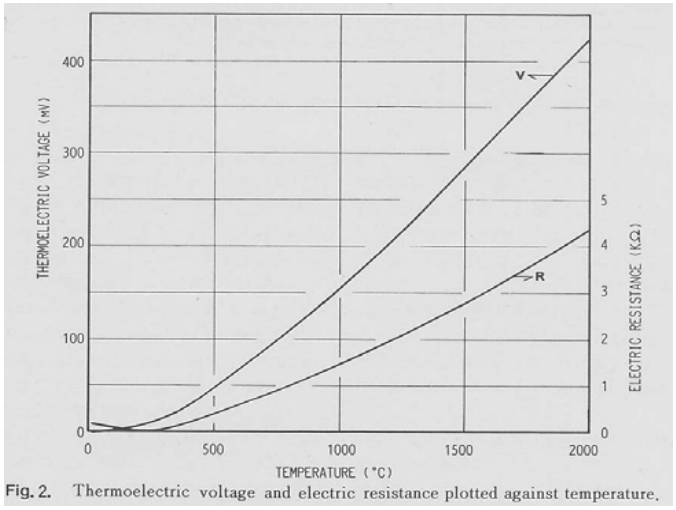


Fig. 2. Thermoelectric voltage and electric resistance plotted against temperature.

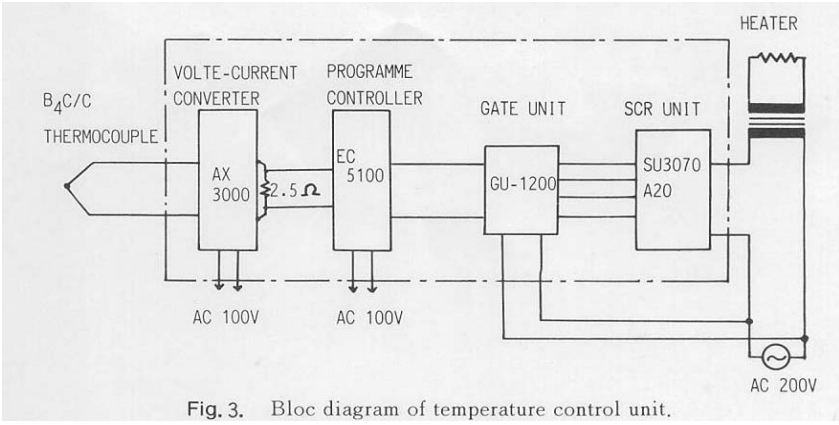
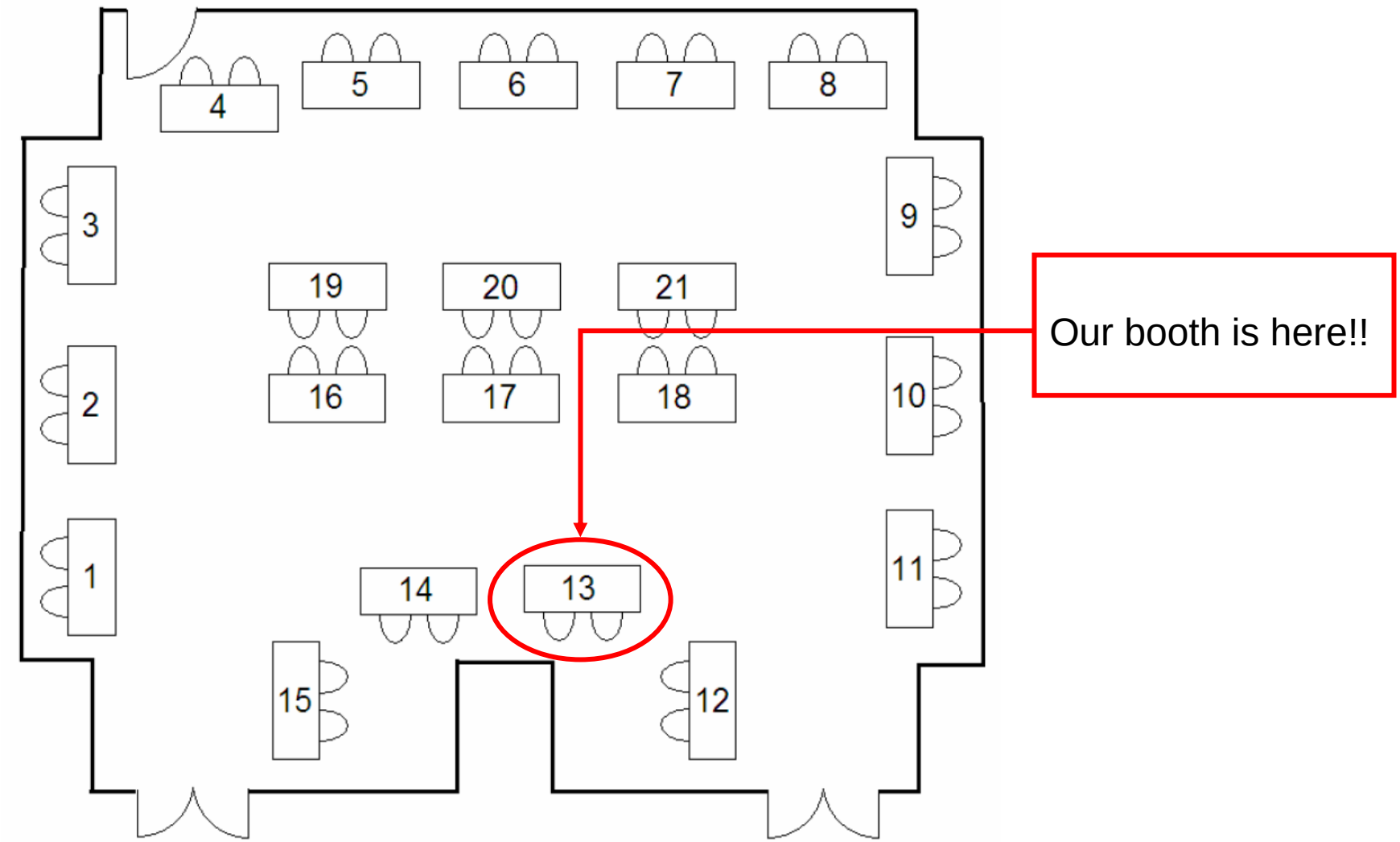


Fig. 3. Bloc diagram of temperature control unit.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