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FIBRE-OPTIC HUMIDITY SENSOR WITH ACTIVE ELEMENT BASED ON $CoCl_2$

Construction of fibre-optic humidity sensor with active element based on $CoCl_2$ is presented in the paper. Static and dynamic characteristics were also determined for the sensor.

Запропоновано конструкцію оптоволоконного сенсора вологості з активним елементом на основі $CoCl_2$. Визначено статичні і динамічні характеристики сенсора.

Introduction

Water in various physical and chemical forms is present almost everywhere and estimation of its quantity plays a very important role in numerous applications. Relative humidity influences many physical and chemical processes. In most cases humidity sensors are based on measurements of electric parameters such as resistance, impedance, capacity conductivity etc. During last couple of years many authors reported their researches upon fibre-optic methods of humidity sensing [1-4].

This paper contains presentation of fibre-optic relative humidity sensor. Its operation is based on light absorption by thin layer of calorimetric factor - PVA/$CoCl_2$ being a part of fibre-optic channel. Realisation of the sensor as well as measuring arrangement and results of the measurements are included in the paper.

Operation of the sensor

Rule of operation of the sensor is based on well known phenomenon – change of colour of the calorimetric factor being a result of absorption of water present in the air. Solution of PVA/$CoCl_2$, placed between heads of fibre-optics, changes colour and at the same time changes the amount of light passing through the fibre.

The amount of light passing between the heads strongly depends on colour of calorimetric factor and, what is obvious, it is correlated with the amount of water in the air. Change of the colour of the detection layer from blue to pink evokes the change of passing light intensity (change of attenuation measured by observer)

Implementation of the sensor

Typical multi mode patch-cord G62.5 produced by OTO Lublin was used for the sensor preparation. This type of fibre is covered by double layer of acrylic coat what makes this fibre-optic very resistive for mechanical treatment such as bending and scratching.

Patch-cord was cut into 2 equal sections. After removing the primary and secondary protection layers, at the sector of 2mm of each fibre, the marrow was gently exposed at the sector of 1mm. Next step was preparation of aluminium substrate for assembling the head of the sensor (fig. 1). Aluminium plate 1cm wide and 2cm long was fraised in order to obtain a groove shaped as V letter. In the centre of the groove a small hollow was formed to play role of calorimetric factor reservoir.

Fig. 1. Head of the sensor.

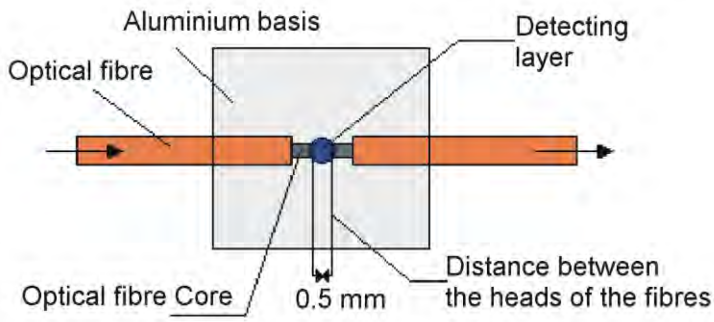

Fig. 2. Construction of the sensor.

Previously prepared fibres were placed on aluminium basis and exposed part of the core was placed in the centre of hollow. V-groove was used to centre the heads of the fibres. Centring of the fibres was controlled by constant measurements of attenuation. Little space between the heads of the fibres was left (0,5mm) in order to assure the place for the calorimetric factor PVA/CoCl2 (fig. 2). Calorimetric factor was added with use of syringe and thin needle.

Remaining parts of the fibres were mounted to the basis with use of water proof and thermally resistive glue. Such prepared sensor was placed inside closed box (fig. 3) in order to avoid accidental damage and eliminate influence of external light. Numerous wholes were made in the box in order to assure circulation of air. Two ST adapters were added in order to connect the unit to measurement equipment.

