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FIBREOPTIC HUMIDITY SENSOR USING OF $CoCl_2$ AS AN ACTIVE LAYER

The paper presents construction of the fibre optic humidity sensor with active layer based on $CoCl_2$. Dynamic properties of the sensor were examined as well as the processing characteristics.

1. INTRODUCTION

Water in various chemical and physical states is present almost everywhere and quantitive estimation of its presence plays essential role in numerous branches. Relative humidity influences to the high extent numerous chemical and physical processes. Contemporary humidity sensors are based mostly on measurements of electric parameters such as resistance, capacity or conductivity. Optical methods of humidity measurements are under increasing interest of numerous research centres.

This paper presents fibreoptic humidity sensor. Its operation is based on absorption of light passing through thin layer of calorimetric factor, covering the fibreoptic pith. This paper contains also discussion of sensors fabrication, its regeneration, measuring system and results of the measurements.

2. FABRICATION OF THE FIBREOPTIC SENSOR.

Aim of the work was the research of the light absorption by calorimetric factor $CoCl_2$. PVA – humidity sensitive polymer was selected as soldering element. $CoCl_2$ is a salt – blue in colour. After absorption of the water it gradually takes pink colour. This process can not be reversed.

Preparation of the calorimetric factor was based on powdering the crystalline $CoCl_2$ and its separation on sieves (I-st degree with diameter ϕ = 0,075mm and II-nd degree ϕ = 0,063mm). Then $CoCl_2$ was mixed with polyvinyl alcohol (PVA) in proportion 1:2 and dissolved in concentration 2 %PVA/1 %$CoCl_2$. This concentration was assumed in order to obtain highest dynamics of designed sensor [1]

Humidity sensor is made of fibreoptic with uncovered pith, which was covered by thin layer of calorimetric factor. We used standard patch cord segment with factory installed plugs. With use of special tool we cut the patch cord and uncovered the pith of fibreoptic by removing the coating and isolation together with protective kevlar fibres. Fibreoptic was uncovered on 12 cm long sector. The pith was uncovered by removing polymer coating on 4.7 cm segment.

Fibreoptic was then welded. Welding was protected from the mechanical damages and humidity by special isolating cover.

Such prepared fibre was placed in a box with specially mounted adapters compatible with ST plugs. Calorimetric factor was then placed on the fibre. Successive layers were attached after drying and evaporation of solvent.

3. REGENERATION OF ACTIVE LAYER

Preliminary measurements proved that new constructed humidity sensor presents good properties but time response strongly depends on contents of water in active layer. In order to assure fast regeneration of the sensors' properties we designed heating system of its active layer. It is composed of high power resistor (80Ω, 1.8W) in ceramic box, placed near to the fibre. In order to regenerate the active factor resistor is being connected to DC - 12V power supply.

4. MEASUREMENTS

Measurements were conducted in the circuit shown in fig. 1 and were based on registration of attenuation of optical signal measured by OPTO-METER and humidity measured by model humidity sensor (TES 1361 - with capacity sensor).

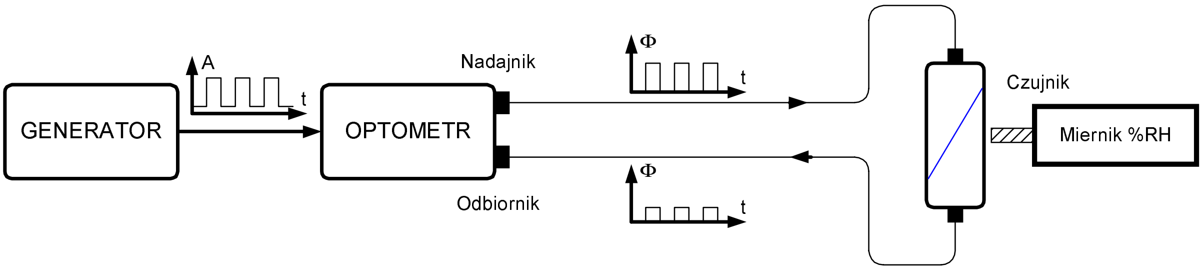

Fig. 1. Scheme of the measurement circuit

For controlling the relative humidity level in measurement chamber were used saturated solutions of various salts and also buffered silica gel [3-4]. All measurements were made in temperature 293K.

5. DETERMINATION OF STATIC CHARACTERISTICS

Measurements of particular points of static characteristic of the sensor were made after 1 hour after putting the sensor in given humidity conditions. It resulted from dynamic characteristics of the sensor. Measurements were made with use of calibrated opto-meter within 10 hours. Obtained results are presented in fig. 2.

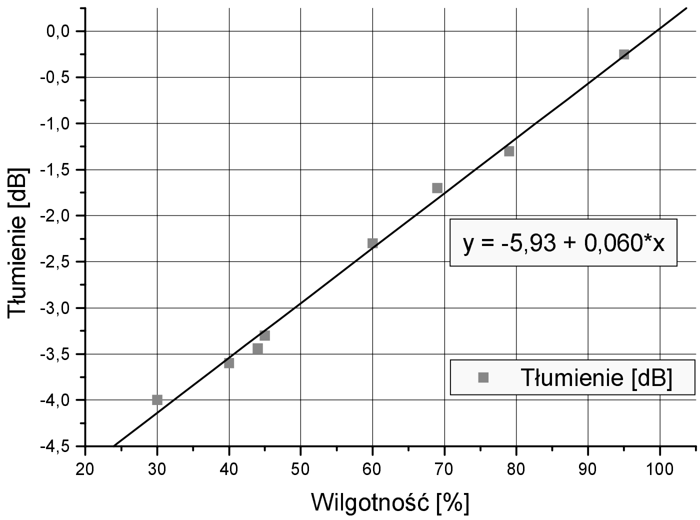

Fig. 2. Static characteristic of examined fibreoptic sensor

It is visible that increase of humidity causes decrease of the optical attenuation. The most probable approximation of the results is a straight line given by equation:

$$y = - 5.93 + 0.060*x \quad (1)$$

It can be observed that the sensor has static characteristic linearly depending on humidity. This is the result of recording the attenuation in logarithmic scale (in dB). Theoretically described dependence (1) presented exponential character. First component of dependence 2 is constant and should be equal to the difference of the calibration level at maximal and minimal (theoretically – 0 %) humidity. Second component of (2) indicates the change of attenuation in case of 1 % change of the humidity. In case of examined sensor we obtained value of 0,6dB/10 % which was satisfying result.

