February 27, 2023

Ball Wave Inc.
JDRONE Co., Ltd.

Announcing the world's first drone-mounted sniffer for industrial-plant irregularities

Drone-mounted ultra-miniature gas chromatograph successfully detects and identifies multiple components in smokestack gas

■ Overview

Ball Wave Inc. (Headquarters: Sendai, Miyagi, Japan; CEO: Shingo Akao) has successfully mounted a Ball Wave gas chromatograph* on a drone operated by JDRONE Co., Ltd. In tests conducted at the Fukushima Robot Test Field (RTF, a public facility operated by Fukushima Innovation Coast Framework), this autonomous flying sensor successfully sampled—and analyzed with high sensitivity—gases emitted from the smokestack of a test plant. These tests demonstrate the feasibility of using drone-mounted gas chromatographs for operational monitoring and accident prevention at industrial plants.

These results will be presented on March 17, 2023, in a joint presentation by JDRONE, RTF, and Ball Wave at the 2023 Spring Meeting of the Japan Society of Applied Physics (JSAP). This presentation was selected as a *Highlighted Seminar* (https://meeting.jsap.or.jp/highlighted) by the JSAP program committee.

* When a blend of two or more gases passes through a specialized flow path—consisting of a hollow tube wrapped around a reel and known as a *column*—the various components of the mixture are naturally separated in time. A *gas chromatograph* is an analytical instrument that exploits this temporal-separation phenomenon to identify and measure the concentrations of the constituents of gaseous mixtures. Conventional gas chromatographs are large instruments typically installed in tabletop configurations; although portable versions have been developed, their sensitivity and precision are generally inferior to those of larger instruments.

■ A breakthrough in sensing technology

Safe, efficient operation of industrial plants—such as chemical plants or power plants—

requires continual maintenance informed by frequent inspections. However, many locations in industrial plants are off-limits to human inspectors due to dangerous heights, high temperatures, or toxic gas emission. The breakthrough reported here solves this problem by mounting Ball Wave's ultra-miniature gas chromatograph on a drone operated by JDRONE (Figure 1). To ensure that the gas samples analyzed by the chromatograph are not disturbed by strong air currents from the drone's propellers, the gas chromatograph is fed by a sampling unit constructed from a 3-meter-long tube made from carbon-fiber-reinforced plastics (CFRP).

To enable the rapid sensing required for plant monitoring, the usual 30-meter length of the metallic solenoid column—the component of the gas chromatograph responsible for separating gases—has been reduced to 10 meters to shorten analysis times.

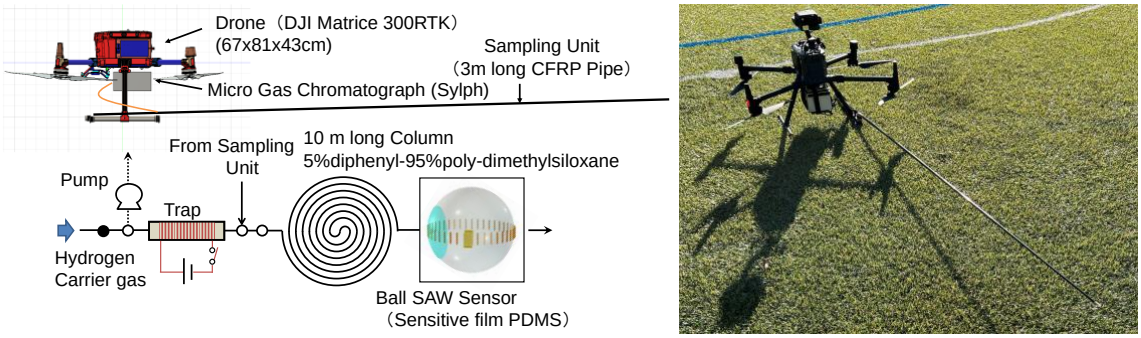

Figure 1: Drone-mounted ultra-miniature gas chromatograph with specialized sampling unit.

■ High-sensitivity analysis with short measurement times

To test the new drone-mounted sensor's capabilities for industrial-plant monitoring, experiments were conducted at the RTF chemical plant. After sampling a test gas emitted from the plant's smokestack for 30 seconds, the sensor correctly detected three compounds commonly observed at oil-burning plants—heptane (C7), octane (C8), and nonane (C9)—all in just 3 minutes including sampling time (Figure 2). After a separate procedure to calibrate the sensor, the average nonane concentration in the sampled test gas was found to be 17 ppmv (parts per million by volume). The low noise content of the detected signal allows high-sensitivity analysis with detection thresholds below 1 ppmv—*despite* the extremely challenging conditions posed by in-flight sampling of local gases. This exceptional performance is made possible by the high-precision control capabilities of the drone, which allow the sensor's sampling unit to be held in a stable position at the edge of the smokestack.