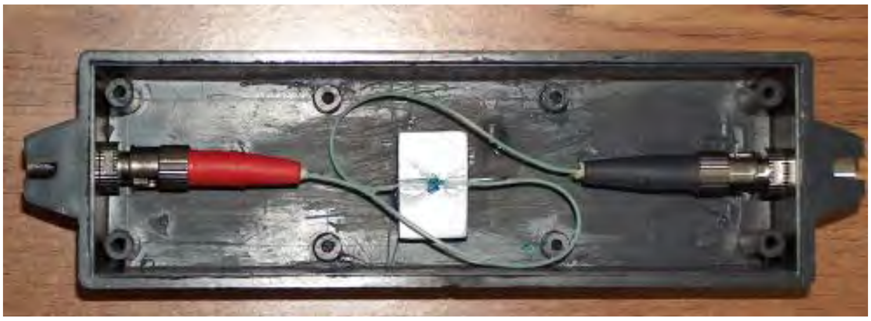

Fig. 3. Assembled sensor

Measurements

All measurements of attenuation, humidity and temperature were performed with use of measuring system presented in fig 4-5. Measurements were based on recording 2 values - attenuation of new designed sensor and relative humidity measured by TES 1361 treated as standard meter. Both instruments were placed in measurement chamber – glass vessel filled by saturated solutions of various salts preserving constant tension of water vapours and constant relative humidity. Following salts were utilised: Lithium Chloride (23.6 %RH), Zinc Chloride (31.1 %RH), Calcium Chloride (43.2 %RH), Chrome Trioxide (45.5

%RH), Magnesium Acetate (84.2 %RH), Potassium Nitrate (88.8 %RH). Temperature was stabilised in the range of 23-23,5 °C.

In case of dynamic measurements additional chamber (with artificially created low relative humidity) was used. Measurements were performed after rapid moving of the sensors from the environment of low humidity (additional chamber) to higher relative humidy environment.

Fig. 4. Measuring System

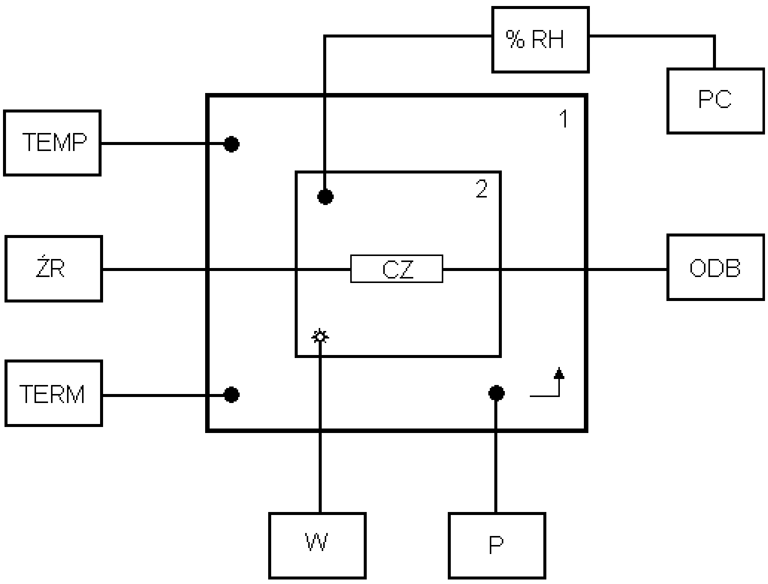

Fig. 5. Block diagram of measuring system:
1 – vessel with water ; 2 – measurement chamber;
ŹR – light source Megger MLS 1000; ODB – attenuation meter Megger MPM 1000;
%RH – relative humidity meter Data Logger type TES 1361;
PC – computer with RS-232 port; P – water pump; W – ventilator;
TERM – thermostat with heater; TEMP – temperature meter; CZ – researched sensor.

Determination of static characteristics

Measurements were performed after minimum 1 hour since the sensor was placed in given humidity conditions. This procedure resulted from observations of dynamic characteristics of researched sensor.

Values of humidity were recorded by model humidity meter TES 1361. At the same time values of attenuation of fibre-optic sensor were recorded by MPM1000 meter.

Recorded values are presented on fig. 6.

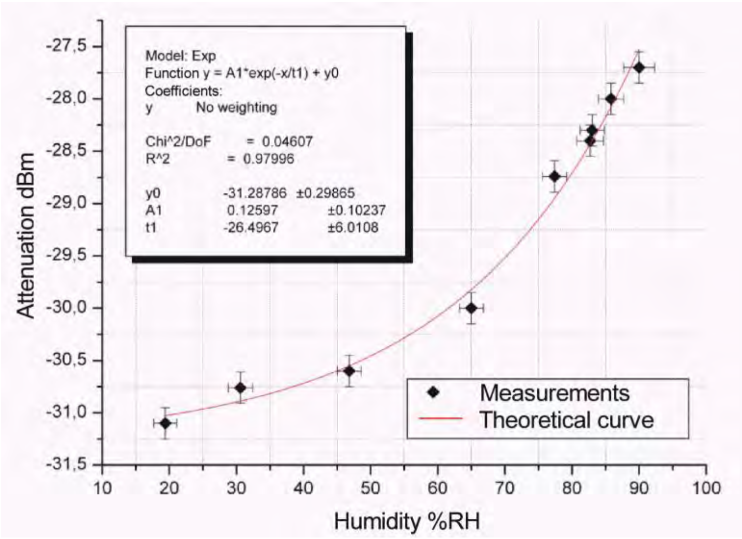

Fig. 6. Static characteristic of researched sensor.

