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I'm speaking at GAS Analysis 2017

The precise temperature control of ball SAW sensors for trace moisture measurement at ppb level of concentration

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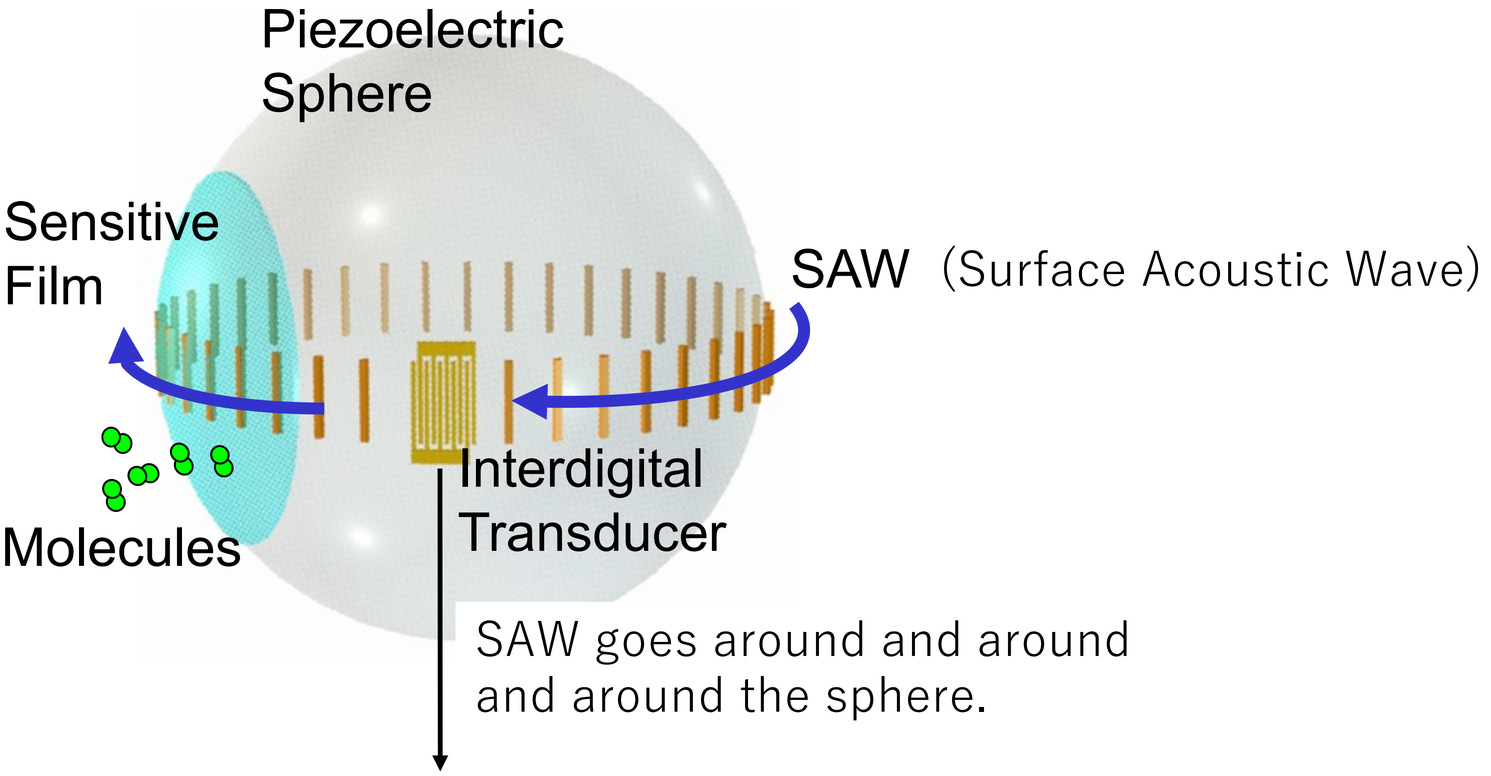
Ball Wave Inc.

The ball SAW sensor

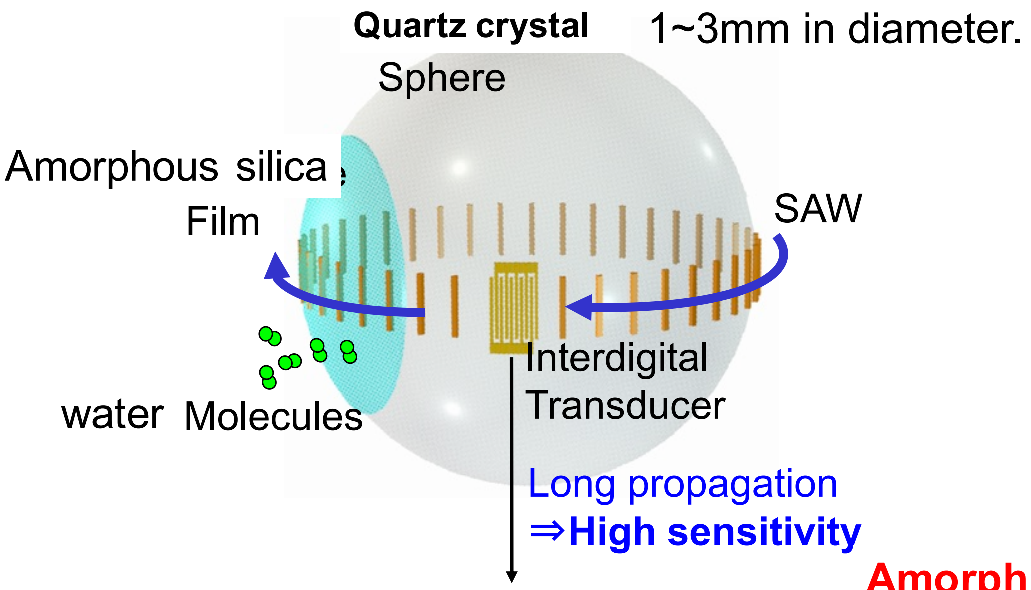
- What is the ball SAW sensor?
- How does it measure the trace moisture?
- We had a difficulty caused by temperature variation.
- How did we solve it?
- Our detection limit is about 1ppbV trace moisture in N_2 gas.
- We detect the trace moisture in hydrocarbon gases with a same calibration curve.
- We detect a-few-seconds spikes of trace moisture.

What is the ball SAW sensor?

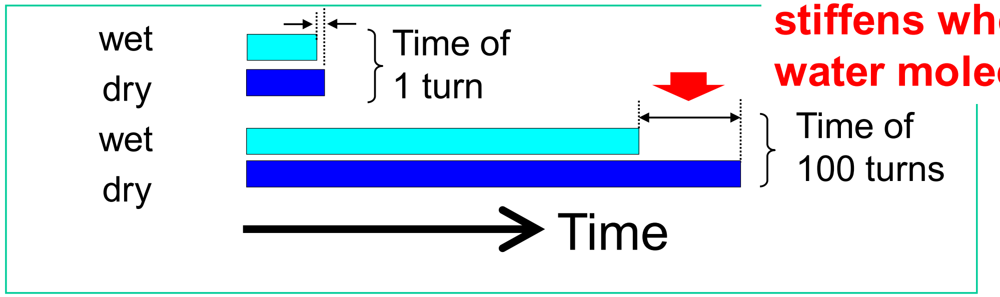


SAW goes around and around
and around the sphere.

