

Structural Control and Health Monitoring



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**Center of Excellence for Advanced
Materials and Structures**



**Advanced Course on Structural Control
and Health Monitoring:**

SMART'01

Warsaw, 22-25 May, 2001

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LECTURE NOTES

1

**Structural Control
and Health Monitoring**

Advanced Course – SMART'01
Warsaw, May 22-25, 2001

edited by

Jan Holnicki-Szulc



**Centre of Excellence for
Advanced Materials and Structures**

WARSAW 2001

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AMAS LECTURE NOTES

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Foreword

The present lecture notes initiate the publication series within the program of *Excellence Centre for Advanced Materials and Structures (AMAS)* supported by the European Commission for the period 2001-2003. The objective of the Centre is to promote research and disseminate knowledge on modern materials and structures accounting for effects occurring at different physical scales and providing proper modeling of their response. The applications of advanced materials in modern technology are also considered. The topic of structural control and health monitoring is interdisciplinary combining knowledge in material science, mechanics, control theory and electronics. The lecture notes provide state-of-art in this area and indicate actual development trends in both fundamental research and technological applications.

Zenon Mróz

Advanced Course on Structural Control and Health Monitoring SMART'01

Objectives, Contributions and Perspectives

► **The objectives** of the *Advanced Course on Structural Control and Health Monitoring – SMART'01* (held in Warsaw, 22-25 May, 2001), dedicated for students of advanced engineering courses as well as researchers and designers working in the field of mechatronics were:

- to present the state-of-the-art in the field of *Mechatronics*,
- to present the actual trends in this field,
- to verify the academic viewpoint vs. industrial needs,
- to search for potential, joint, academia-industria innovative initiatives.

►► **Mechatronics** (the term coming from the combination of Mechanics and Electronics) is a new, dynamically developing during last ten years interdisciplinary Hi-Tech science and technology area covering the following main fields:

- structural control (various types of structures equipped with controlled devices to get a synergetic effect drastically improving the overall structural performance, e.g. vibration, stress or shape control),
- actuators (e.g. so called MEMS: Micro Electro-Mechanical Systems, applicable e.g. in biomechanics),
- active materials (e.g. Piezo-Electrics, Shape Memory Alloys, Magneto-Rheological Fluids),
- sensors and structural observability,
- control systems,
- structural health monitoring,
- software tools for design of adaptive structures.

Examples of the mechatronics' application areas are the following Hi-Tech engineering fields: micro-mechanics and optics (e.g. precise positioning), robotics (e.g. motion control), aerospace and aeronautics (e.g. vibration control), automotive and high-speed trains' applications (e.g. suspension and brake control), civil engineering (e.g. design for extreme loading by earthquake and wind), damage detection and identification.

►►► **The majority of short courses** given by 14 lecturers from European and Polish universities, research institutes and companies are presented below in full version in the following chapters:

- *Vibration Control* (◦ A. Preumont ◦ J. Holnicki and Z. Marzec),
- *Active Materials and Actuators* (◦ R. Le Letty and F. Claeysen ◦ W.M. Ostachowicz and M. Krawczuk ◦ W.M. Ostachowicz, M.P. Cartmell and A.J. Žak ◦ A. Tylikowski),
- *Software Tools and Optimal Design* (◦ A. Borkowski ◦ J. Holnicki and T. Bielecki ◦ J.P. Narkiewicz),
- *Controllability and Stabilization* (◦ J.J. Telega ◦ L. Socha),
- *Structural Monitoring* (◦ T. Uhl ◦ J. Szelażek and J. Deputat ◦ J. Holnicki and T.G. Zieliński ◦ W.M. Ostachowicz, M. Krawczuk and M.P. Cartmell).

12 of 46 participants have given their short-poster presentations.

►►►► **The thematic network: *Smart Materials and Structures*** has been created as the result of discussion dedicated to new forms of research community integration. Further activities (to be animated through the SMS network) have been planned. One of them is the next meeting (SMART'03 Workshop), to be organised in vicinity of Warsaw.

Jan Holnicki-Szulc
The Course Organiser

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Posters

During the course the following posters were presented:

- S. BYTNER, B. GAMBIN and A. GAŁKA
Piezoelectric layered composites: Mindlin's model with polarization gradient
- Z. DROZD, A. GROCHOWSKI and M. SZWECH
Mechatronic system for investigations of flip-chip technology
- A. GAŁKA, J.J. TELEGA and R. WOJNAR
Influence of temperature on macroscopic moduli of piezoelectric composites
- P. KOLAKOWSKI
Design of adaptive structures for improved load capacity
- J. KONOPKA
Research on the relation between frequency of modulation of acoustic wave and lateral resolution of Scanning Acoustic Pressure Microscope (SAPM)
- S.L. ŁUCZAK
Dual-axis MEMS tilt sensors
- B. MIARA
Controllability of a piezo-electric body
- M. MILLER
Simulation of smart-control – hardware in the loop approach
- Z. RYMUZA
Mechanical and wear tests of MEMS materials
- M. SKŁODOWSKI
Sensors for monitoring of structural integrity of historical monuments
- E. SZWAJCZAK
Synovial fluid as a smart system
- R. WOJNAR
Chondrocyte deformation and the regulation of cartilage activity