As one can notice increase of the humidity results in decrease of attenuation.

Determination of dynamic characteristics

Dynamic response of the sensor on rapid increase/decrease of humidity (jump conditions) was also investigated. As in case of previous measurements two values (humidity and attenuation) were measured with use of the same devices. Results of measurements are presented in fig 7-8

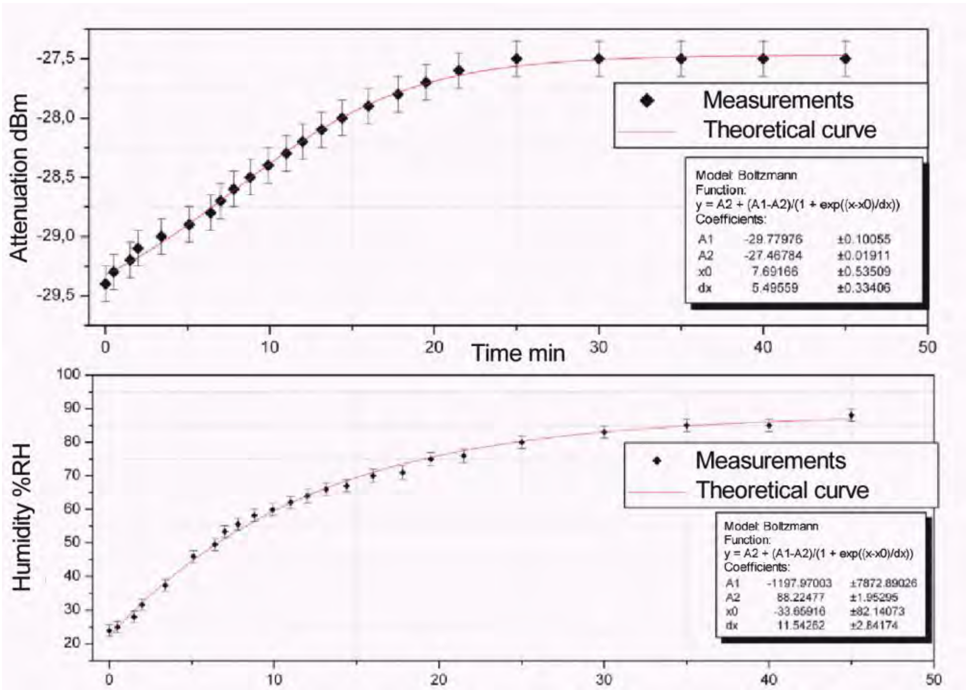

Fig 7. Dynamic characteristics of researched fibre-optic sensor and model humidity meter (before warming) Response for the jump increase of humidity.

