

Amorphous chalcogenide sensor unit

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It is described the electronic unit for the amorphous chalcogenide sensors. The electronic unit is designed to match a variety of sensors with chalcogenide layers of different compositions. The unit solves two problems: first - the heating of the sensor up to the designed temperature and second - the measurement of the electrical resistance of the sensor.

(Received December 23, 2007; accepted January 7, 2008)

Keywords: Electronic unit, Amorphous chalcogenide, Gas sensor

1. Introduction

The ability of the material coupled with an appropriate electronic equipment to detect the methane gas is based on the sensitivity of the semiconductor thin films to the adsorption of gas molecules on their surfaces.

The electronic unit is designed to match a variety of sensors with amorphous chalcogenide layers of different compositions. The unit solves two problems: first, the heating of the sensor up to the designed temperature and second, the measurement of the electrical resistance of the sensor.

By convenient selection of the films the sensitivity to certain gases may be increased, enabling the discrimination between adsorbed species.

The sensor unit is designed as a versatile tool in the detection of dangerous or toxic gases. The same unit may be used with different sensors, and optimized for detection of various gases. Two units may be used to detect simultaneously, e. g. CH₄ and CO, and a computer could be coupled to collect and interpret the measuring data, and, finally, providing a warning signal.

Exceeding the limit of 5000 ppm methane concentration in atmosphere creates the hazard of producing explosion in closed spaces as coal mines, underground buildings with gas pipes, industrial buildings in chemical and petrochemical industry. Such situation requires a careful control.

It is well-known that avoiding distresses, especially in mining, mainly depends on warning about the emergence of a dangerous concentration level of methane in the air. Heating safety in houses may be surveyed using gas sensors, both methane and carbon monoxide leakage being monitored simultaneously.

The electronic properties of many semiconductor films are sensitive to the adsorption of the gas molecules and thus such films can be used as gas sensors [1]. The gas adsorption modifies the carrier concentration and determines the bending of the energy bands at the film surface. The change of the carrier mobility influences the electrical conductivity, through the alteration of the potential barrier height between crystallites. In some films photoconduction as well as photoluminescence changes occur.

Conductivity may be increased or diminished as a function of penetration of the adsorption layer at different depths, thus influencing both surface and volume

properties. The layer morphology at the microscopic scale plays a significant role.

Selecting adequate layers the sensitivity to certain gases may be increased, offering the possibility to discriminate between the adsorbed gases. Often, different gases generate similar conductivity changes and therefore additional measurements, as e. g. response time or activation energy, are required to discern between different gas compositions.

It is known that SnO₂ semiconductor material used in classical gas sensors "smells" the methane gas by changing (decreasing) the electrical resistance of a thin dioxide layer in the presence of the gas. Gas sensors based on tin dioxide are of industrial concern and they were widely investigated [2].

Last years much attention was paid to glassy chalcogenide materials and polymers, as possible materials for gas (electronic nose) and liquid (electronic tongue) sensors [3-12]. ZnO:H sensors for NH₃ detection [13], as well as ceramic sensors based on BiFeO₃ nanostructural material [14] and based on magnetic oxide [15]

Polluting gases sensors, based on vaporized chalcogenide layers from dimorphite (As₄S₃) and As-Ge-Te alloys were developed by Tsiulyanu et al. [16, 17].

Resistive sensors made of chalcogenide layers yield a strong response to nitrogen dioxide and propylamine, react rapidly and have a good reproducibility. They operate at room temperature.

Humidity chalcogenide sensors based on the volume conductivity dependence of the ambient gas humidity [18] have been, also, developed.

The designed sensor unit uses SnSe₂ based chalcogenide films that are particularly sensitive to the presence of the methane gas in a polluted atmosphere.

The SnSe₂ film, processed in oxygen atmosphere, becomes active and senses the methane gas charged atmosphere by significant change (diminishing) of the electrical resistance of the chalcogenide film [19].

