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Palestra

COMPOSITE MATERIALS, SMART STRUCTURES AND NANO-COMPOSITES

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The advances in modern engineering are determined, to a large extent, by the development and application of advanced composite materials. Today's composites outline traditional materials. They are light-weight, corrosion-resistant, and very strong. Composite materials are made of at least two different constituent materials, for example fibers and resin matrix. The combined properties of the reinforcing fibers and matrix can provide the optimal overall properties of the composite structure required for the particular engineering application. To make the best composite material, we should know very well the local and overall mechanical properties of the structure (for example to evaluate its stiffness and strength), and we also should develop the best fabrication technologies. The major types of composite materials and structures, their properties and applications will be introduced and discussed.

The next topic of presentation will be on the carbon nanotubes and the emerging nano-composites. Nano-composite is a multiphase material where one of the phases has at least one dimension of less than 100 nanometers, which is 1000 times smaller that the width of a human hair. The carbon nanotube diameter is about 5 nanometers, and yet the extraordinary mechanical properties of carbon nanotubes qualify them as the ultimate fibers ever made. In the last few years, carbon nanotube reinforced composite materials have shown considerable developments. *It is estimated that global market for nano-composites will expand with an annual growth rate of 24% from 2014 to 2019. The structure, properties and applications of carbon nanotubes and nano-composites will be presented in the* understandable way for a not specialized audience.

The further topic of presentation is related to the emerging smart composite structures. These innovative materials are making revolutionary changes in the modern engineering. They can be described as adaptive structures, which incorporate sensors and actuators. Smart structures can assess their own state and perform self-repair and self-adjustment as conditions change and thereby enhance their functionality and survivability. The physical properties of smart materials can be controlled by means of changes of certain environmental or operational parameters, for example, force, temperature, electric or magnetic fields. The ultimate objective of smart materials is to replicate biological functions in man-made structural elements. These functions include a "skeletal" or load-bearing system, achieved for example, through the use of a composite host material, a "nervous" or structural health monitoring system by virtue of the integrated sensors, and a "motor" or adaptive response system through the use of appropriate actuators acting like muscles. The role of the brain in actively controlled smart structures is carried out by real time processors. Smart structures encompass aerospace, terrestrial and aquatic vehicles, civil engineering and off-shore structures, machines and industrial equipment, household devices, to which smart materials are incorporated aiming at achieving a range of functionalities, such as: shape and position control, vibration and noise reduction, structural health monitoring, and power generation. The examples of already existing smart structures include a smart wing with fitted actuators that suppress aeroelastic wing flutter, or a smart ski actively cancelling out shocks and vibrations, or a building that can phone in its status after an earthquake. For the optimal design and fabrication of composite materials and smart structures, it is necessary to know very well their mechanical behaviour, their mechanical properties both on local and overall levels. Major types of smart structures will be introduced and discussed, and the author's results in the analysis of practically important smart composite structures will be presented in the understandable way for a not specialized audience.

Alexander L. Kalamkarov, D.Sc, PhD, PEng, FASME, FCSME

Dr. Alex Kalamkarov is a Professor of Mechanical Engineering at the Dalhousie University in Halifax (Canada) since 1993. Dr. Kalamkarov is a founding Director of the Smart Materials Centre at the Dalhousie University since 1995. He was awarded the Doctor of Sciences (Habilitation) degree from the Academy of Sciences of the USSR in 1990 and the PhD from the Moscow Lomonosov State University in 1979. His academic career spans over 36 years in Research and University teaching.

Prior to Dalhousie University he worked in the Moscow Lomonosov State University, École Centrale Paris (France) and the University of Toronto (Canada). He was a Visiting Professor (during sabbatical leaves) at the Université Pierre et Marie Curie (Université Paris VI) and École Centrale Paris in France; University of Manchester (England); University of Tokyo (Japan); University of Hawaii (USA); Moscow State University (Russia); University of Wollongong (Australia); University of Natal (South Africa) and University of Toronto (Canada).

Research performed by Dr. Kalamkarov in Mechanics of solids, specifically in the areas of Micromechanics of composite materials and smart materials and structures is internationally recognized. He has made major contribution to the fundamental analysis, design and optimization of composite materials and smart composite structures. He developed general approaches in micromechanics of composites, established a new general theory of smart structures and developed methods of optimal design of composite materials and smart structures, developed new multi-scale asymptotic homogenization technique for the analysis of thin-walled composite structures, elaborated a novel general theory of defects in continuous media, introduced a new boundary-layer method in Fracture Mechanics of composite materials, and developed new modeling techniques for carbon nanotubes and nano-composites.

Dr. Kalamkarov made significant contribution to the design, fabrication and experimental evaluation of smart fiber-reinforced composite structures and has 2 US patents on new manufacturing technologies for smart composites.

Prof. Kalamkarov has authored more than 300 research publications, including over 130 archival refereed journal papers and 5 Research Monographs. His research results have been reported at the numerous International Conferences and Seminars. He presented 20 Invited Keynote Lectures at the International Conferences on composite materials and smart structures; developed and chaired 21 International Conferences in composites and smart structures.

Dr. Kalamkarov is a member of several prestigious International Editorial and Advisory boards in composite materials and smart structures, he has served as a Vice-President of the Canadian Society for Mechanical Engineering (CSME).

He was awarded a Fellow of the American Society of Mechanical Engineers (ASME) in 2002, and a Fellow of the Canadian Society for Mechanical Engineering (CSME) in 2001. In 2011 Prof. Kalamkarov was awarded the CANCAM (Canadian Congress of Applied Mechanics) Gold Medal for the outstanding contribution in Applied Mechanics.