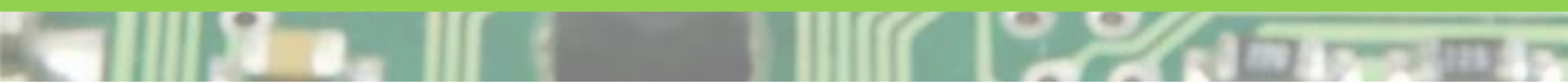
Fire Precursor Detection

～ Detection of gases emitted from printed circuit boards ～



Research Objective

In recent years, high-density packaging of electronic components on a printed circuit board has become increasingly common due to the sophistication and miniaturization of electronic products as IoT becomes more widespread. Long-term use or heat accumulation of such high-density PCBs can lead to a high risk of deterioration, which in the worst case could result in a fire. To prevent such accidents, various protection devices such as fuses are commonly used. However, none of them is 100% effective, and double or triple safety measures are required for applications that require a high level of safety, such as data servers and automobiles.

In this study, we attempted to use our semiconductor-type gas sensors, to detect the odorous gas components generated by the heat produced when an overcurrent is applied to an electronic circuit board, and found the possibility of detecting the initial abnormal stage of the circuit board before it starts to smolder or catch fire.

The gas sensors used in this study

TGS2600

TGS2602

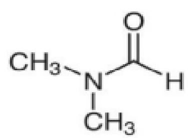
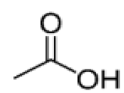
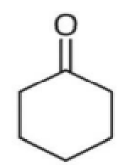
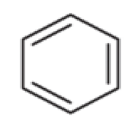
TGS2603

Research Results

1. Analysis of volatile gases produced from circuit boards

Gas chromatography and mass spectrometry analysis was performed on the volatile gases produced when five different types of circuit boards were heated to 250° C. The analysis identified different types of gases for each type of circuit board.

The gases detected can be broadly classified into the following five groups of gases. ＊Reference 3)

Classification	(a) Alcohol	(b) Amides	(c) Acidic gases	(d) Ketones	(e) Aromatic compounds
Chemical structural formula					
Representative gas	1-Hexanol	N,N-Dimethyl-formamide	Acetic acid	Cyclohexane	Benzene

Research Results

2. Selection of sensor models and optimum heater voltage

The sensitivity characteristics of each sensor model to the five gas groups at different working voltages (heater voltages) were studied to determine the optimum working voltage. The concentration of each representative gas was 10 ppm.

The sensitivity characteristics of each sensor model are shown in the radar graphs below.

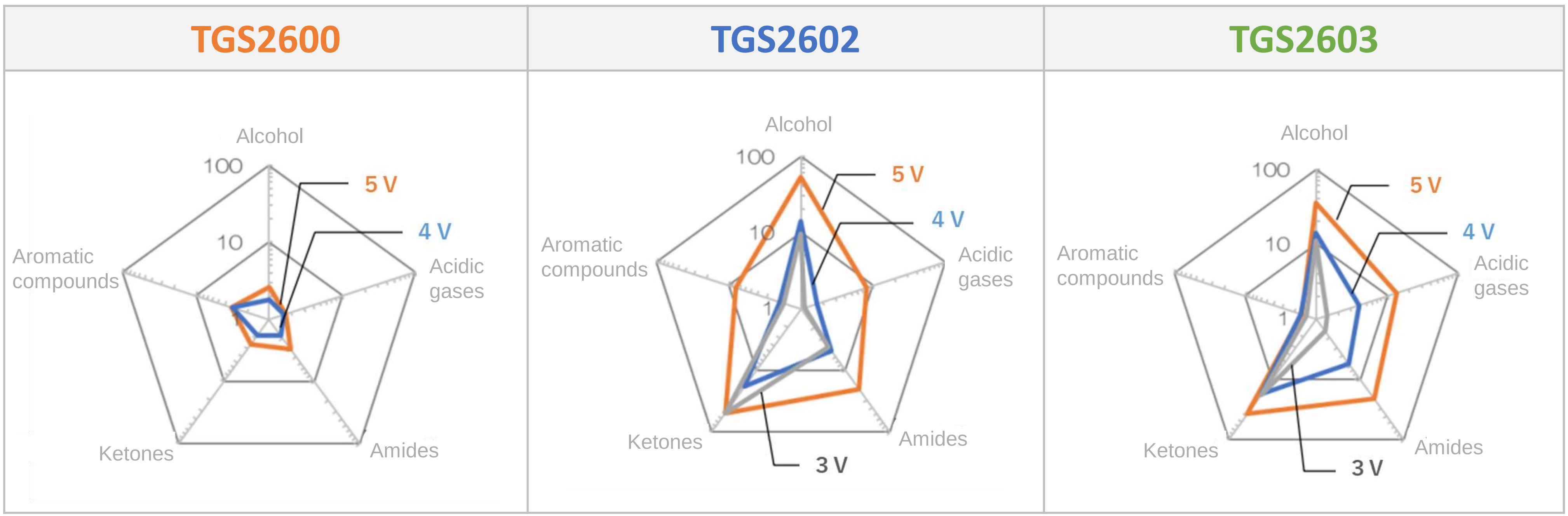


Figure 1: Sensitivities to 10 ppm of representative gases at different heater voltages (axis: sensor resistance ratio)

Research Results

2. Selection of sensor models and optimum heater voltage

The main sensitivity characteristics of each sensor model are as follows.

