- **Bilaterally cooperation between romanian and germany parts**
- **Title project no. 333/08.10.2009: Preparatory –project smart miniaturized sensor-system for water treatment Pre-SenSyWa**
- **For proposal project FP7 submit to Bruxelles at 27.10.2009 with title: Smart miniaturised <u>sen</u>sor-<u>sy</u>stem for <u>wa</u>ter treatment SenSyWa**
- Romanian partner: National Institute for R&D in Electrical Engineering ICPE-CA , Bucharest, ROMANIA
- General Manager: Prof. PhD Phys. Wilhelm Kappel
- Project manager: Dipl. Eng. Gabriela Telipan
- Germany Partner: ARTEOS GmbH Seligenstadt Germany,
- General manager Dipl. Eng. Winfried Korb

1.1. Concept and objectives

The aim of this collaborative research project smart miniaturized sensor –system for water treatment SensyWa consists in the task of this multi sensor system for measuring of cleaned water in decentralized waste water cleaning plants. Our reason for this project is a cheap smart miniaturized sensor-system for water treatment. This system sensor measure all the important data (turbidity, ammonium and phosphorous) with one system. Our innovative method is to develop nano structured materials for the different sensor cells and create a new multi sensor with a innovative approach of micro-nano-integration.

1.2. Progress beyond the state-of-the – art

Urbanization, which is proceeding at an accelerated speed around the world, has posed several new problems before urban residents. Inadequate water supply and poor water quality have been provoking serious contemporary concerns for many municipalities, industries, agriculture, and the environment. Communities are thirsty for potable as well as process waters. It has not been possible for communities living in the suburb to get even 10 L of water per person per day. On one hand, there is an escalating demand for water for domestic, agriculture, as well as industrial purposes. On the other hand, the available water is getting deteriorated as a result of disposal of domestic and industrial effluents.

Disposal of partially treated and mostly untreated effluents into rivers and lakes and run off from urban and agricultural areas are the two main reasons responsible for deterioration of drinking water resources. In addition, excessive withdrawals of water for agricultural and municipal utilities as well as use of rivers and lakes for religious and social practices, as well as perpetual droughts limit the capacity of river for dilution of wastes.

For the cleaning of waste water wee need waste water plants. The past concept was to clean all the waste water in centralized waste water plants. In last few years the experts become more and more understanding the centralized way for all tasks is very expensive. The new approaches are decentralized waste water plants for decentralized areas.

There are several ten-thousand of decentralized waste water plants only in Germany. In other European countries we have the same situation. Approximate over 90% of this decentralized waste water plants have no cleaned water control. Nobody knows is the water full cleaned or not. No body knows the rate of pollution. In the future the government will know this rate of pollution. All the owner of the decentralized waste water plants need a monitoring system. The basis of this monitoring system is a sensor system for measuring of the rate of water cleaning.

There are several sensors on market for this basis monitoring system but not a system of sensors. Actual we need for every measuring type (turbidity, ammonium , phosphorous sensors)one sensor (Fig.1) and most a transducer for a signal type (Fig. 2). This is very expensive in comparison to the cost of a decentralized wastewater cleaning plant. For example one sensor for C-measuring cost approx. 500,- EURO (and more), the whole decentralized wastewater cleaning plant costs approx. 3.500 EURO.

Fig.1: Several water sensors, length ~150 - 200 mm; Ø ~ 12 mm (source JUMO / Germany)

Our reason for this problem is a cheap smart miniaturised sensor-systems for water treatment. This sensor system SenSyWa measure all the important data (turbidity of water, ammonium, phosphor sensors) example of this kind of sensor is customized multi sensor system from Sensortechnics GmbH / Germany (Fig. 3). This example sensor combined only three sensors and is to complex and to large.

Fig.2: Electronic transducer for N and temperature signal evaluation (source JUMO / Germany)

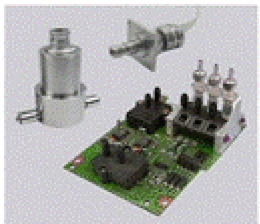

Fig. 3: Customized multi air-sensor system (source Sensortechnics GmbH / Germany)

Fig. 4 Multi Gas sensor (not for water) (source FZK/Germany)

Our innovative way is to develop nano structured material and combine this to a sensor cell with the approach of micro-nano-integration new sensor cells. A good example for that kind of sensor is a multi gas sensor from FZK/German (Fig.4)

The two partners in this collaborative research project "SenSyWa" Arteos and ICPE-CA have the know-how in sensors, microelectronic, micro- and nanotechnology, packaging and micro-nano-integration. So, we can do the work and build the basic for the FP7-proposal "SenSyWa". Fig. 5 and 6 show the sensors for CO_2 detection with sensitive layer semiconductor oxides CeO_2-Nb_2O_5- fig. 5 and sensor and apparatus for CO_2 detection in air with polymeric sensitive layer organo-siloxane supramolecular polymer– Fig. 6 produced in ICPE-CA. Fig. 7 and 8 present the flow rate gas sensor wires Ø 1µm + 10 µm- Fig. 7 and the nano wires gas sensor, wire-diameter = 300nm- Fig. 8 .

