

PREFACE

A NATO Advanced Research Workshop (ARW) entitled “Advanced Materials and Technologies for Micro/Nano Devices, Sensors and Actuators” was held in St. Petersburg, Russia, from June 29 to July 2, 2009. The main goal of the Workshop was to examine (at a fundamental level) the very complex scientific issues that pertain to the use of micro- and nano-electromechanical systems (MEMS and NEMS), devices and technologies in next generation commercial and defense-related applications.

Micro- and nano-electromechanical systems represent rather broad and diverse technological areas, such as optical systems (micromirrors, waveguides, optical sensors, integrated subsystems), life sciences and lab equipment (micropumps, membranes, lab-on-chip, membranes, microfluidics), sensors (bio-sensors, chemical sensors, gas-phase sensors, sensors integrated with electronics) and RF applications for signal transmission (variable capacitors, tunable filters and antennas, switches, resonators). From a scientific viewpoint, this is a very multi-disciplinary field, including micro- and nano-mechanics (such as stresses in structural materials), electronic effects (e.g. charge transfer), general electrostatics, materials science, surface chemistry, interface science, (nano)tribology, and optics. It is obvious that in order to overcome the problems surrounding next-generation MEMS/NEMS devices and applications it is necessary to tackle them from different angles: theoreticians need to speak with mechanical engineers, and device engineers and modelers to listen to surface physicists. It was therefore one of the main objectives of the workshop to bring together a multidisciplinary team of distinguished researchers.

To progress towards overcoming many of these fundamental obstacles, we formulated a workshop, the main goal of which was to develop a better fundamental understanding of the science and technology behind MEMS/NEMS. During the four-day ARW, NATO Country and Partner Country leading researchers met, tutored each other about both their recent results and thinking, and discussed where research and development should be directed. Many of the speakers were from Europe and the U.S. Several key speakers came from NATO Partner Countries including researchers from leading centers in the former USSR (Moscow and St. Petersburg), and Ukraine. The list of researchers represented a diverse international group of recognized scientists and engineers who brought a broad array of backgrounds and strengths into the workshop. The group came from academic, industrial and governmental labs, and had both experimental and theoretical researchers with backgrounds in basic and applied areas of physics, chemistry, mechanical and electrical engineering, surface and materials science.

The meeting was organized thematically. Following introductory presentations, the first day concentrated on MEMS/NEMS technologies and market trends, as well as device physics aspects. This day was concluded by a poster session in the evening, giving special priority to younger researchers to present and discuss their work. The second day was dedicated to applications, with leading experts in the

field discussing progress and sharing their vision for future research. This was followed by a discussion of the important area of sensors for chemical and biological agents. On the last day, we continued with modeling discussions and the role of surfaces, as well as device applications. In the afternoon, a review of NEMS and nanotechnologies was held.

The enjoyment of the week came not only from the quality presentations and stimulating discussions, but also from the beauty of St. Petersburg amplified by gorgeous summer weather. The foreigners among us were not only delighted in the “physical” beauty of the city (architecture, Neva-river, canals, palaces, parks, etc.) but enjoyed rich cultural experiences and the hospitality of the local people.

The editors would like to thank the members of the International Advisory Committee, Prof. Reza Ghodssi, Dr. Fred Roozeboom, Dr. Vladimir Vaganov and Prof. Alexander Vul’, for help in selecting participants from different countries and for their valuable comments on the scientific program. We would also like to thank all invited speakers and contributors to this book for their support and encouragement during the early planning stages of the Workshop and cooperation in meeting publication deadline. The success of the meeting would not have been possible without the excellent planning and operation of the local team in St. Petersburg led by Dr. Sergey Kidalov and Mrs. Irina Vorobieva. It was a real pleasure to collaborate with this professional team again, after two previous successful NATO ARWs on “Fundamental Aspects of Ultrathin Dielectrics on Si-based Devices: Towards an Atomic-scale Understanding” in 1997 and “Defects in Advanced High-k Dielectric Nano-electronic Semiconductor Devices” in 2005. We are very grateful to Dr. Vadim Siklitsky for developing and maintaining the website (<http://www.ioffe.ru/natoarw/2009/>) and also for his help during the Workshop. We are thankful to all participants for their excellent presentations, active participation (including peer-review of papers presented in this book) and fruitful discussions at the Workshop. Finally and most importantly, we would like to acknowledge the hard editorial work of Ms. Michele Gardner who helped us to put together the presented papers into this book. The Workshop would not have been possible without financial support from the NATO Public Diplomacy Division. We also greatly appreciate financial contributions from co-sponsors, the Russian Foundation for Basic Research, NT-MDT, and Qualcomm.

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Evgeni Gusev
Eric Garfunkel
Arthur Dideikin

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Gusev, E.; Garfunkel, E.; Dideikin, A. (Eds.)

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