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Scientific awards of the Division IV Technical Sciences of the Polish Academy of Sciences in 2004

For many years it has been a great tradition of the Division IV of Technical Sciences of the Polish Academy of Sciences to recognize the outstanding achievements of young scientist with several Awards related to various fields of technology. The awarded candidates have to satisfy the requirements specified in suitable Regulations.

In 2004 the Scientific Award Fund of the Division IV was supported by the well known international Siemens company what significantly augmented the status of the Awards.

The list of Awarded Winners and the brief description of their achievements prepared by the authors are as follows.

In the field of Electrical Engineering:

Multifrequency identification algorithms in eddy current nondestructive testing systems

Tomasz Chady, PhD, D.S.

Katedra Elektrotechniki Teoretycznej i Informatyki, Szczecin University of Technology

The electromagnetic methods feature the simplicity, zero adverse environmental effect, low costs and high sensitivity. One of the principal problems encountered when using this methods is the interpretation of obtained signals and the identification of tested structure's condition on their basis. Solution of that issue is possible owing to the use of properly selected algorithms of digital signal processing and identification.

On the basis of numerous performed tests, author demonstrates that the application of multifrequency electromagnetic eddy current inspection systems and inverse algorithms based on the neural networks allows to precisely identify the heterogeneities and flaws in conducting and magnetic materials. Author presents the concept and manner of implementing the new type of multifrequency algorithms. Particular attention is paid to the analysis of frequency characteristics of the transducer-defect system. It is shown that such characteristics enable very accurate estimation of defect's parameters. Performed tests and calculations have confirmed the effectiveness of such type of algorithms and the possibility of replacing the traditional methods based on the analysis of amplitude-phase characteristics by them. Furthermore, an effective algorithm for defect's profile identification with the use of artificial neural networks is proposed. The concept of neural model of the transducer has been verified by both the computer simulations and the measurements performed in the events of natural defects. Presented neural models make a vital alternative for various types of identification methods which predominantly consist in the use of iterative procedures. Especially, the inverse neural model was proved as an effective tool for immediate defect identification.

Results of the works were presented at various international conferences and published in well known scientific periodicals. All the achievements were summarized in the monograph.

In the field of Automatics:

Modelling and control of nonlinear systems using neutral – like methods

Andrzej Dzieliński, PhD, D.S.

Faculty of Electrical Engineering Warsaw University of Technology

This work has emerged as a result of the research in the area of neural networks application to modelling and control of nonlinear dynamical systems. The goal of the research carried out in recent years was to examine the possibilities and to create the theoretical foundations for applying neural networks to modelling and adaptive control of nonlinear systems. In the publications accompanying the work a detailed analysis of neural adaptive systems was presented. Several structures and learning algorithms for modelling, identification and control of nonlinear dynamic systems were proposed. Also the evaluation of the methods presented from the point of view of nonlinear control theory has been performed.

These were the subjects of several scientific projects successfully completed in the Institute of Control and Industrial Electronics, Warsaw University of Technology and in the Centre for Systems and Control, University of Glasgow. The results presented may serve as a firm foundation to elaboration of an engineering methodology for designing neural, nonlinear, adaptive control systems.

In the field of Mechanical Engineering:

Problems of acquired anisotropy and coupled thermo-mechanical fields of CDM

Artur Ganczarski, PhD, D.S.

Institute of Mechanics and Machine Desing Fundamentals Kraków University of Technlogy

Brief description of the major problems discussed in the awarded work is:

- Problems of acquired anisotropy in coupled thermo-mechanical fields of CDM such as: objective derivative of damage tensor, thermodynamically based constitutive equations, damage acquired anisotropy, non-classical problems of thermo-mechanical coupling accompanying damage and also optimization of structures subjected to damage when thermo-mechanical coupling is taken into account.
- Description of anisotropy resulted from damage cummulation considering damage influence on such mechanical properties as stiffness or compliance and thermal properties as conductivity or expansion.
- Limitation of applicability of the Reissner's plate theory in modelling of processes associated with damage nucleaction and growth.
- Concept of continuous effect of damage deactivation accompanying unloading process.

In the field of Metrology:

Metrological evaluation of the complex measurement of the gear with Coordinate Measuring Machines (CMM)

Mirosław Grzelka, PhD

Institute of Mechanical Technology
Poznań University of Technology

Gears are used in motor and aircraft industry, which require especially high accuracy. Gears are geometrical elements of a complicated shape, so to control their accuracy one need to use specialized measuring systems with advanced technologies.