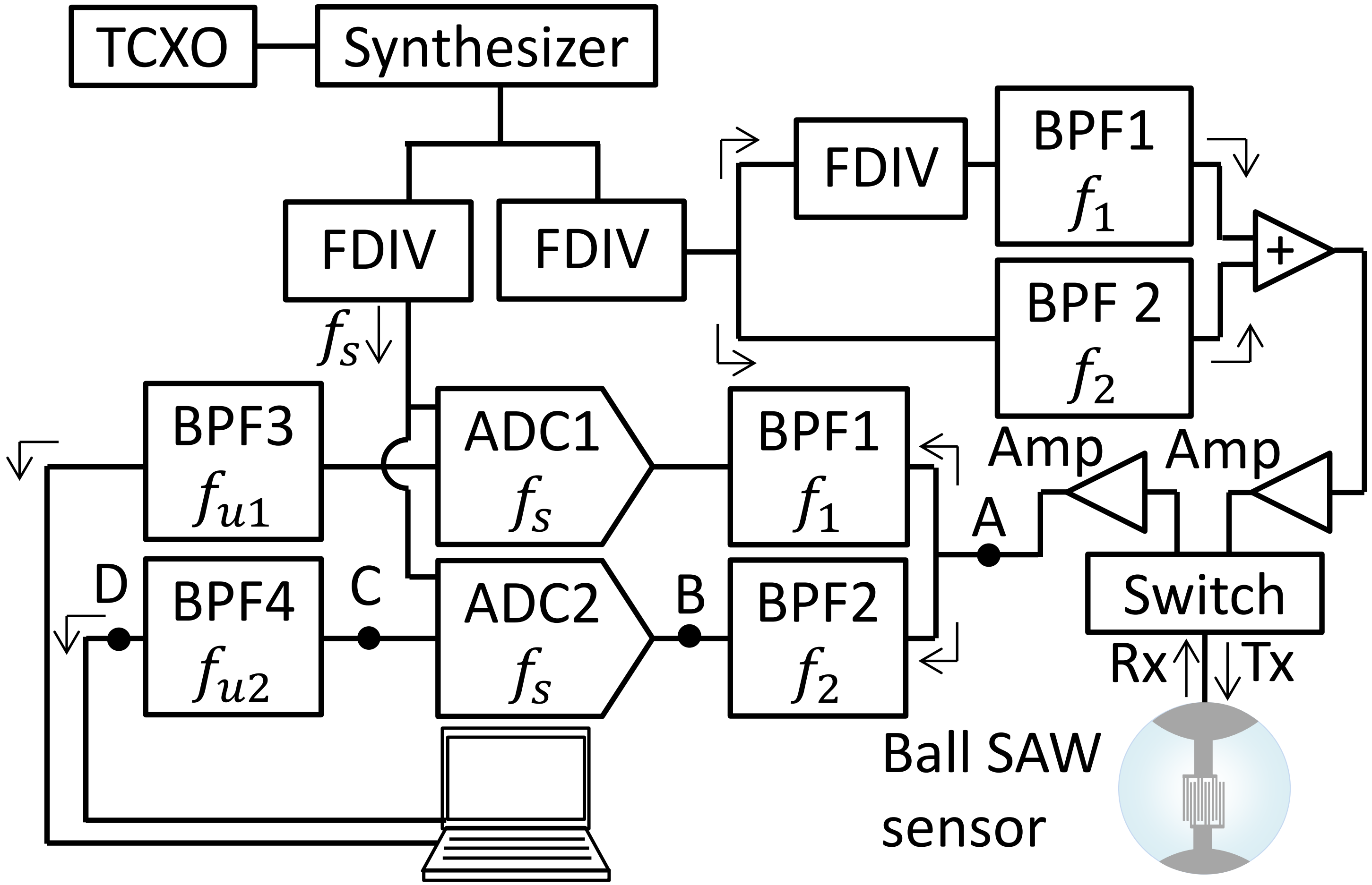
What is the ball SAW sensor?



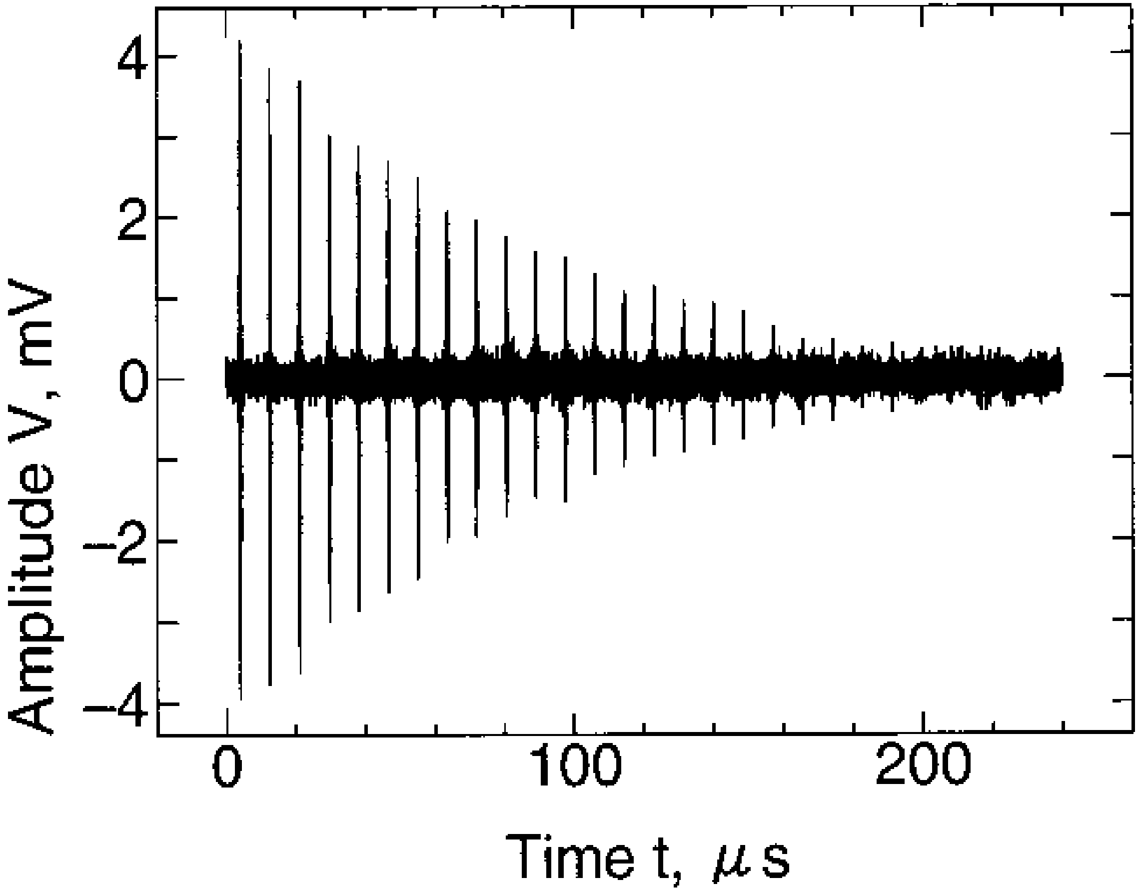
Amorphous silica film stiffens when it absorbs water molecules.



How does it measure the trace moisture?



How does it measure the trace moisture?