2. Experimental

The graph of sensor's resistance vs. temperature guided us to set experimentally the limits of variation of the measurable resistance between about 100 Ω (at 5000 ppm) and about 400 Ω (at 500 ppm) for CH₄.

These values are valid for a heating temperature of the sensor of 600 °C. For a concentration of CO in the range 300 - 800 ppm at a temperature of the sensor of 280 °C the

resistance varies between 27.6Ω and 28Ω . We determined experimentally the trip of the sensor's supply voltage, that being from 2.5 V and 10 V for a current of 2.2 A. First of all we designed a constant current generator to feed the measurable resistor and a voltage directly proportional to the measured resistance. The measured data are also transmitted to a PC enabling their digital processing. This generator is fed from a stabilized source, while the generated current is 1 mA, being adjustable in order to anneal various errors that may occur during the measuring process. The measurement must be stable with the temperature, so the 1 mA current generator must be also stable with the temperature. We succeeded a thermal stabilization better than 1 %. Such variations in measurement are fully acceptable when determining gas concentrations. The measured data are sent to a PC via an IR optical interface to the serial port COM 1 or COM 2.

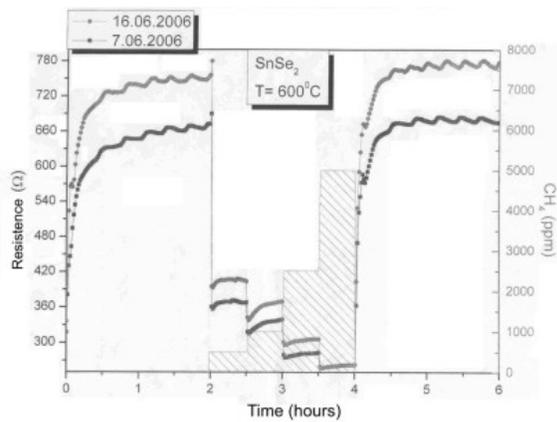


Fig. 1. Calibration graph.

A comparator, adjustable by the user, sets an upper limit of the gas concentration (which is a lower limit of the resistance) an alert level that must be notified switching on a red LED and also yielding a current signal of 5 mA at a 5 V voltage. This external signal may start a sound alert system or an other intended control. Corrections were provided to eliminate the errors due to the tolerances of the electronic components. The power supply voltage is stabilized, its variations may generate errors during the measurements.

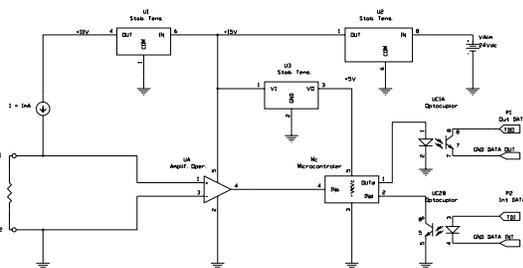


Fig. 2. The electrical scheme of the sensing unit.

The controller of the sensor heater is another stabilized but adjustable source that generates a current of maximum 2.3 A, sufficient to heat the sensor (dropping a voltage of 2.5 - 10 V on a heating resistor) up to the required temperature (e.g. 600 °C). Adjusting the voltage the required temperature may be set.



Fig. 3. Gas sensor electronic unit.

3. Results

A versatile and easy to use sensor electronic unit was designed. It consists of several modules:

- Power supply module, that provides all necessary voltages and currents for the other modules
- Sensor heating module that brings the sensor to the required working temperature and stabilizes it.
- Sensor resistance measurement module, that accurately measures the resistance of the sensor
- Output information display module, that displays digitally the measured resistance
- Device control module, that controls the unit and also transmits the information to an external PC via a serial interface
- A set of different sensors, each one matched for the detection of a different gas.

4. Conclusions

The sensor electronic unit is designed as a versatile tool in the detection of dangerous or toxic gases. The same unit may be used with different sensors, optimized for detection of different gases. Units coupled to different sensing films can be used to detect simultaneously CH_4 and CO . A coupled computer, optimize the sensor working parameters and collects the data from the units yielding the appropriate alert signal, if is the case.

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