The only metrologically correct way to value the accuracy of the detail (examined gear) is to give its whole, complex accuracy characteristics. It covers all informations about accuracy of manufacturing of a gear and its ability to work. The complex characteristics without metrological analysis of the measuring errors, accuracy of measurement and uncertainty of measuring tools, does not enables to present the measuring results properly.

To perform the gear measurement with CMM (Coordinate Measuring Machine), the new algorythms have been worked out. They contain corrections of the measuring points moving them into actual points laying on the actual gear profile. The algorythms became a basis for a software allowing a gear measurement with a switching probe. The existing program for digital single-flank simulation was improved and included into the program, and a software for complex evaluation of the gears was created.

The measuring errors for particular values of the gear, their deviations depending on the CMM's uncertainty and the accuracy of the coordinate center determination, have been examined and described. The results became a basis for recommendations, how to choose the appropriate CMM to ensure metrologically correct measurement of the given gear manufactured in certain accuracy class.

The software may be improved to be applied for the measurement of other type gears.

In the field of Acoustics:

Propagation of the ultrasonic waves in critical mixtures and magnetic liquids

Tomasz Hornowski, PhD

Institute of Acoustics
University of A. Mickiewicz, Poznań

The Award of Division IV of Polish Academy of Science was granted for the series of papers (including habilitation thesis) devoted to the investigations of the propagation of ultrasonic waves in critical mixtures and magnetic liquids. The studied binary systems permitted quantitative tests of the predictions of dynamic scaling theory, renormalization group theory and modified by the Author version of mode-coupling theory both in the asymptotic and non-asymptotic region. Additionally, viscosity measurements near critical point were carried out in order to calculate characteristic relaxation rate associated with order parameter fluctuations. The awarded papers dealt also with the propagation of ultrasonic waves in magnetic liquids.

In the field of Civil Engineering:

Shear band pattern formation in soil

Danuta Leśniewska, PhD

Institute of Civil Engineering
Polish Academy of Sciences, Gdańsk

The purpose of in this work was to study the phenomenon of shear banding (especially the patterning of shear bands) in soil. The study includes discussion of different arrangements of shear bands, observed on radiographs, collected in archive belonging to the Cambridge University, and the preliminary theoretical analysis of the experimental material. Presentation of radiographs in the form proposed in the study may serve as a database for further theoretical research on shear banding. Two simple theoretical models, used in the study, enabled obtaining the analytical relations, associating the characteristic distance between two subsequent shear bands and the relative soil density.

In the field of Material Engineering:

Microtextural determinations of the primary recrystallization in fcc metals

Henryk Paul, PhD

Institute of Metallurgy and Material Engineering
Polish Academy of Sciences, Kraków

The performed investigations were concerned with the problem of the formation of band-like strain inhomogeneities in metals with fcc lattice and with differentiated stacking fault energy (SFE), tacking into consideration their influence on the initial stages of the recrystallization.

They present the results of detailed measurements of local orientation with the application of transmission (TEM) and scanning (SEM) electron microscopy, and the modern techniques: *convergent beam electron diffraction* (CBED) and *electron back scatter diffraction* (EBSD). These techniques allowed to undertake new, basic and systematic investigations of a greatly controversial, not explained until now, problem of the shear bands and their influence on the nucleation of new grains in the recrystallization process. There have been presented many surprising results of experimental studies out of which a coherent concept of the nucleation mechanism has been created. In these investigations related to the greatly discussed problems of plastic deformation and recrystallization there has been described in a complex way the mechanisms responsible for the formation of the recrystallization textures in metals with fcc lattice.

In several publications there has been explained the mechanism of the formation of shear bands. It has been also demonstrated in what way the orientations identified in the bands area can modify the global deformation texture. These first literature reports present the results of systematic measurements of local orientations by the TEM technique and show the way in which the layered structure of the matrix becomes incorporated into the shear bands area. The results of the investigations have definitely revealed the crystallographic nature of the shear bands, providing a decisive answer to this much and long discussed question.