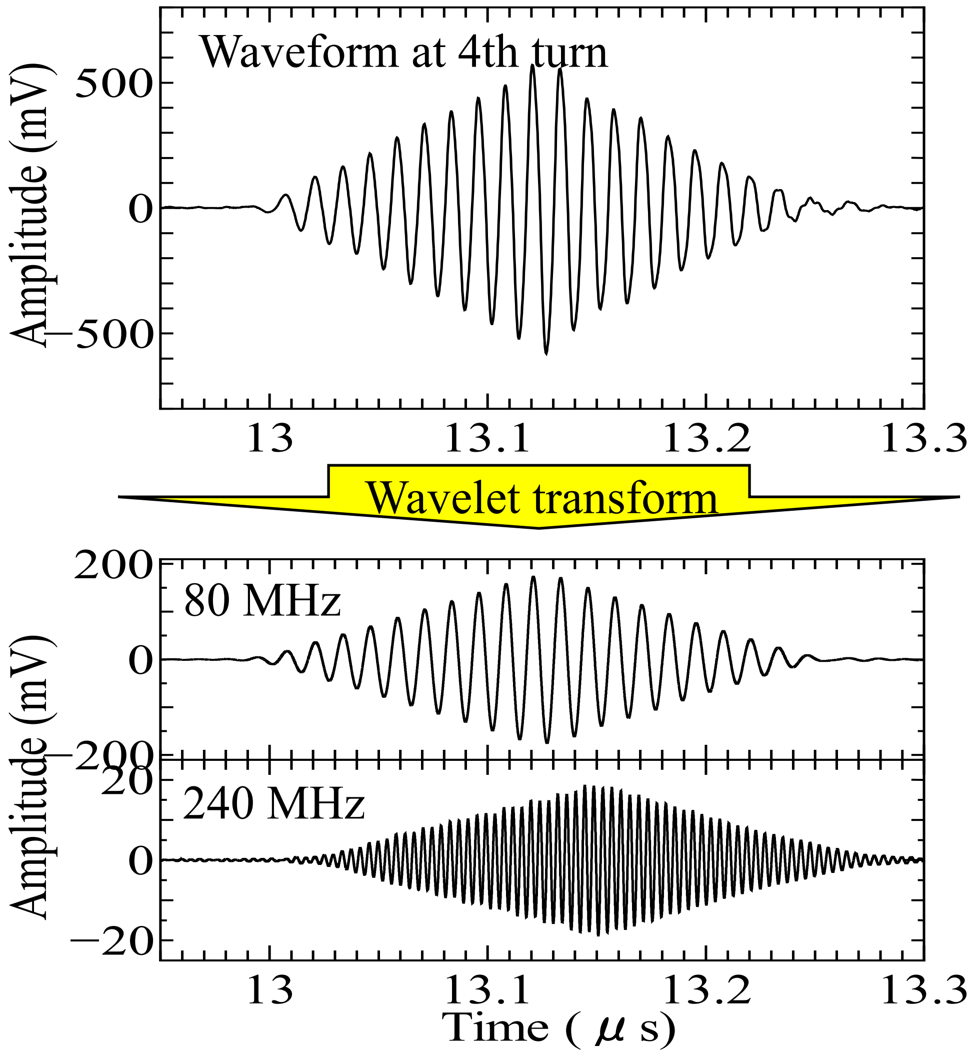
We measure
(1) the decay rate and
(2) delay-time of pulses.

Difficulty caused by temperature variation.

- We have to measure the ppm level of change in the delay-time of pulses.
- But the delay-time strongly depends on temperature.
- We need to compensate it for the trace moisture detection at ppbV level.

How did we solve it?

We use two frequencies to compensate for the temperature variation.



How did we solve it?

Relative delay time changes at frequencies f_1 and f_2, are given by

$$\Delta t_1 = B(T) f_1 G(w) + A_1 (T - T_{\mathrm{REF}})$$

$$\Delta t_2 = B(T) f_2 G(w) + A_2 (T - T_{\mathrm{REF}})$$

where w and T are moisture concentration and temperature, respectively.

From these equations, we obtain

$$\Delta t_W = \Delta t_2 - C\Delta t_1 = (f_2 - C f_1) B(T) G(w)$$

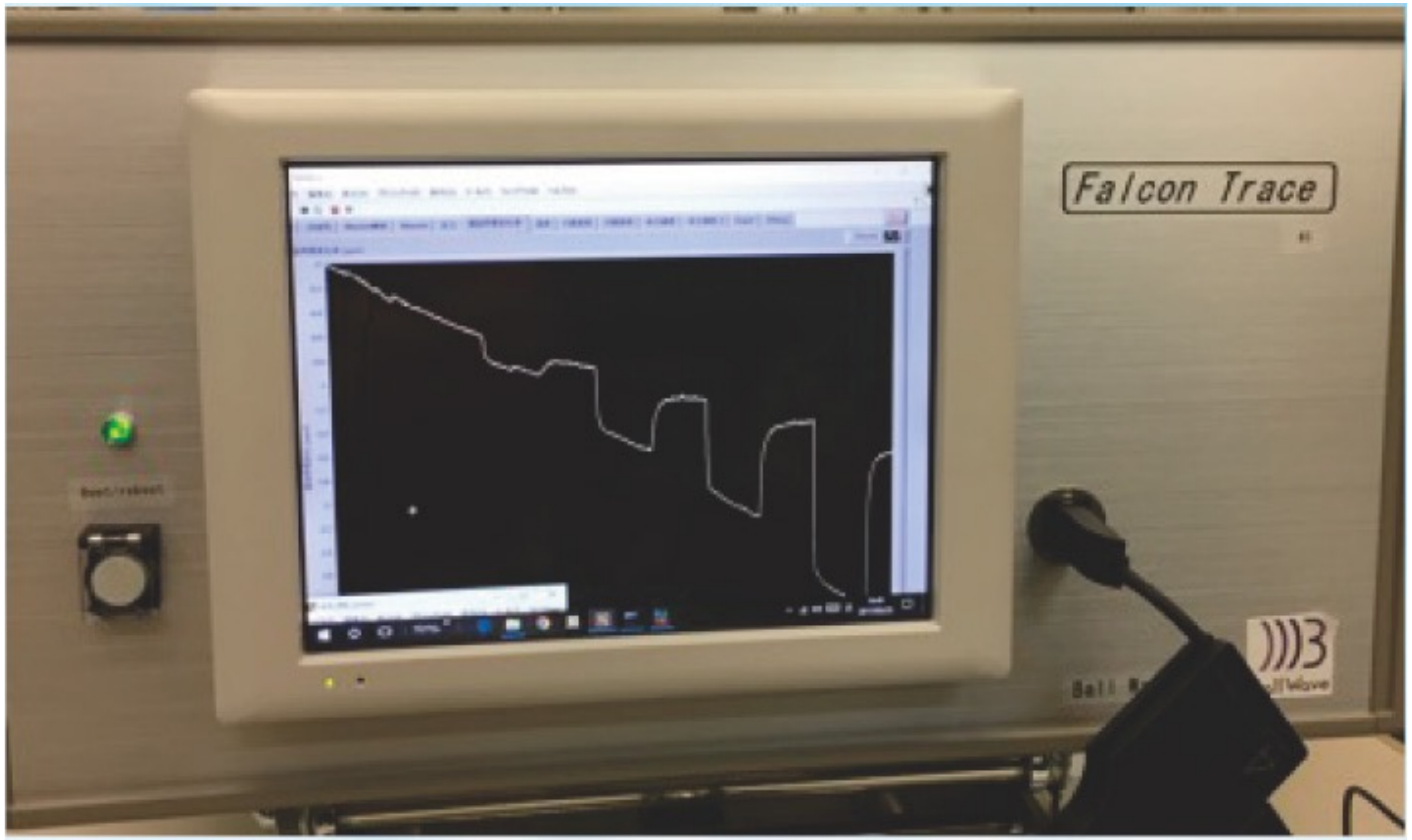
$$\Delta t_T = A_1 (T - T_{\mathrm{REF}}) = \frac{(f_2 / f_1)\Delta t_1 - \Delta t_2}{(f_2 / f_1) - C}$$

where $(f_2 - C f_1) B(T) = a \exp\left[\Delta\varepsilon / k_{\mathrm{B}} (T + 273)\right]$

and $C = A_2 / A_1$.

