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Micro twinbridge Catalytic LNG Gas Sensor Reliability Performance Analysis

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Abstract—According to the special requirements of security for monitoring and features for LNG gas sensor in the long-term use of exposed during the various problems, analyzing the failure mode of LNG gas sensors and failure mechanism, related to the study of testing and analysis method of reliability assessment of LNG gas sensors do reliability intensifying test last, it concludes that effect criterion of product reliability.

Keywords-Reliability intensifying test, LNG gas sensors, reliability

1. Introduction

Along with the coal industry and petrochemical industries such as the development of energy industry, flammable, explosive and poisonous gases and type of application have been increased. This kind of gas in the production, transportation and use process, although taken a lot of safety measures, but once leakage occurs, could trigger poisoning, fire or explosion accident, seriously endangers public security and safety of the lives and property of the people

Long-term use of gas sensor is the problems exposed by the product's reliability problems. How to improve product quality, improve the sensor consistency, interchangeability and stability, and ensure the safety and reliability of the products to work, it is placed in front of scientific and technical workers a difficult problem. Quality problems forcing people to attaches great importance to study the reliability, pay attention to study the reliability in gas sensor design, development, production, management to use and maintenance of process applications.

According to the special requirements of security for monitoring and analysis of the features of gas sensor failure mode and failure mechanism, related to the study of testing and reliability evaluation analysis method, to realize for detection sensor system industrialization and applied to provide safeguard.

2. Gas sensor structure, the principle analysis

The micro twinbridge catalytic LNG gas sensor for the new Al2O3 base catalytic combustion gas sensor, and its use of MEMS technologyprocess,electrical-controlled students long Al2O3 membrane by chemical processing, glue,photolithography, micro processing, peel, modification and heat treatment process make micro twinbridge structure, as Al2O3 - H2PdCl2 - ThO - the SiO composite catalysts, realize the carrier with catalyst sensitive components (known as black piece) and a without catalyst compensation components (known as white pieces) monolithic integration, produce the LNG gas sensors. Figure 2.1 for gas-sensitive element structure diagram, figure 2.2 for gas-sensitive element quadratic encapsulation samples.

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(a) Sensor chip (b) Sensors structure

Figure 2.1 gas-sensitive element structure schematic drawing

Figure 2.2 gas-sensitive element quadratic encapsulation samples

Micro twinbridge catalytic LNG gas sensor of the working mechanism is the catalyst, under the action of combustible gas (H2, CO, CH4) with the oxygen in air happening reaction, produce homopolymer (no flame catalytic combustion heat), make the sensitive components interior temperature, platinum silk resistance increases accordingly. Therefore, as long as the determination of sensitive components platinum silk resistance change value, can test the combudstible gas concentration in the air.

3. Reliability Intensifying Test Plan

3.1. Selection of intensifying test stress

According to the investigation, this gas sensor main failure modes for: no output, the output drift, sensitivity, low response time slow, etc. Comprehensive analysis sensor failure principle, think be centralized sensitive stress test for the temperature stress, vibration stress

Gas sensor reliability intensifying test profile

3.2. Temperature stress test

Based on the routine test equipment temperature of intensifying test contains low and high temperature stepping stress test. Before the test should be based on product set low or high temperatures globe temperature, when reaching globe temperature haven't found the products of destroy limit, can stop the step test, the sample into the next step test.

3.3. low temperature stepping stress test

Input test sample 3, from 10 ℃ beginning, step of - 10 ℃, using equipment highest cooling rate. Every stage in temperature stability began after function and performance testing, after five times, ensuring through power test each test its function and performance can be fully recovered. When the product performance appear bigger change, change incrementing - 5 ℃ until find work limit, when find work will step length to limit ℃ until 2 find destroy limit, as shown in figure 3.1 test profile is shown.

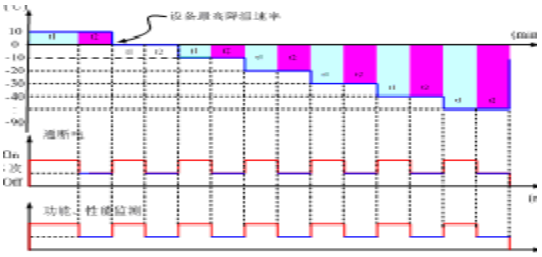

Figure 3.1 low-temperature stepping test section

Note: t1 represents temperature stabilization time (products completely cold through the time needed), t2 representation function test and five times tong power test of time.

