Intelligent Textiles and Clothing for Ballistic and NBC Protection

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Intelligent Textiles and Clothing for Ballistic and NBC Protection

Technology at the Cutting Edge

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Preface

This Advanced Study Institute was organized to fill the need to bring together experts from several parts of the world to make a critical assessment of existing knowledge in the area of defense-related textiles and clothing for ballistic and NBC-protection and to identify the needs for future research into these materials and products.

The Advanced Study Institute brought together eminent scientists and engineers and gave young researchers the opportunity to closely interact with the invited experts. A remarkable fact was the rather high participation of industry in the ASI. It is indicative of the interest in this fast developing field, expected to lead to interesting collaborative research opportunities.

This book contains the papers of the most important speakers at the ASI. As can be seen, the variety of themes is interesting. It also shows the multidisciplinary nature of the ASI and areas in which future research will be performed. Protective clothing has appearance and performance characteristics which sharply contrast with those of about 10 years ago. For the next 10 years, cutting edge research will lead to even more changes that hardly anybody is able to foresee today. That change will be the result of the accelerated introduction of smart (electronic) technology in textiles and clothing, the application of nanotechnology including electrospinning and biotechnology, and the use of sophisticated testing by applying (physiological) mannequins and advanced modelling.

As co-directors, we would like to express our sincere thanks and appreciation to all who contributed to the success of the ASI: to NATO for the generous grant, to the fellow members of the organizing committee, viz., Prof. H.A.M. Daanen (TNO, the Netherlands), Dr. T. McLellan (Defense R&D, Canada) and Dr. S. Ramkumar (Texas Tech University, USA). Many thanks goes to Mrs Els Van der Burght (Ghent University, Department of Textiles) for the general logistics of the whole ASI and to Mrs Noëlla Van Reepingen, the wife of Prof. Kiekens (co-director) for playing a magnificent role as a host lady contributing to the overall friendly and enjoyable atmosphere of the ASI.

The organizers are very proud of having had the chance to welcome several distinguished guests during the opening session on Tuesday, April 6. The Ministry of Science and Education and the Ministry of Defense of Croatia were present. The Universities of Zagreb and Split sent their highest delegates. Also, the city of Split and Split-Dalmatian County sent their Excellencies. A word of thanks is expressed for the presence of Prof. Darko Ujevic, Dean (University of Zagreb) and to Prof. Paul Van Cauwenberge, Rector (Ghent University, Belgium) who opened the ASI. Thanks to many others who contributed, but who are not mentioned here.

Last but not least, we have to thank Prof. S. Jayaraman (Georgia Institute of Technology, USA) for preparing this book for publication.

Ghent University, Belgium — Paul Kiekens
EMPA, St. Gallen, Switzerland — René M. Rossi
University of Zagreb, Croatia — Ana Marija Grancaric

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Introduction

Technology is the key to combating terrorism and protecting ordinary citizens, first responders and soldiers from danger. The area of *intelligent* or *smart* textiles is an emerging discipline that is rapidly transforming defense-related textiles and clothing for ballistic and NBC protection. This book presents the fundamentals of defense-related protective clothing and addresses technology at the cutting edge in this field.

Park and Jayaraman lay the foundation for the engineering design of intelligent protective textiles and clothing. They define an intelligent individual protection system and illustrate the use of the structured methodology for designing a mass incident garment for chem-bio protection. They highlight the need for a transdisciplinary approach to the field of intelligent individual protection to realize the ultimate objective of cost-effective protection *anytime*, *anywhere* for *anyone*.

Lobnik presents a detailed analysis of one of the key building blocks for intelligent protection systems, viz., optical chemical sensors. These sensors can be embedded into textile structures by using conventional dyeing, printing processes and coatings, while fiber-optic chemical sensors and nanofiber sensors can be incorporated by weaving, knitting or laminating.

Freney and Renaud trace the emergence of biological warfare to historic times and discuss the role of textiles as potential vectors of infections in hospitals or communities. They describe the major characteristics of antimicrobial textiles and their role in protecting individuals from both involuntary infections that occur in hospitals and communities, and voluntary infections due to terrorist attacks.

Rossi and Psikuta present the complexity of assessing coupled heat and mass transfer in protective clothing since the layers of the system are a combination of fabric and air layers that constantly change with the movements of the wearer. The simulation of the human thermoregulatory mechanisms requires the combination of physical models representing the body (manikins) with physiological (mathematical) models. They discuss examples of advanced measurement methods to characterize the thermal properties of fabrics and garments.

McLellan and Daanen highlight the importance of sweat evaporation in promoting cooling and maintaining thermal homeostasis. Sweat evaporation is severely hampered in protective clothing and can lead to catastrophic consequences for the wearer.

They discuss several methods to reduce heat strain in protective clothing to enhance the safety and comfort for the wearer.

Langenhove et al., introduce the concept of smart textiles and explain how textile materials and structures can be used as sensors, actuators, communication devices, energy sources and storage tools, and even processors. They discuss the important role of smart textiles in thermoregulalation and present the details of a smart suit for rescue workers.

Maillet et al., present the need for protecting soldiers from ballistic and CBRNE threats. Currently, ballistic, CBRNE and tactical jackets are three different components, developed separately and worn on top of each other. They discuss the accomplishments on the EPIDARM project whose goal is to provide optimum protection while reducing cost and weight of the system.

Grancaric et al., discuss the importance of protective clothing against radioactive contamination and the need to make such clothing reusable, especially for use on the space station. They discuss research aimed at modifying cotton fabrics with natural zeolite nanoparticles for imparting the ability to protect from radioactive contamination.

Sata and Ramkumar discuss the importance of individual protection of warfighters, first responders and civilians to meet the current threat of toxic chemicals and chemical warfare (CW) agents. They discuss decontamination technologies such as adsorptive carbon and enzymes and other recent developments in the field. They highlight the importance of decontamination technologies as a countermeasures strategy for sustaining the operational capability of warfighters.

Turaga et al., provide an overview of the applications of nanomaterials such as nanofibers and nanoparticles in military and industrial sectors including the latest developments in the field. They highlight the need for research that focuses on functionalized stand-alone nanofiber webs and stress the importance of investigating the toxic and lethal effects of nanoparticles-based materials before bringing them into the defense arena.

Thus, the various chapters in the book complement each other and address the broad spectrum of defense-related protective textiles and clothing.

Sundaresan Jayaraman