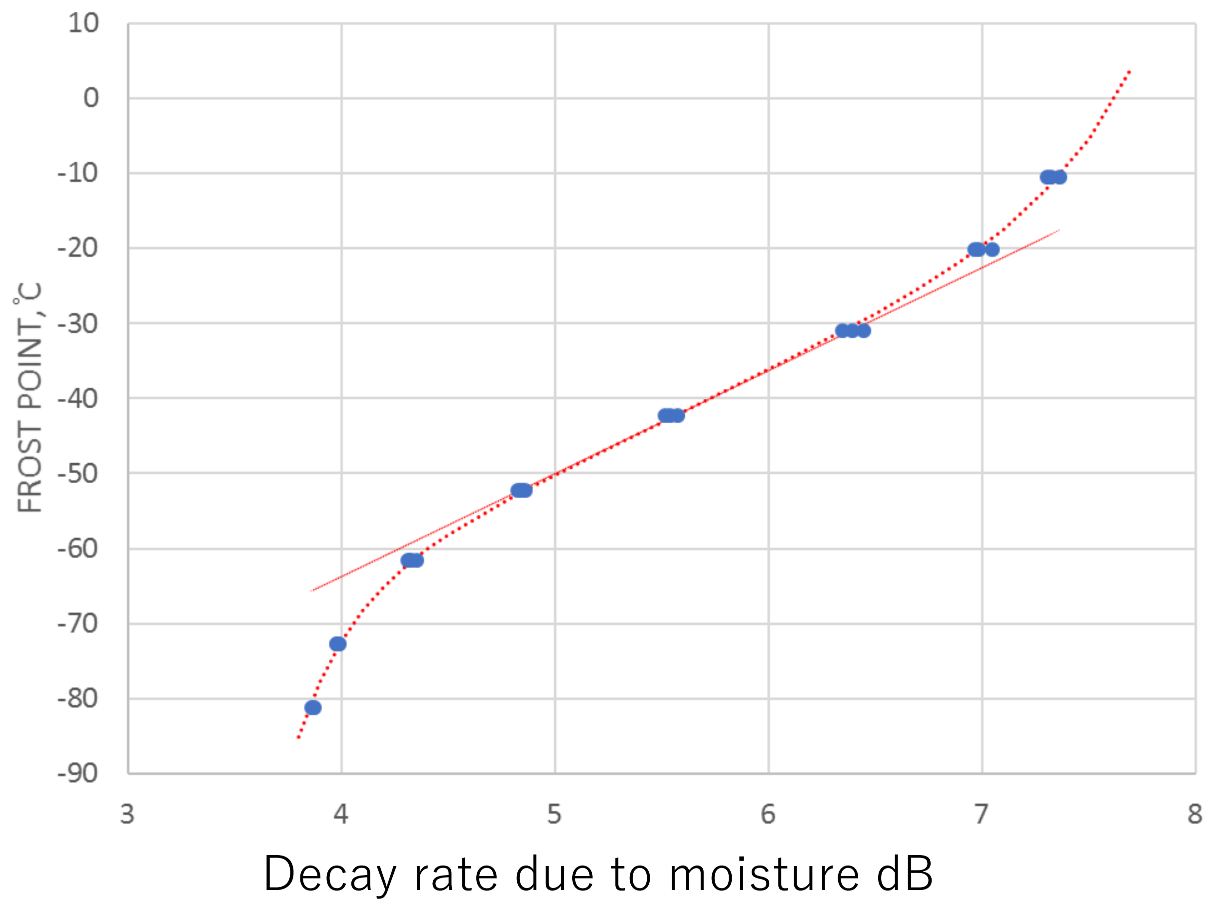
Ref: Proceedings of Symposium on Ultrasonic Electronics, Vol. 37 (2016) 16-18 November, 2016

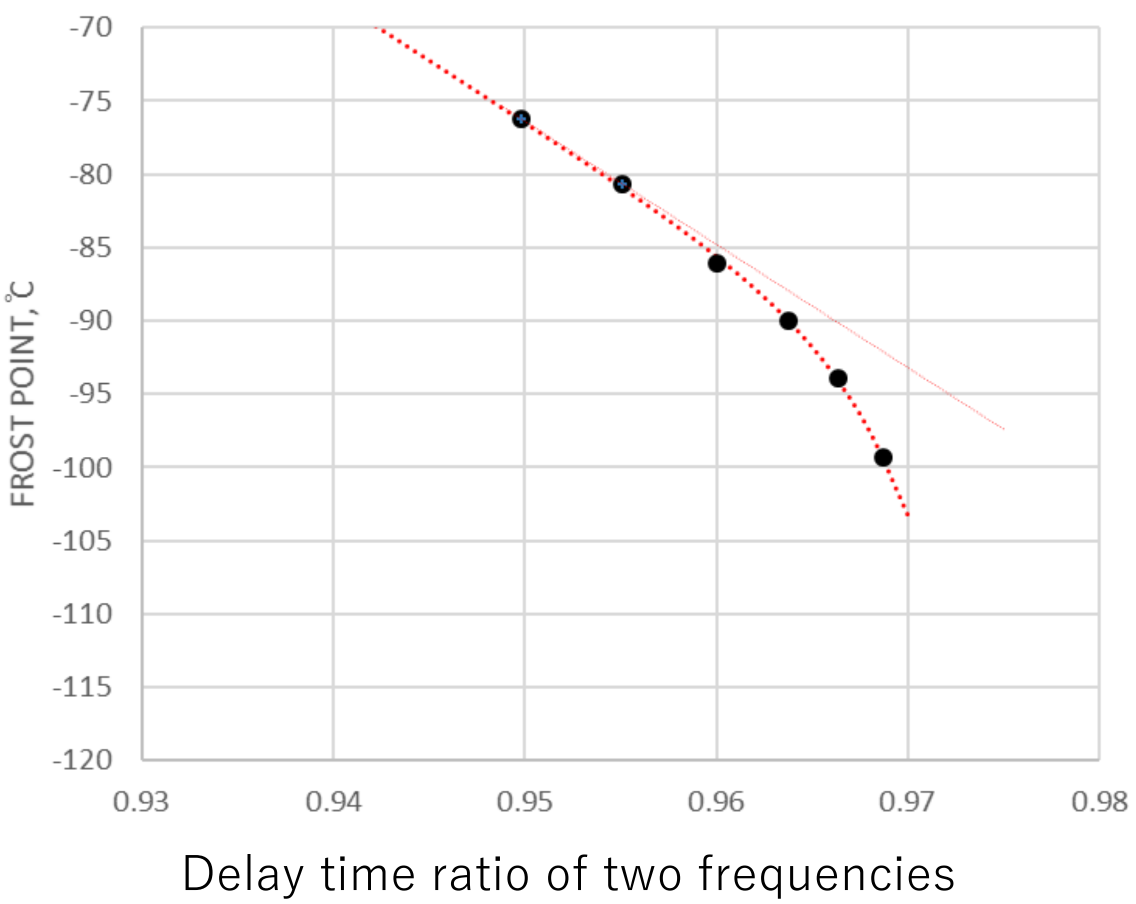
Falcon Trace (code name)



We implemented the method in a prototype.