3.4. High temperature stepping stress test

Input test sample 3, ℃ start from 30, step of + 10 ℃, using equipment highest rate of temperature. Every stage in temperature stability began after function and performance testing, after five times, ensuring through power test each test its function and performance can fully recover, until find being measured products limit, when find work will step length to limit ℃ until + 2 find destroy limit, as shown in figure 3.2 shows test profile.

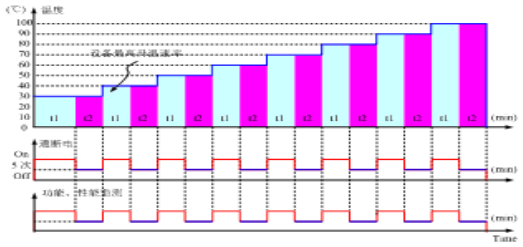

Figure 3.2 high-temperature stepping test section

Note: t1 represents temperature stabilization time (products completely heat through the time needed), t2 representation function test and five times tong power test of time.

3.5. Stepping stress vibration test

Test at room temperature, into six samples. Starting vibration for 2Grms, vibration frequency bandwidth in 2000Hz 20Hz - range, the step of 2 ~ 5Grms, use acceleration sensor monitoring of product vibration response. Each steps to keep t1 minutes to function and performance test, later again for five times, ensuring through power test each test its function can fully recover, until find being measured products limits and destroy limit.

If the vibration value to the globe vibration quantity (for example 30Grms) haven't find work to limit or destroy limit, can stop the step test. Test section 3.3 shows, as shown in figure vibration spectral type 2423.11-1997 "by GB electrical and electronic products environment test section 2: test method test Fd broad-spectral-bandwidth random vibration general requirement of the reference spectra type, as shown in figure 3.4shown.

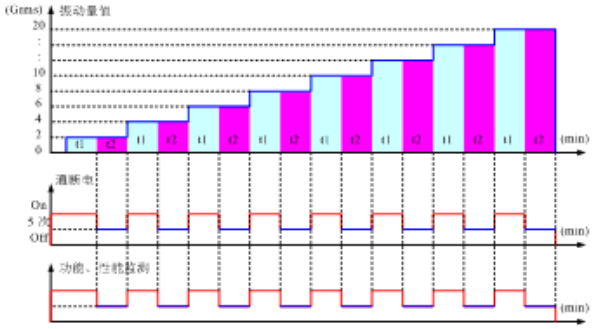

Figure 3.3 vibration stepping test section

Note: t1, t2 said test-bed vibration time representation function test and five times fluctuation electricity functional testing time. If stress method for single axis, the duration t1 should not be less than 10min, if is stress way for three axis, the duration t1 should not be less than 5min.

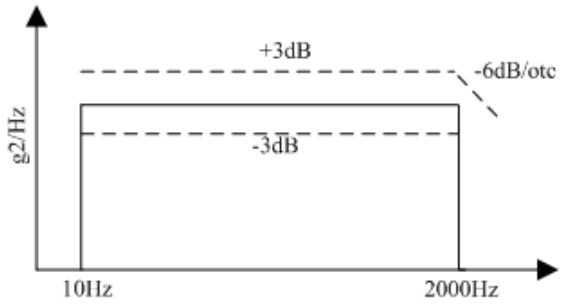

Figure 3.4 vibration stress spectrum type

Failure criterion

Parameter drift in LNG gas sensor failure modes in proportion. Among them in this article, we mainly discuss zero output with aggrandizement stress variation caused the drift, according to the LNG gas sensor precision index, LNG gas sensor with reinforced stress variation zero output failure criterion for:

$$\frac{\Delta U}{U_{FS}} \le 0.5\% \tag{3.1}$$

Among them: for corresponding aggrandizement stress change generated by zero output variation value; UFS sensor is full range output.

Namely in aggrandizement stress, under the action of sensor zero output variation exceeds 5% UFS x, judgement to failure.

(2) LNG gas sensor output zero without output namely

Other failure criterion

In the test process, should also check sensor appearance structure, if appear rupture, crack and mechanical damage also determine sensor failure.

4. Test Results and Analysis

Using the above test profile of silicon pressure sensor reliability of intensifying test, as shown in figure 5 shows. Before the beginning of the experiment of sensor for the performance test, obtain test sample in ambient environment zero output for 1V (or 4mA).

