

# Sensors & Transducers

ISSN 1726- 5479

© 2003 by IFSA

<http://www.sensorsportal.com>

## Modern MEMS Technologies and Advanced Signal Processing: How to Obtain More Benefits in Smart Sensors Systems?

Some Conclusions to NATO Advanced Study Institute (ASI) 'Smart Sensors and MEMS' (Povoa De Varzim, Portugal, 8-19 September 2003)

Sergey Y. YURISH

International Frequency Sensor Association (IFSA),  
46, Thorny Vineway, Toronto, ON, Canada, M2J 4J2  
Tel/fax:+1 (416) 233-4546, e-mail: [info@sensorsportal.com](mailto:info@sensorsportal.com)  
<http://www.sensorsportal.com>

---

NATO ASI 'Smart Sensors and MEMS' - high-level tutorial course - has taken place in Povoa De Varzim (Portugal) on 8-19 September 2003 and organized by International Frequency Sensor Association (IFSA) together with University of Aveiro, Portugal (Department of Chemistry) at NATO financial support (Grant PST ASI 979712). It was a first attempt to discuss in the same event different physical, chemical, biological sensors and MEMS technologies in point of view of smart sensors creation. Fourteen experts from Czech Republic, Germany, Italy, Israel, Netherlands, Portugal, Russia, Switzerland, Ukraine and USA have been invited to give lectures on latest achievements in sensors area and technologies.

Modern microsystem technologies offers new ways of combining sensing, signal processing and actuation on a microscopic scale and allows both traditional and new sensors to be realized for a wide range of applications and operational environments.

The main task of measuring instruments, sensors and transducers designing has always been to reach high

metrology performances. At different stages of measurement technology development, this task was solved using technological methods, consisting in technology perfection, as well as structural and structural-algorithmic methods. Historically, technological methods have received prevalence in the USA, Japan and Western European countries. The structural and structural-algorithmic methods have received a broad development in the former USSR and continue developing in NIS countries. The improvement of metrology performances and extension of functional capabilities are being achieved through the implementation of particular structures designed in most cases in heuristic way, and using advanced calculations, algorithms and signal processing (for example, Lyapunov's characteristic functions, weight functions, inferential calculations for soft sensors, advanced self-adaptation methods for frequency-to-code conversion, etc.). Digital and quasi-digital smart sensors and transducers are not the exception.

Today's crisis in the area of high technologies has evidently shown, that it is not enough to use only the

technological methods. Despite of crisis, we need now smart sensors with increased accuracy, reliability and speed. Nowadays, intelligent sensors are extremely necessary for such applications, as electronic noses and tongues, smart vision systems, personnel (human body) detection, authentication systems, building monitoring system, etc. Most effectively for achievement of this purpose is a combination of technological methods and structural-algorithmic methods. It allows to achieve the same performances (or even better) at reduced material and human costs, with a much faster response.

The NATO ASI has brought together experts from the various and highly diverse areas of this broad field and to diffuse their work in the field of smart sensors and MEMS. The diffusion and share of concepts is very important and timely for the future developments in this emerging scientific area. In fact, the main objective of the NATO ASI was to disseminate up to date knowledge concerning the new and emerging applications of modern smart sensors (including their usage in the defense against terrorism) and to stimulate active international cooperation in the area of novel physical and (bio) chemical sensing principles, modern microsystem technologies and new methods of signal processing and conversion.

The NATO ASI 'Smart Sensors and MEMS' has presented the state-of-the-art and given an excellent opportunity to provide a systematic, in-depth treatment of the new and rapidly developing field of smart sensors and MEMS. The ultimate goal of the NATO ASI - to encourage the participants from many countries to work together on different smart sensors and to develop joint projects in the future has been achieved in full.

In addition to the round table and two panel discussions, the addition discussion on 'Smart Sensors Systems' has been initiated by lecturers and participants and held during the NATO ASI. It has been considered that there are a lot of new technologies, suitable for smart sensors creation [1], for example, micro- or nano-cantilevers (lecturer *P. Datscos*, Oak Ridge National Laboratory, USA) porous silicon (lecturer *U. Mescheder*, University of Applied Science, Furtwangen, Germany), thick films (lecturer *V. Ferrari*, Università di Brescia, Italy), resonant piezoelectric (lecturer *F. Josse*, Marquette University, USA), molecular architecture and nanotechnologies (lecturer *E. Katz*, The Hebrew University of Jerusalem, Israel) and other modern technologies let to produce different sensors classes: physical, chemical and biological. But still there is a

problem how to joint them and use in a frame of smart sensor systems. One of points of view was to use novel frequency-to-code conversion methods and converters (lecturer *S. Yurish*, International Frequency Sensor Association, UA) in order to move from traditional analog (voltage and current) signal domain to the frequency-time signal domain. The last one lets to eliminate a lot of technical problems due to properties of frequency as informative parameters. No output standardization is necessary like in the case of analog signal domain. Nevertheless, as rule, the sensitive response of many sensors is in *mV*, it is expediently to use the voltage-to-frequency intermediate conversion. In additional such approach will give an opportunity to create new self-adaptive smart sensors (*S. Yurish*).

New conversion methods and advanced signal processing will play role a bridge between many different technologies at smart sensor systems design. But of course, at first, it is necessary to eliminate some demerits. Firstly, in order to use novel conversion methods in frequency-time signal domain, a customer or designer must be an expert in these methods. Secondly, they must buy a license. Nevertheless the exclusive license is not so expenses as modern technological process, it sometimes very big and unexpected problem for large corporations and companies as well as SME. How to eliminate such kind of problems ? The answer is based on scientific and business approaches: to create new chip that can be used for frequency-time signal domain like standard ADC for analog signal domain.

This chip will be based on modern conversion methods that allow to achieve high, programmable and constant accuracy in all frequency range, non-redundant conversion time, self-adaptation possibilities, multifunctionality, etc., so in other words all that can not be realized in modern ADC by technological methods. Such kind of research has been initiated by IFSA [2] and now is a hot topic for big international joint research project.

Based on principal scientific conclusions, the future need is to build a networks structure (like networks of excellence) on Smart Sensors, Systems and MEMS because of the modern approach based on joint technological methods of performances improvement and structural-algorithmic methods needs strong international cooperation. It has been considered that it will be expediently to organize the next NATO ASI or NATO ARW on Smart Sensors Systems topic. In order to continue fruitful collaborative ideas some preparation for joint research projects have been initiated among NATO

ASI participants.

### Acknowledgements

The NATO ASI 'Smart Sensors and MEMS' has been supported by NATO Grant PST ASI 979712.

### References

- [1]. Smart Sensors and MEMS: Tutorials and Posters Abstracts, NATO ASI 'Smart Sensors and MEMS', *Preprints*, Ed. by Maria Teresa Gomes and Sergey Y. Yurish, Povoá De Varzim, 8-19 September 2003 (ISBN 0-9733840-0-X).
  - [2]. Yurish S.Y., Novel Measurement Techniques up for License, *IFSA Press Release*, 21 November 2002, Toronto, ON, Canada, <http://www.sensorsportal.com>
-