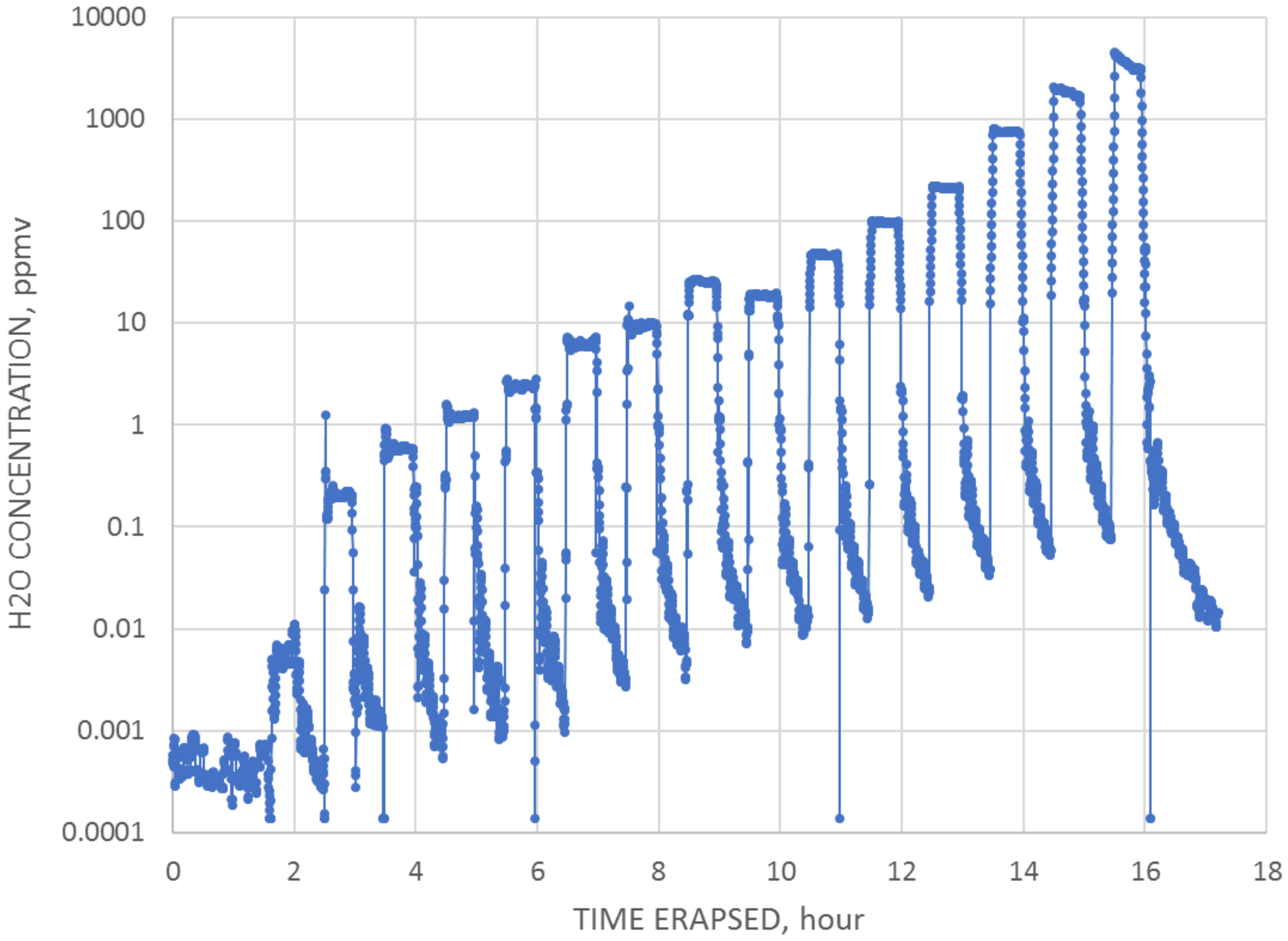
Our calibration curves for high end and low end





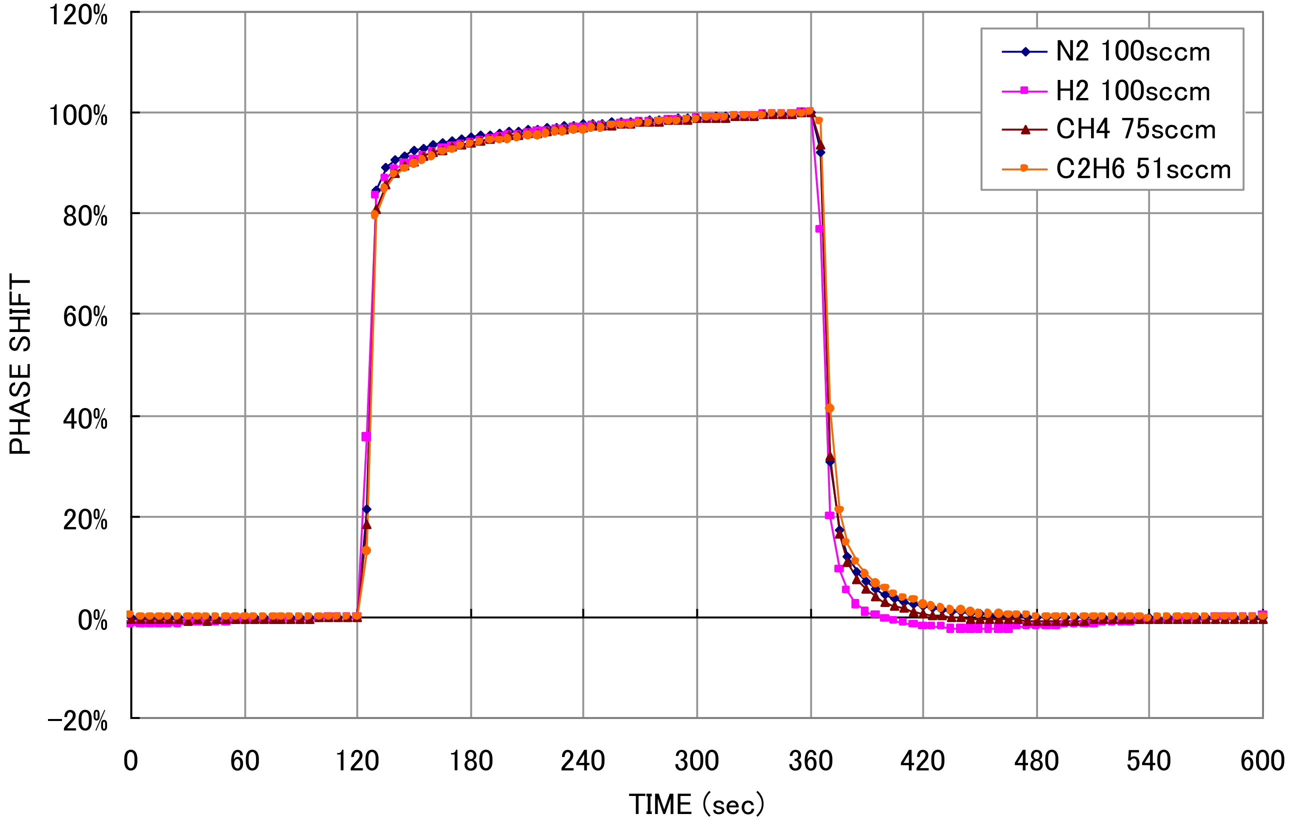
Our detection limit is about 1ppbV.

Trace moisture measurement in the nitrogen gas



Trace moisture in hydrocarbon gases.

