Carbon Monoxide Gas Sensor Based on Pt/CeO_2-ZrO_2-SnO_2 Catalyst

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Carbon monoxide (CO) is one of the typical toxic gas species which causes a serious damage for human body even by the low concentration of CO aspiration, and therefore, it is important to detect rapidly the CO gas emission into air for preventing the serious accidents caused by the CO aspiration. However, since CO is a colorless and odorless gas, we always require the compact CO gas monitoring tool to check the CO gas concentration in our lives.

Until now, the various types of compact CO gas monitoring tool such as potentiostat, semiconductor, and catalytic combustion types have been developed. Among them, potentiostat type sensor has a disadvantage of using liquid electrolyte although high selectivity for CO gas. The semiconductor type sensor has also an essential problem of poor selectivity caused by the principle gas detection mechanism. On the other hand, catalytic combustion type gas sensor is one of the promising candidates for on-site CO gas monitoring tool, because this type sensor can be fabricated with a simple sensor system made by Pt coil and CO oxidizing catalyst and shows a stable sensing performance for a long period. Although Al_2O_3 loaded with Pt or Pd are widely known as the commercially available CO oxidizing catalyst, they require about 400°C for the complete combustion of CO, and as a result, commercial catalytic combustion type CO gas sensor can operate only at elevated temperatures above 400°C. However, not only CO but also other gases such as hydrocarbons and hydrogen are also burnt on the catalyst at such a high temperature, which directly affects sensor performance, and therefore, it is strongly required to lower the operation temperature of the sensor with CO oxidizing catalyst to realize selective gas detection.

In our previous studies on the environment catalysts, we have succeeded in demonstrating that 10wt% Pt-loaded cerium-zirconium-tin oxides solid solution ($10wt\%Pt/Ce_{0.68}Zr_{0.17}Sn_{0.15}O_{2.00}$) can completely oxidize some volatile organic compounds [1] at lower temperature compared to the other reported catalysts, and it is also expected to oxidize CO at low temperatures.

In this study, we applied the $10wt\%Pt/Ce_{0.68}Zr_{0.17}Sn_{0.15}O_{2.00}$ catalyst to realize a low temperature operable catalytic combustion type CO gas sensor, and its CO gas sensing performance was investigated.

$10wt\%Pt/Ce_{0.68}Zr_{0.17}Sn_{0.15}O_{2.00}$ catalyst (Pt/CZSn) was prepared by a sol-gel method [1]. Figure 1 shows the schematic illustration of the sensor cell. After dispersing the Pt/CZSn into ethylene glycol to give slurry, it was loaded over Pt coil and then heated at ca. 150 °C for 30 s to remove off the ethylene glycol and to sinter the Pt/CZSn. The test gas was regulated by mixing the 1000 ppm CO diluted with air with synthetic air, and total gas flow rate was kept constant at 40 $ml \cdot min^{-1}$. The sensing performance to CO gas (0–1000 ppm) was investigated by monitoring the DC voltage.

We have confirmed that the Pt/CZSn successfully combustion CO gas to give CO_2 at 65 °C, and therefore, we decided the sensor operation temperature at ca. 70 °C which can be realized by passing the DC current of 90 mA through the sensor element. Figure 2 depicts a representative sensor response curve observed when the CO gas concentration was varied from 0 to 1000 ppm and vice versa at ca. 70 °C. In this type of sensor, since the sensor output is obtained by the electrical resistance change of Pt coil by the CO combustion on the catalyst, we defined the sensor signal to the ratio of the resistance in the atmosphere with CO to that in the blank air (R_{gas} / R_{air}). A clear sensor response for CO gas with the response time less than 10 min (including the gas replacing time in the test tube) was observed both in increasing and in decreasing the CO gas concentration, indicating that the present sensor shows the stable, reproducible, and continuous response. Figure 3 depicts the CO gas concentration dependence of the sensor signal (R_{gas} / R_{air}). Since the sensor signal changes linearly with the CO gas concentration, it is clear that the present sensor exhibits a quantitative response for the CO gas variation at ca. 70 °C.

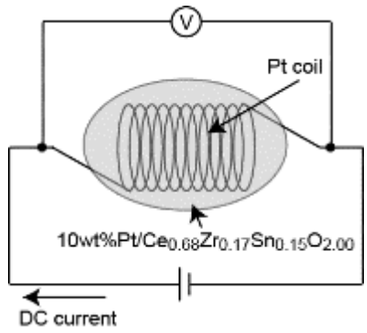

Figure 1. Overview of the present CO gas sensor applying the $10wt\%Pt/Ce_{0.68}Zr_{0.17}Sn_{0.15}O_{2.00}$ catalyst.

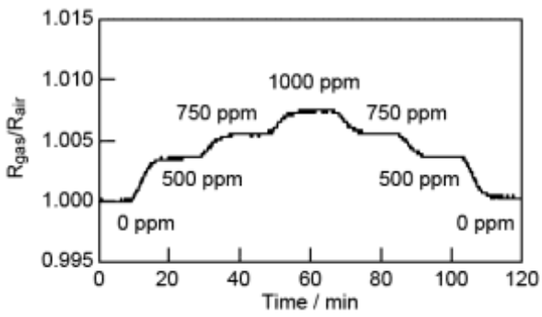

Figure 2. One of the typical response curves for the sensor with the $10wt\%Pt/Ce_{0.68}Zr_{0.17}Sn_{0.15}O_{2.00}$ catalyst at ca. 70 °C.

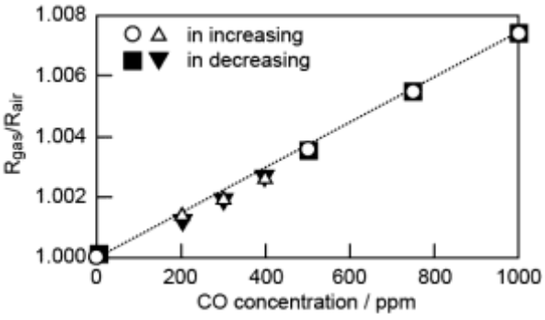

Figure 3. Relationship between the sensor signal and CO gas concentration at ca. 70 °C. The sensor signals for 200–400 ppm CO are also plotted (Δ▼).

Reference

[1] K. Yasuda et al., *Bull. Chem. Soc. Jpn.*, **85**, 522 (2012).