Detailed description of changes in the orientation of the crystal lattice in the bands formation was the starting point for the analysis of processes occurring at the initial recrystallization stages. Extensive studies explain the microtextural relations between the orientations of the deformed state and the orientations of the nuclei appearing in the area of the specific *nanostructure* of the band at the initial recrystallization stages. Extremely interesting is a new concept, which combines the geometry of the slip systems, active in the deformation process, with the misorientation at the 'head' of the recrystallization front. The successive important result is the determination of the place in the process of the texture transformation taken by the known mechanisms of oriented nucleation, oriented growth and recrystallization twinning, and the description of the system of selection of the rotation axis in the relation of the misorientation at the 'head' of the recrystallization front. It has been demonstrated that these principles operate in all examined cases of metals with low and high SFE.

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The suitable procedure aiming at the determination of the Award'2005 Winners will start soon.

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Forecasting the development of micro and nanotechnology in Poland from 2004 to 2007

M. BOSSAK, J. KOZAK and J. SZMIDT

Micro and Nano Technology (MNT) is supposed to become one of the key enabling technologies of the 21st century. Its economic potential is forecast to be a market of several hundred billion Euros in next decade. Therefore, micro/nanotechnology has attracted the interest of many industry sectors and many companies redirecting internal activities to prepare themselves for this new challenge. At the same time governmental R&D decision makers all over the world are setting up new nanotechnology-specific research programmes aiming at putting their respective countries in a favourable position for the future.

According to decision of the Committee of Mechanical Engineering at the Polish Academy of Science, the report/expertise on "Forecasting the development of micro and nanotechnology in Poland from 2004 to 2007" has been prepared by the Section of Micro and Nanotechnology.

The report consists of seven sections:

In first four sections an overview of Microsystems and evolution of microfabrication that led to the production of Microsystems is presented. The emerging miniaturization technologies are perceived by many as potentially key technologies of the future that will bring about completely different ways people and machines interact with the physical world. High levels of miniaturisation may be achieved by applying micro/nano-technologies. The term micro/nano-technology is broadly defined to encompass the synthesis and integration of materials, processes and devices of sub-millimetre to submicron size. It is used to mark a distinction between micro (current state of the art in disciplines such as electronics) and nano (mostly understood as referring to molecular devices). These technologies allow the production of Micro Systems Technology (MST, the European term) and Micro Electro Mechanical Systems (MEMS, the American term), understood to be the integration of microelectronics with peripherals and micromechanics, and resulting in devices such as application-specific integrated microinstruments (ASIM) and eventually nano/pico-satellites (satellites weighing only a few kilograms/grams). Micro Systems Technology offers a number of currently realizable advantages as well as potential promises which include:

- Small size (volume, mass and weight) through miniaturization
- Low power consumption
- Increased functionality
- Modular design methodology
- Low fabrication costs via mass production processes

Further generalizations for microsystems include:

- ASIMS (Application-Specific-Integrated-Micro-instruments System)
- MOEMS (Micro-Opto-Electro-Mechanical Systems)
- μTAS-ów (Micro Total Analysis System)
- Nanoelectronics (atomic / molecular)
- μEngineering
- Smart structures

Microengineering is a discipline dealing with the design, materials synthesis, micro-machining, assembly, integration and packaging of miniature 2-D and 3-D sensors, actuators, and microelectronics (i.e. MST/MEMS). The goal of the discipline is to develop and produce intelligent micro- instruments, and some results are currently being applied, in among other areas, medicine or the automotive industry: smart (chemical, pressure, temperature) sensors to reduce emissions, smart micro accelerometers for crash detection and airbag deployment, and smart micro-gyroscopes in active suspension systems. Printer manufacturers also continue to invest heavily in this technology for the development of, high resolution, micromachined ink-jet print heads. The pharmaceutical and medical businesses are also keen to apply this technology to their products as are the telecommunication industries. Indeed, it was confirmed that the, world-wide, MEMS market tripled by the year 2002 to approximately \$38bn and is estimated to increase to \$60bn by 2005.

MST/MEMS devices and components are, in general, fabricated on silicon using conventional silicon processing techniques. Although silicon may be the ideal material for many applications, other materials are gradually becoming more commonly used.

Microsystems manufacturing relies mostly on the equipment and fabrication techniques used for very large scale integration in the electronics industry, as for example to produce microprocessors. It is expected that the advantages shown by these techniques in terms of cost and reliability, e.g. in current computers, will also apply to microinstruments and microsystems. Other techniques are specific to microsystems, such as bulk and surface micromachining and LIGA, or deep-etch X-ray lithography, electroforming, micro moulding, micro electrical discharge machining, micro laser beam machining, micro electrochemical machining etc.