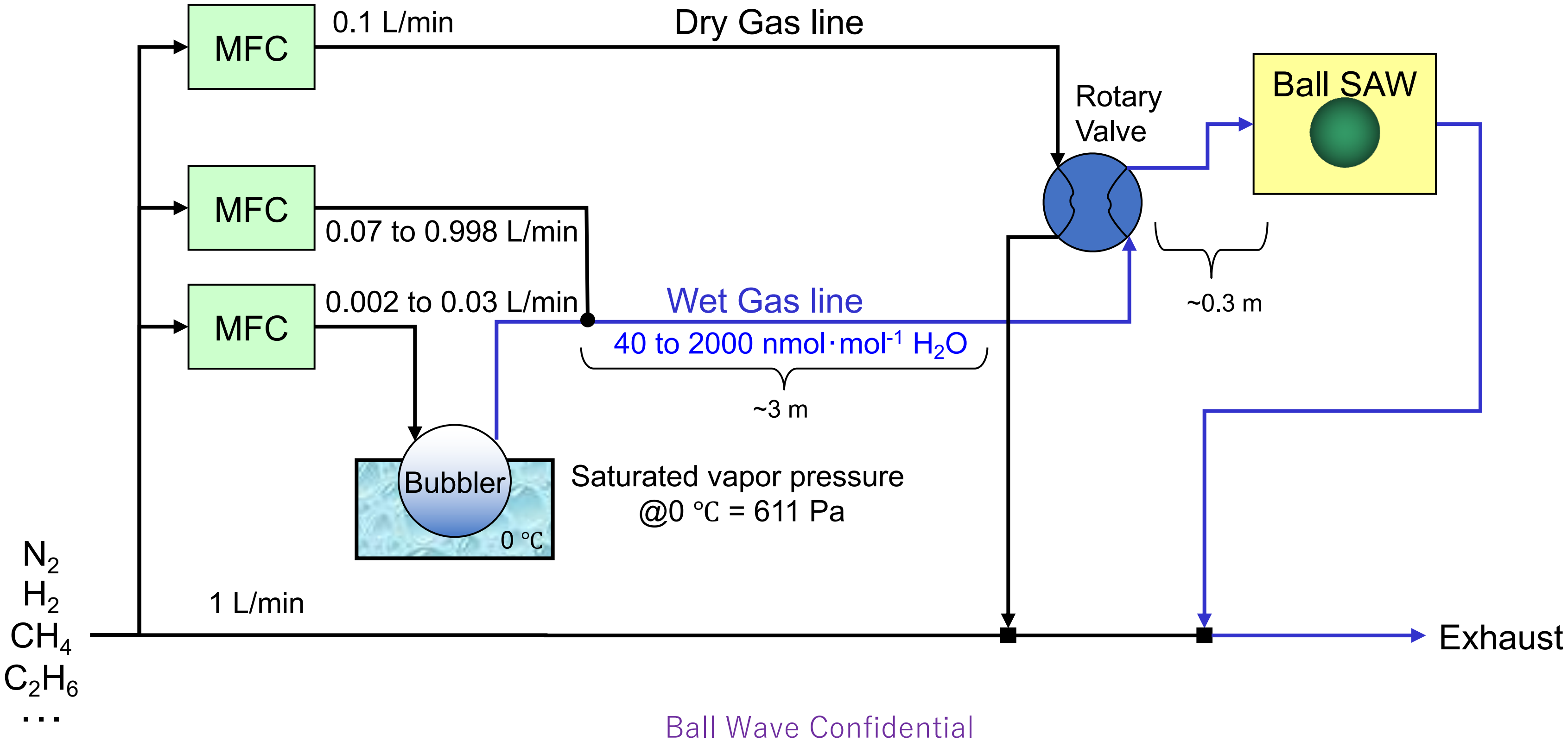
- It works in hydrocarbon gases with the same calibration curve.



Transient Characteristics
@ 1,800ppm H_2O Injection

Trace moisture in hydrocarbon gases.

H_2O Vapor Generation Case 1: Bubbler Method



Ball Wave

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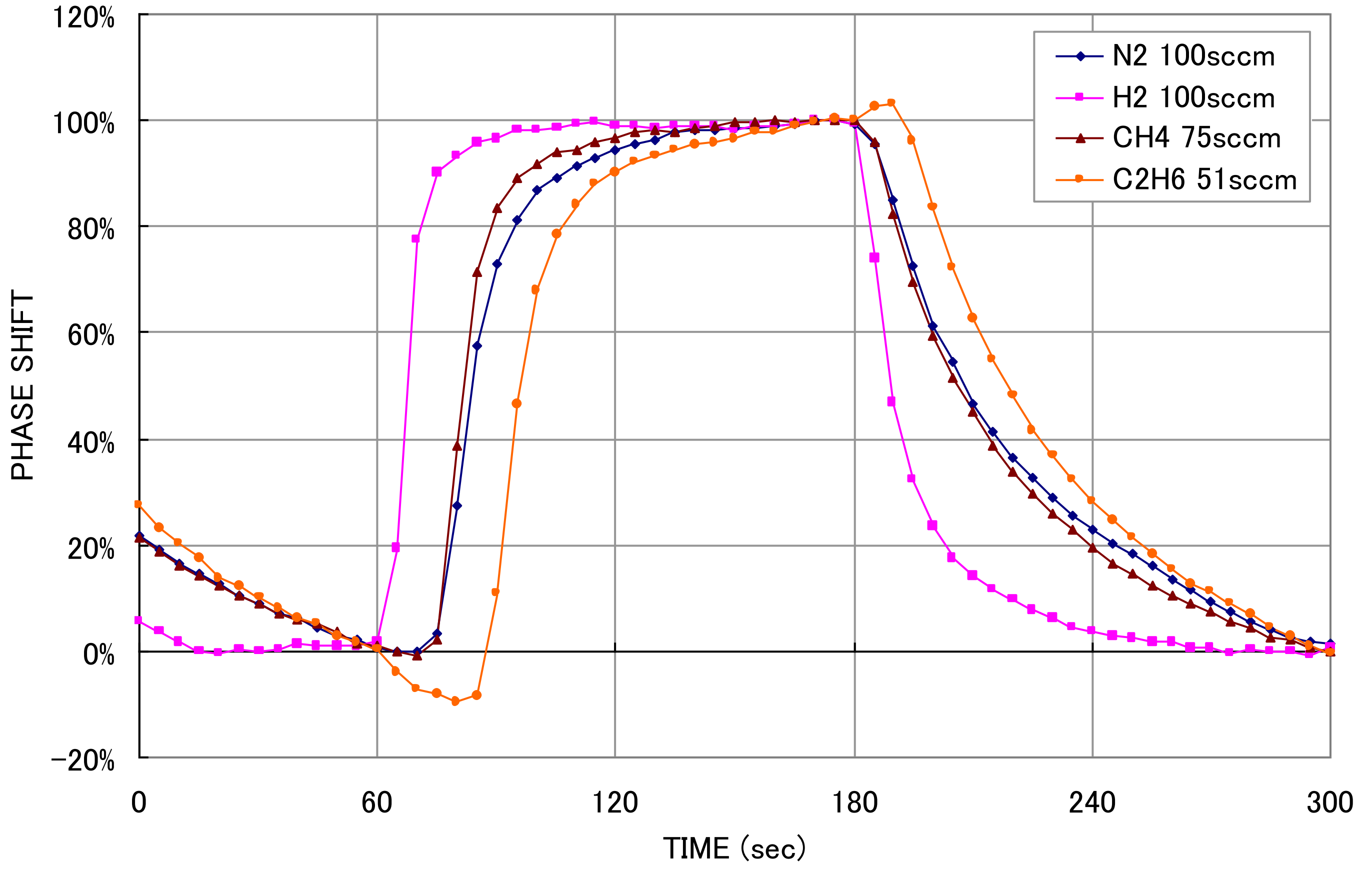
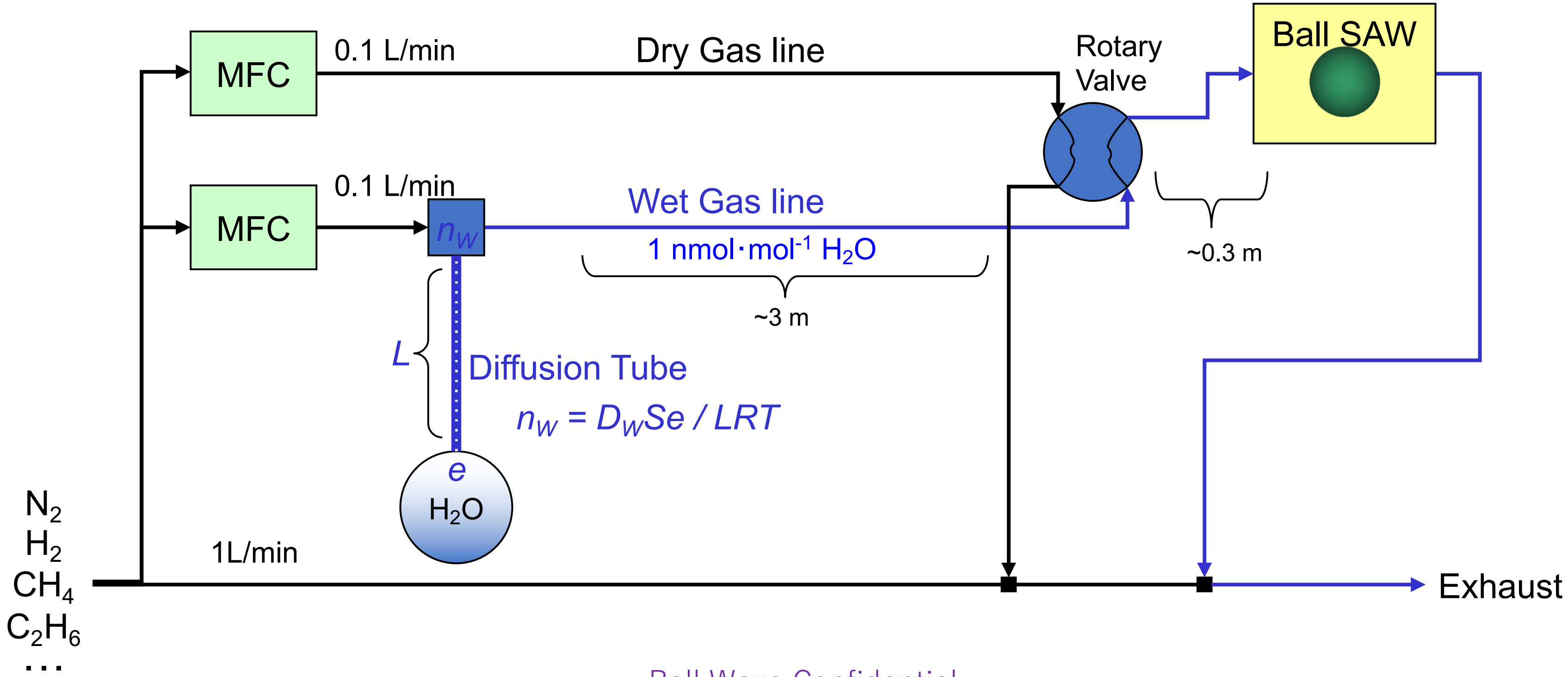
Trace moisture in hydrocarbon gases.