6. DETERMINATION OF DYNAMIC CHARACTERISTICS

Presented sensor was also examined in case of its response to the jump of humidity. Results of measurements are presented in fig. 3 and 4.

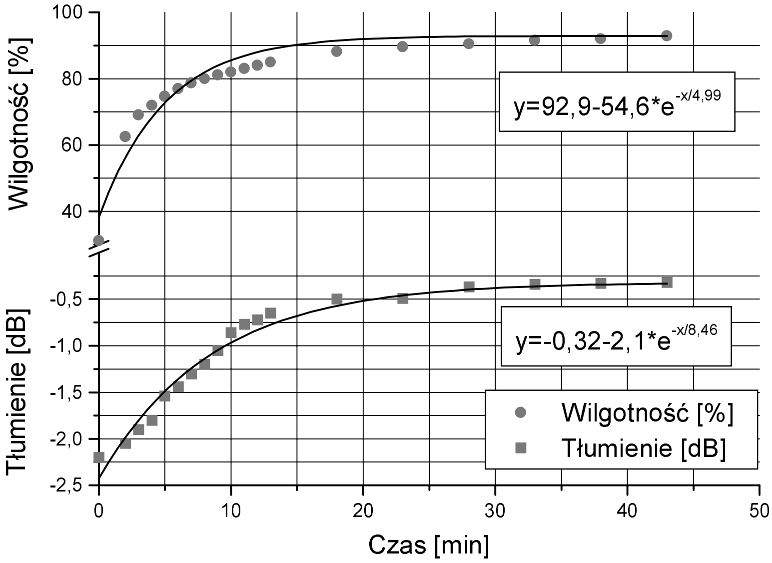

Fig. 3. Dynamic characteristics of the examined and model sensor before regeneration. Response to the rapid change of humidity

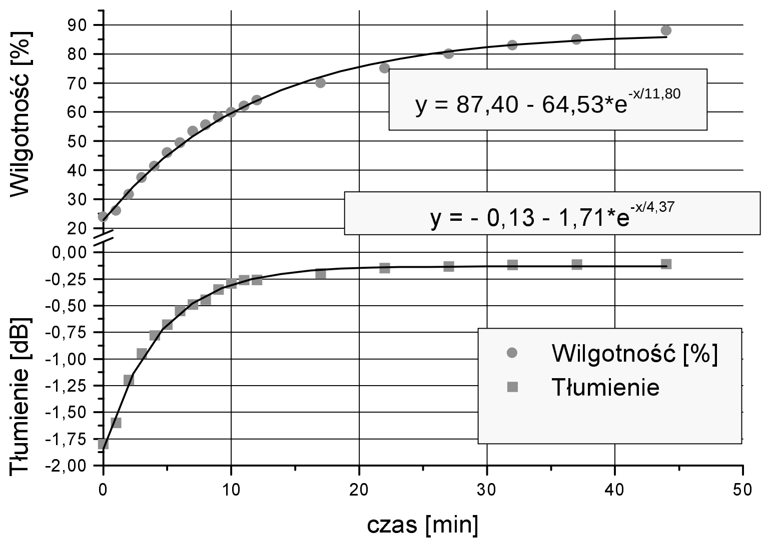

Fig. 4. Dynamic characteristics of the examined and model sensor right after regeneration

Measurements of dynamic characteristics were based on registration of humidity and attenuation. At the beginning of the measurement process measurements were recorded every 1 minute and after 15 minute every 5 minutes.

Measurements were made for two jumps of humidity (54,6% and 64,5%). Second measurement was made after regeneration (heating) of the sensor. Model sensor was also regenerated by heating but in this case we observed disadvantageous influence of this process on time constant of the sensor (fig. 3 and 4)

Measurements of dynamic characteristics in case of humidity jumping down were also performed. In this case response of the sensor was very long (about 40 minutes). This observation effected in designing the regeneration resistor that makes possible successive measurements of humidity in relatively short time intervals.

7. CONCLUSION

All characteristics presented in this paper were prepared and visualised with use of ORIGIN package. Obtained results were approximated by the first order inertia function and the formulas for particular measurements were attached to the graphs. Time constants for fibreoptic and model sensor were also put on presented graphs for each measurement.

Analysis of time constants of the sensor's answer proves that better dynamic properties are observed when measurements are made after regeneration of the sensor. In such case time constant decreases almost 50 % (8,46 min before and 4,37 min after regeneration). Regeneration of the model sensor gives inverse effect i.e. time constant increases over 50 % (4,99 min before and 11,80 min after regeneration).

Simultaneous measurements with use of model sensor and regenerated fibreoptic one gave almost similar values of time constants (4.49 min – model sensor, 4,37 min – examined sensor)

New designed fibreoptic sensor of relative humidity presents satisfactory values of basic parameters but still requires further experiments in order to improve it.

8. REFERENCES

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