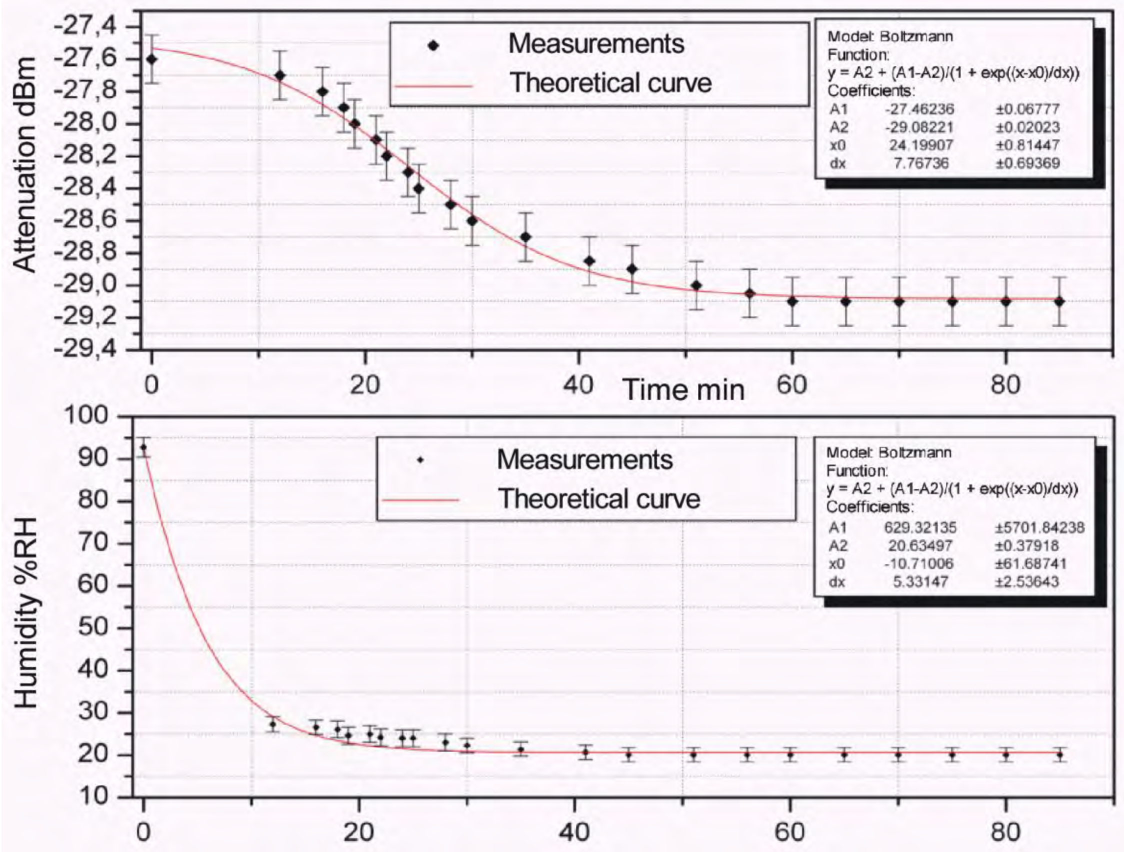

Fig 8. Dynamic characteristics of fibre-optic sensor and model humidity meter (before warming). Response for jump decrease of humidity.

Resume

All characteristics were visualised with use of ORIGIN software. Parameters of models for each measurements are attached to the draws.

Analysis of obtained results (fig 6) let us state that new constructed humidity sensor presents higher sensitivity in the range of higher humidities. The most appropriate model solution is given by equation:

$$y = A_1 \cdot e^{\frac{-x}{t_1}} + y_0$$

Analysis of dynamic characteristics let us state that the most fitting theoretical model is based on Bolzman's equation:

$$y = A_2 + \frac{A_1 + A_2}{1 + e^{\frac{x - x_0}{dx}}}$$

Time of stabilisation in case of jump increase of humidity (fig. 7) is 25min and is lower then in case of model humidity meter (45min). In case of jump decrease of humidity (fig. 8) time of stabilisation was 60min which is much worse result then in case of model meter (45min). This fact was caused by slow evaporation of water from calorimetric factor.

Time constant for the transition from high to low humidity is 7.76min and is higher then in case of model meter (5.33min). Lower value of time constant was obtained in case of transition from low to high humidity – 5.49min (11.54min for model unit)

New designed fibre-optic humidity sensor presents satisfactory parameters but still demands further researches in order to improve its performance.

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ПРИСТРІЙ КАРТОГРАФУВАННЯ МАГНІТНОГО ПОЛЯ ЦИКЛОТРОННИХ МАГНІТІВ НА ОСНОВІ МАТРИЦЬ ХОЛЛІВСЬКИХ СЕНСОРІВ

Проаналізовано задачу картографування магнітного поля в циклотронних магнітах. Особливістю цієї задачі є високопрецизійне вимірювання неоднорідного магнітного поля багатоканальними магнітометрами на основі матриць радіаційностійких холлівських сенсорів (похибка – не більше 0.01%). Розкриті нові рішення щодо побудови таких вимірювальних пристроїв, а також структура та результати апробації розробленого картографа Mapper-MSL.

The task of magnetic field mapping in cyclotron magnets is discussed. The feature of this task is the high precision measurement of non-uniform magnetic field by multi-channel magnetometers on the base of a matrix of radiation stable Hall sensors (error – less than 0.01%). New solutions toward developing such measurement devices, as well as, structure and approbation results of developed Mapper-MSL device are shown in article.

Вступ. Формулювання та аналіз проблеми

Однією з прогресивних методик лікування ракових пухлин вважається імплантація в пухлину іонів, зокрема кремнію. Беручи до уваги, що глибина проникнення іонів у тіло пацієнта повинна бути достатньо великою, необхідно використовувати достатньо потужні прискорювачі. Під час експлуатації таких прискорювачів виникають значні дози проникаючого випромінювання, що обумовлює проблему погіршення надійності функціонування вимірювальної апаратури, зокрема для магнітного поля систем відхилення та сепарації іонів.

Особливої актуальності ця проблема набуває під час створення прискорювачів на компактних циклотронних магнітах. Необхідною умовою успішної експлуатації циклотронних