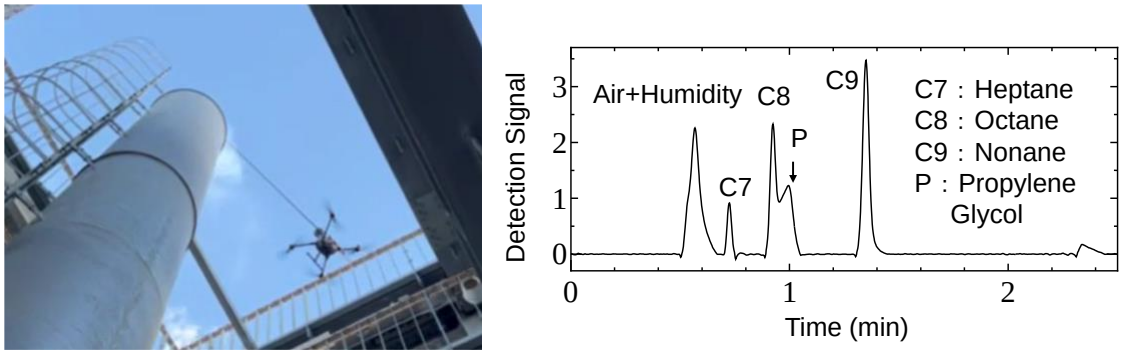

Figure 2: Smokestack from which gases were sampled (left) and results of component analysis (right).

■ Detecting irregularities in plant operation

A particularly noteworthy result of these tests was the unambiguous detection of a peak for propylene glycol (P) in the immediate vicinity of the octane (C8) peak, despite the fact that these gases have entirely different properties. Typical plants do not produce propylene glycol when operating properly; thus, this detection result demonstrates the ability of the drone-mounted sensor to separate standard gases from irregular gases indicating abnormalities in plant operation.

The key component responsible for this breakthrough in sensing technology—the first of its kind anywhere in the world—is Ball Wave's ultra-miniature gas chromatograph [1], which, at just 1.2 kg, is dramatically smaller and lighter than conventional gas chromatographs. This device, in turn, is made possible by the ball-SAW sensor, Ball Wave's proprietary sensor technology based on novel physical principles [2]. The new drone-based monitoring system will allow detection of irregularities during plant operation, helping to prevent accidents and optimize operating conditions to improve energy efficiency. More generally, this approach will also be useful for improving safety in public spaces, including preventing accidents and detecting and identifying toxic substances.

References: [1] Iwaya et al., Jpn. J. Appl. Phys. 61, SG1051 (2022).
[2] Yamanaka et al., Appl. Phys. Lett. 76, 2729 (2000).

■ About Ball Wave Inc.

Ball Wave Inc. is a startup company founded to develop the technology of the ball-SAW sensor—a chemical sensor that blossomed from technical seeds sown at Tohoku University—for high-speed, high-sensitivity detection of substances such as trace moisture and multiple gas species, thus helping to lay foundations for safe, secure, clean, and

sustainable future societies. Ball Wave develops, manufactures, and sells measurement instruments—such as trace-moisture analyzers and gas chromatographs—equipped with ball-SAW sensors. In addition to the high temperature, pressure, and corrosion resistance of crystal spheres, these sensors boast over 100 times the sensitivity of conventional technologies and significantly faster response times.

Website: http://ballwave.jp/

■ About JDRONE Co., Ltd.

With core expertise in the operational management of unmanned aerial vehicles, JDRONE offers a variety of solution services involving unmanned helicopters, unmanned airplanes, multicopters, and other unmanned aerial vehicles optimized for specific objectives and customer needs. JDRONE's unique capabilities in the field of unmanned helicopters with autonomous flight capabilities have been used for continuous monitoring of radioactive substances dispersed from the Fukushima nuclear plant after the 2011 earthquake and tsunami disaster, greatly assisting the recovery effort. In addition to operating services for multicopters—commonly known as drones—JDRONE also provides customization, maintenance, and operational instruction services.

Website: https://jdrone.tokyo/lineup/

For questions concerning this press release, contact:

Ball Wave Inc. (Contact: Takuya Mori, Administration Department)

E-mail: mori@ballwave.jp / Phone: 022-302-6659

JDRONE Co., Ltd. (Contact: Hirokatsu Hirayama, Manager)

E-mail: Hirokatsu_Hirayama.jdrone@totec.co.jp / Phone: 0244-26-6966