- **TGS2600**

The sensitivity to each gas type is relatively low at both working voltages, but well balanced.

- **TGS2602**

TGS2602 shows a similar sensitivity pattern to TGS2603. This sensor shows a well-balanced sensitivity pattern to all types of gases with increased sensitivity to aromatic compounds at the higher working voltage.

- **TGS2603**

This sensor shows low sensitivity to aromatic compounds, but higher sensitivity to alcohols and ketones at the higher working voltage.

The gas sensor characteristics required for this application are uniform sensitivities to various gases rather than high sensitivity to a specific gas. In this respect, the TGS2602 operating at 5 V is considered to have the best characteristics.

Research Results

3. Sensor responses to volatile gases generated from the circuit board

Changes in the sensor resistance of TGS2602 and appearance changes of the circuit pattern with line width of 1 mm, line length of 50 mm, copper thickness of 35 μm printed on a PCB were examined when applying an overcurrent of 12A to the PCB placed inside a sealed container.

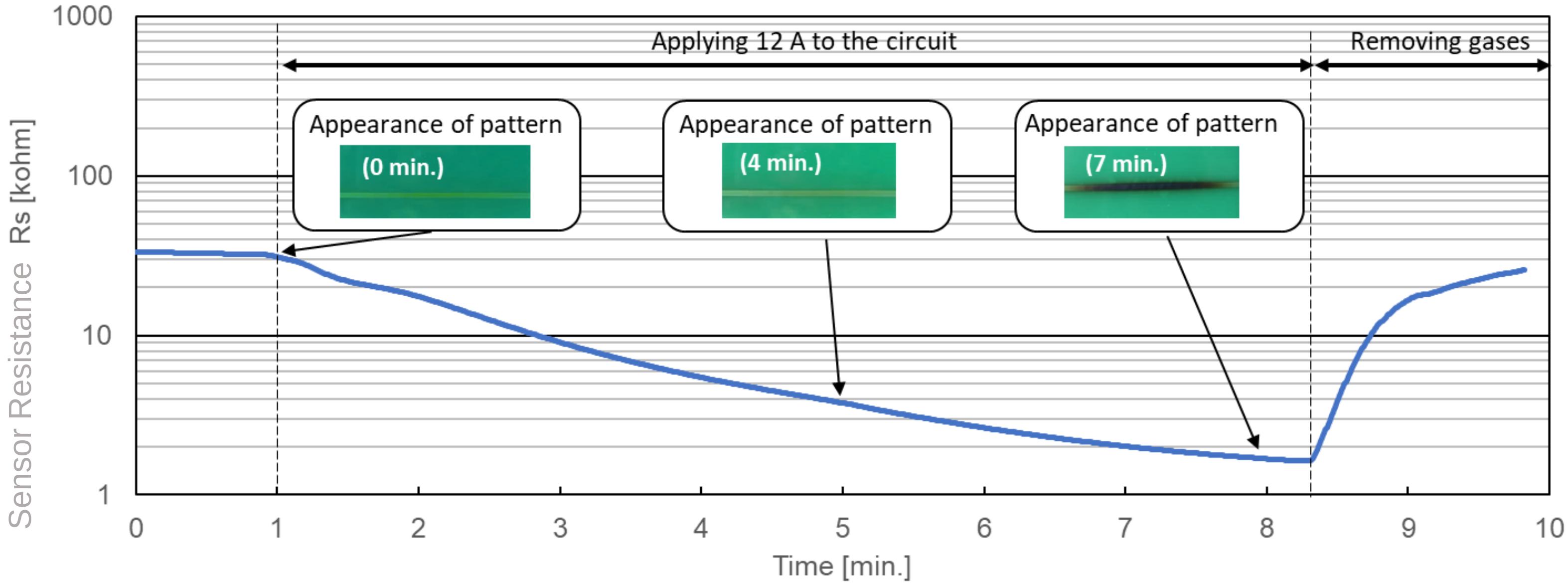


Figure2: The sensor resistance change of TGS2602 as a response to volatile gases generated from a circuit board and the changes in circuit pattern appearance by applying an overcurrent.

Immediately after the overcurrent was applied, a decrease in sensor resistance was observed, indicating the generation of certain gases from the circuit board pattern. In addition, after 7 minutes, production of a strong odor was detected, and a black discoloration was seen in the center of the circuit pattern.

Conclusion

This research suggests the possibility of detecting abnormal heat generation on a circuit board much earlier than the time to smolder or catch fire by installing a gas sensor in an enclosed space or near a potential source of odorous gases.

For example, by installing a gas sensor and a shutdown circuit that operates on the sensor output signal on a circuit board, it is expected that it will be possible to prevent system failures and minimize damage from electrical fires by detecting abnormal conditions much earlier than current fire detection systems commonly used to monitor large indoor areas.

*References.
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2) Hisao Kitaguchi , JETI, 50, 51-54 (2002)
3) Atsushi Horikawa , Yoshinobu Marumoto , The Japan Institute of Electronics Packaging , 34, 3B2-01 (2020).

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Conference presentations related to the contents of this document
■ Society of Automotive Engineers of Japan, Inc.
Academic Meeting at 2021 Autumn Conference October 13-15, 2021
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