Fig. 5: Sensor for CO_2 detection with oxides sensitive layer (source ICPE-CA)

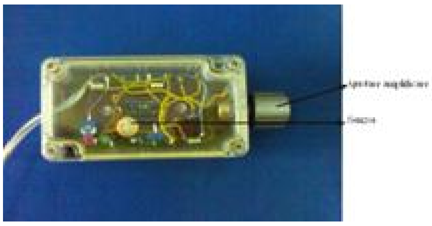

Fig. 6. Sensor and apparatus for CO_2 detection semiconductor with polymer sensitive layer (source ICPE-CA)

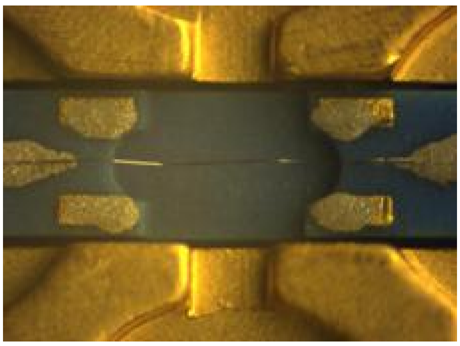

Fig. 7: Flow rate gas sensor , wires Ø 1µm + 10 µm(source Arteos)

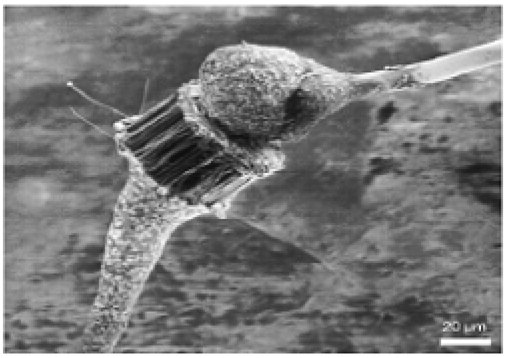

Fig. 8: Nano wires gas sensor, wire- diameter = 300nm, (source Arteos

1.3. Methodology and associated work plan

1.3.1. Turbidity sensor

Principle operation

Turbidity sensor is made by using an optical principle. An optical transistor and optical diodes, working together and measures the turbidity. Two differential amplifiers AMP 03, [1] and high precision reference AD 580 is used to build schematic diagram, (the design electronic conditioning for turbidity sensor). The AMP 03 is a precision, high speed differential amplifier. Incorporating a matched precision thin film resistor network, the AMP 03 features stable operations over temperature without requiring expensive external components. The positive continuous voltage of 2.5 V_{cc} given by the specialized circuit AD 580, [2], Analog Devices, is applied to the operational amplifier integrated circuit AMP 03, used in inverter connection. The differential amplifier topology of the AMP 03 provides extremely high rejection of the common mode input voltage [3]. Common mode rejection (CMR) is 100 dB typical and slew rate approximately 9.5 V / µs type.

References

1. Analog Devices, Precision, Unity – Gain Differential Amplifier, AMP03, 2003.

1. Analog Devices, High Precision, 2.5 V IC Reference, AD 580, 2004.

2. Charles Kitchin and Lew Counts, "A Designer's Guide to Instrumentation Amplifiers, 3ND Edition, 2006 Analog Devices, Inc. Printed in U.S.A., pp 6-23, 24, 25.

1.3.2. Ammonium sensor

Impedance sensor- operation principle

Structure sensor SAW (sensor acoustic wave)

An impedance sensor for the determination of ammonium in aqueous solution is realized by using a series piezoelectric crystal (SPC) a quartz crystal ST device or lithium niobate crystal, which is constructed by connecting of the piezoelectric crystal with a probe in series. The probe is filled with an internal electrolyte solution that is separated from sample solutions by a gas-permeable membrane. Such a gas sensor based on the SPC device can overcome the influence of water vapors efficiently and can be used in the determination of ammonia in water..[1]. A SAW sensor consists by a device coated with a organic sensitive layer for ammonium like L-glutamic hydrochloride [2], or polyaniline layer [3]. The proposed sensor exhibits a favorable frequency response to 5×10^{-7}–1×10^{-3} mol l^{-1} NH^{+}_{4}. The limit of detection is 1×10^{-7} mol l^{-1}.