Transient Characteristics
@ 1ppm H_2O Injection

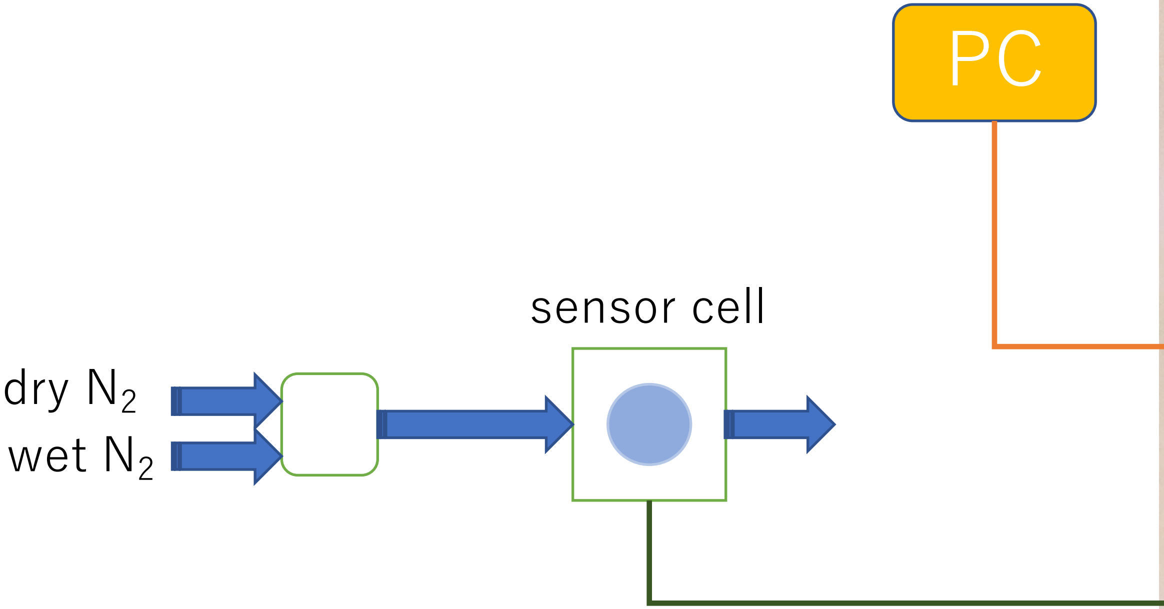
Trace moisture in hydrocarbon gases.

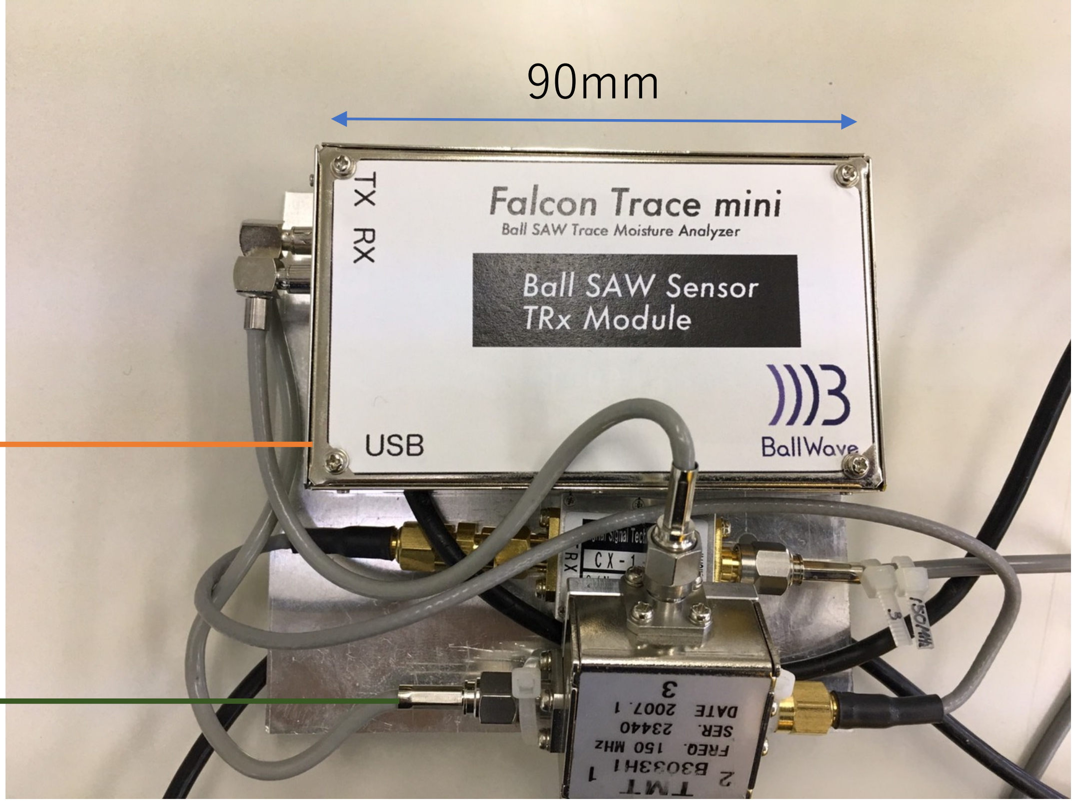
H_2O Vapor Generation   Case 2: Diffusion Tube Method



A-few-seconds spikes in the trace moisture.