Section 5 presents an overview of nanotechnology. Nanoscience and nanotechnologies are widely seen as having huge potential to bring benefits in areas as diverse as drug development, water decontamination, informa-

tion and communication technologies, and the production of stronger, lighter materials. They are attracting rapidly increasing investments from governments and from businesses in many parts of the world; it has been estimated that total global investment in nanotechnologies is currently around €5 billion, €2 billion of which comes from private sources. The number of published patents in nanotechnology increased fourfold from 1995 to 2001. Although it is too early to produce reliable figures for the global market, one widely quoted estimate puts the annual value for all nanotechnologies-related products (including information and communication technologies) at $1 trillion by 2011-2015 (NSF 2001).

In chapter 6, the analysis of state of the MNT in Poland and examine some of the barriers to its take-up by industry is presented. In last chapter 7, the findings and recommendations are provided, as following:

1. Currently it is necessary to use microtechnology if one wants to design and manufacture competitive and innovative products. Taking into account that sensors and actuators are available on the market, it is reasonable to start in near future the activity focused on applications rather than production of microsystems. It is essential to activate Polish SMES in designing and manufacturing innovative products (containing micro and nanosystems) in the following areas:
   Automative industry,
   Biomedical engineering,
   Telecommunication,
   Automatization and robotization of manufacturing processes,
   Environmental protection,
   Household goods,
   Aerospace industry,
   Armaments and military equipment.
2. It is purposeful to start priority research and development project on microtechnology, during coming three years 2005-2007.
3. It is recommended to make an effort for establishing a consortium devoted to micro and nanotechnology. The main goal of the consortium is a transfer of technology to SMES. Additional justification for the consortium is EU guidelines for R&D projects.
4. It is possible to take part in some of micro and nanotechnology projects in cooperation with foreign enterprises acting in Poland (DELPHI, Pratt & Whitney, General Electric, Siemens etc.).
5. It is of vital importance to introduce, as soon as possible (2005-2007), the subjects connected with microtechnology into syllabus for mechanical engineers.
6. It is very important to start permanent education in the area of microtechnology, mainly for SMES employees.
7. It is appropriate to continue developing awareness of microtechnology through publications, seminars, conferences etc.

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Actualities

We have a great pleasure to announce that Professor Tadeusz Kaczorek, full member of the Academy associated with our Division IV – Technical Sciences PAN has been honoured with the exceptional title of the Doctor Honoris Causa of the Warsaw University of Technology.

Therefore we would very much like to congratulate Professor T. Kaczorek and wish him further successes.

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Note on CALPHAD XXXIII conference

An International Conference on Phase Diagram Calculation and Computational Thermochemistry, May 30–June 4, 2004, Kraków, Poland

The Calphad conference was organized for the first time in Poland, which has now become part of the United Europe. The conference was organized by the Institute of Metallurgy and Materials Science, Polish Academy of Sciences (PAS) (chairman: Prof. Zbigniew Moser, secretary: Dr Wojciech Zakulski) in co-operation with the Jagiellonian University, Kraków (vice-chairman: Prof. Rafał Kozubski), AGH-University of Science and Technology, Kraków (vice-chairman: Prof. Krzysztof Fitzner) and the Committee of Metallurgy PAS. The conference took place in Kraków, in one of the oldest European Universities, the Jagiellonian University, established in the year 1364.

Following its tradition, CALPHAD (Computer Coupling of Phase Diagrams and Thermochemistry) aimed at promoting computational thermodynamics through the development of models of thermodynamic properties of various phases. That permitted the prediction of properties of multicomponent systems from binary and ternary subsystems, critical assessment of data and their incorporation into self-consistent databases, development of software to derive and optimize thermodynamic parameters and the development and use of databanks for calculations to improve understanding various industrial and technological processes.

148 participants from 29 countries presented 157 papers during 17 oral sessions, including plenary, invited and regular ones. Additionally, 60 papers were displayed in poster sessions.

Five sessions were devoted to environmental problems connected with experimental studies on new soldering materials and completing their databases, due to the fact that EU countries committed themselves to a complete elimination of lead from any products starting from 2006.

The Organising Committee managed to cover the costs of participation of 37 persons, who otherwise would have not been able to take part in Calphad due to the high fee. 27 of them were members of the Associated Phase Diagram and Thermodynamics Committee from Poland, Bulgaria, the Czech Republic, Hungary, Romania, Serbia & Montenegro, Slovakia, and Slovenia.

Z. Moser
W. Zakulski