References
1.Yuanjin Xu, Changyin Lu, Yan Hu, Lihua Nie and Shouzhuo Yao**, “** Impedance sensor for dissolved nitrogen oxide using a series piezoelectric crystal device**”,** ***Analyst***, 1996, **121**, 883 – 886.
2. Chi-Yen Shen, Cheng Liang Hsu, Jiu-Shing Jeng, „ Shear horizontal surface acoustic wave resonators for ammonia detection”, *Proceedings* of the 9 the International Conference on circuits, 2005, paper 25.
3. Yu-Tang Shen, Cheng-Liang Huang, Long Wu,:” Using Shear Horizontal Surface Acoustic Wave with Polyaniline Film as Ammonia Sensor”, *Jpn. J. Appl. Phys*. 44 (2005), pp. 1844-1846.

1.3.3. Phosphorous sensor

Principle operation

The sensor incorporates microfluidic technology, colorimetric detection and wireless communications into a compact and rugged portable device. The detection method used is the molybdenum yellow method, in which a phosphate-containing sample is mixed with a reagent containing ammonium metavanadate in an acidic medium. A yellow coloured compound is generated and the adsorption of this compound is measured using a light emitting diode (LED) (370 nm) light source and a photodiode detector. The absorption is directly proportional with the phosphate concentration in the original sample.
All channels are 200 nm in width and depth. The material of the the chip is PMMA (poly methyl methacrilate) The chip layer are bonded using a pressure sensitive adhesive . The tubes are inserted into the inlet and outlet ports and are held in place using epoxy adhesive resin [1,2]

The characteristics of the sensor

Good linearity in the range measurement: o-50 ppm phosphate
Limit detection 3 ppm
Response time: max. 2 minutes

References
[1]. John cleary, Conor Slater, Dermot Diamond, “ Analysis of phosphate in waste water using an autonomous microfluidics based analyzer”, World Academy of Science, Engineering and Technology, 52, (2009), pp. 1996-1999.
[2]. Cristina McGraw, Shannon Stitzel, Dermot Diamond, “ Autonomous phosphate sensor for environmental monitoring”, Dublin University, 2005

1.4. Dissemination

All partner involved in this project participle of the dissemination of results by:

- Participation of the international workshop, conference, symposium and congress with the papers about the field of the project with publication in Proceedings of the scientific
- Publication of scientific papers in the international journals with data base like:
- ISI, Thomson Scientific master Journal List, The British Library, EBSCO´s “Computers and Applied Sciences Complete.
- Participation of the international exhibition with the products resulted from the project research;

- Elaboration in common or each partner at the patents minim 10 international patents;
- Publication at international publishing house of books with the system of microsensors for treatment water subject;
- Elaboration of CD-ROM with the project research;
- Web page with the results of the project SenSyWa;
- Elaboration for universities of courses, dissertation and theme doctorate.

1.5. Impact

Impact on the competitiveness of the proposers

The consortium for the project SenSyWa is make by the 2 SME companies ARTEOS GmbH Germany, Meltec Systementwicklung Germany, an national research institute ICPE-CA Romania and 2 university Technical University of Crete and Technische Universität Wien Austria. The partner involved in this project have great experience in water treatment. **ARTEOS GmbH Germany**

Economic justification

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Contribution to Community societal objectives

Objectives for community societal obtained by the results research of the project SenSyWa:
- good quality of water;
- good health of citizens;
- good quality of life;
- good quality of environment;
- creation of many jobs in the field of quality and treatment water.

1.6. Consideration about gender

Description

The actions that would be undertaken during of the project to promote gender equality in our project:

- Participation of the conferences, symposium and congress for the dissemination of the results of the project SenSyWa
- Participation of the patented results in part or total.

- Participation of the scientific and technical aspects of the work package
- Participation of the events organized in schools and universities, courses, doctorate themes, dissertations
- Participation of the actions related to the project consortium: improving the gender balance in the project consortium, measure to help reconcile work and private life.

1.7. Working visits effected on the length of the bilateral project

Visit in Germany to the company ARTEOS GmbH, Seligenstadt :

1. Eng. Gabriela Telipan
2. PhD. Eng. Lucian Pislaru-Danescu

In the period: 19.10.2009-28.10.2009.

1.8... Possibility of economic valorification of obtained results

- tranfer technologic immediate
- european project FP7-ICT
- fabrication sensors at low cost

Responsible project
Dipl. Eng. Gabriela Telipan