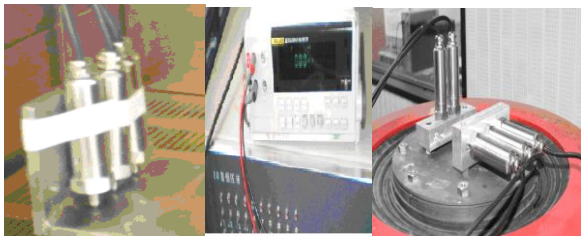

Figure 5 sensor reliability intensifying test

4.1. low-temperature stepping stress test

(1) Low temperature stepping the results

Figure 3.16 for cryogenic stepping test get sensor zero voltage output amplitude variations.

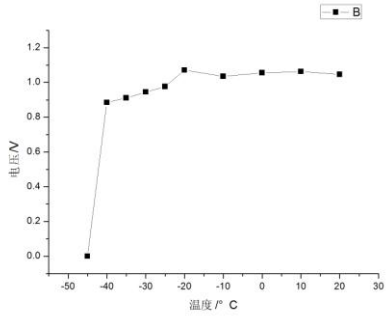

Figure 3.16 low-temperature stepping test results

When testing temperature from 20 ℃ began to 10 ℃ stride lengths dropped to - 20 ℃, the sensor of zero voltage basic stability, when sample in 25 ℃ insulation 30min, voltage suddenly dropped to 0.976 V. At this time, change the step of - 5 ℃, when testing temperature for 40 ℃, insulation 30min, the sensor output is not normal.

Will return to room temperature testing temperature sensor, after the zero voltage output, which can get back to normal temperatures of the sample for work limits, more than 40 ℃ design specification limits low 15 ℃. At this time, tentatively will temperature for the step of - 2 ℃ continue to fall, when the temperature drops to zero - 46 ℃, the sensor of zero voltage output zero, available sensors for - 46 low-temperature destroy limit ℃. When under room temperature recover after period of time, sensor output normal. The analysis indicates that appear this phenomenon is because the gas sensor gas-sensitive element internal cannot maintain normal working temperature (about 500 ℃), leading to the gas sensor doesn't work.

high-temperature stepping stress test

Figure 3.17 for high temperature stepping test get sensor zero voltage output amplitude variations.

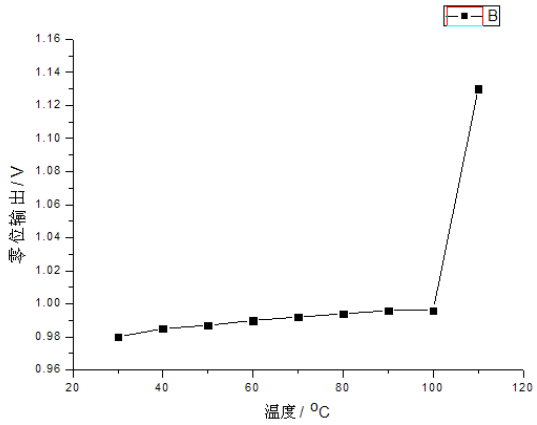

Figure 3.17 high-temperature stepping test results

When test from 30 to 10 ℃ began ℃ step bosses to 110 ℃, the sensor of zero voltage with the rise of temperature gradually increased, when sample in 110 ℃ insulation 30min, voltage rises abruptly to 1.130 V, sensor output is not normal. Put the samples under room temperature recover after period of time, the zero voltage output sensor, which can get back to normal sample of high-temperature working limits of 110 ℃ than design specification requirements. ℃ upper limit of high 40 。At this time, tentatively will temperature for the step of 2 ℃ continues to rise, when the temperature rise to 120 ℃, the sensor of zero voltage output zero, thus available sensors of high temperature destroy limit for 120 ℃. The analysis shows that the phenomenon is due to appear in SCM gas sensors, resulting in case of damage of gas sensors doesn't work. Will circuit board to dismantle the gas-sensitive element test, gas-sensitive element working normally.

complimentary

The sensor technology is currently the most rapidly growing high-tech, directly affects one of information system and industrial automation technology level. Reliability intensifying test as a new experiment technology, high efficiency, low cost, can be improved fundamentally the reliability of silicon pressure sensor, quickly get early high reliability, thereby significantly shortening product development time, improve the product's market share and competitiveness

According to the principle of intensifying test reliability of LNG gas sensors conducted reliability intensifying test. Taking gas sensor typical working environment for the basis, to accelerate the reliability of the weak link of gas sensors for the purpose, and according to strengthen stress without changing sensor failure mechanism or to introduce new failure mechanism of principle, determine the specific reliability intensifying test plan, through testing samples analysis suggests that no change not only strengthen stress sensor failure mode, and accelerate the sensor failure process, shorten test time and raise the efficiency and reliability statistics analysis and assessment for the foundation.

5. References

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