- Injected dry N_2 gas and 10ppmv wet N_2 gas alternatively in 5 seconds into the sensor cell.





A-few-seconds spikes in the trace moisture.

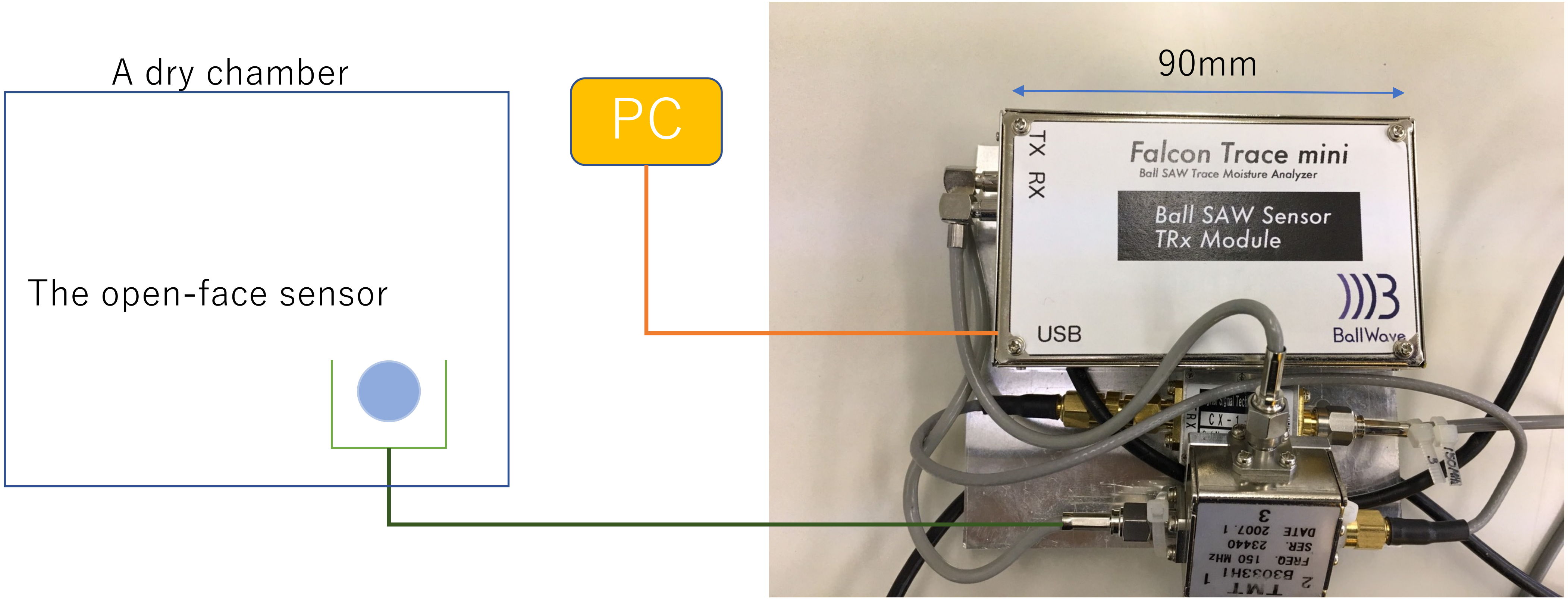
Background is not an artifact but is due to the adsorption of moisture on the inner surface of piping.

-65°C FP

-90°C FP

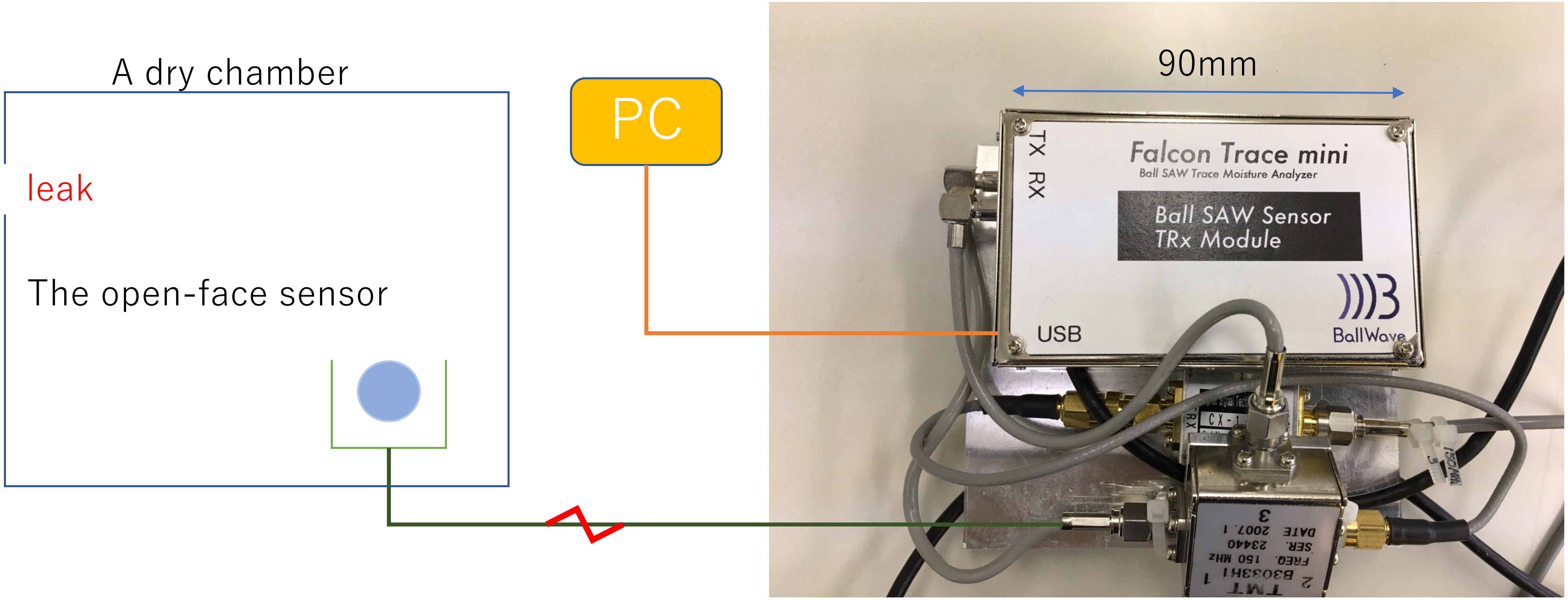
A-few-seconds spikes in the trace moisture.

The ball SAW sensor works with 0 flow rate.



A-few-seconds spikes in the trace moisture.

We can monitor a leakage in a moment.



Thank you for listening.

- We offer a unique solution for the trace moisture measurement with versatile capabilities.
- A prototype for commercial model is available now for early access.