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# Engineering Power

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## EDITOR-IN-CHIEF'S WORD

At the end of this year you are holding in your hands the latest fourth issue of our Engineering Power Bulletin, in which we have been regularly publishing interesting scientific topics of our renowned members for years.

This time, Prof. Saša Zelenika, PhD, full member of the Croatian Academy of Engineering, is presenting a part of his team's research work on a very scientific and engineering topic of the problems and possibilities of nanotechnology, especially microsystems in technology.

I hope that these papers will arouse your professional interest and provide you with new and useful insights.

Editor-in-Chief
Vladimir Andročec, President of the Croatian Academy of Engineering

## EDITOR'S WORD

Dear readers,

It is my pleasure to present in this edition of the HATZ-Bulletin Engineering Power prominent research activities in the field of precision engineering and micro- and nanotechnologies carried out at the University of Rijeka.

The guest editor of this edition is Saša Zelenika, Member of the Academy and Professor at the Faculty of Engineering of the University of Rijeka, who presents part of the research work of the Faculty's Precision Engineering Laboratory and the Centre-for Micro- and Nanosciences and Technologies of the same university.

Editor
Zdravko Terze, Vice-President of the Croatian Academy of Engineering

## FOREWORD

Precision engineering and micro- and nanotechnologies are of outmost importance in promoting engineering as a driving factor for the development of Croatian economy, since they have an enormous financial and stimulating potential for interdisciplinary R&D in manufacturing, materials science, optics, robotics, measurement technologies, ICT, energy, transportation, biomedicine or consumer goods. Indeed, they are the key enabling technologies identified in the smart specialisation strategies at EU and Croatian level, which have great potential to boost high value-added sectors of the economy fostering productivity and employment.

The potentials of precision engineering and micro- and nanotechnologies are illustrated herein through examples of the developments at the Precision Engineering Laboratory of the Faculty of Engineering (precenglab.riteh.uniri.hr) and the Centre-for Micro- and Nanosciences and Technologies (nanori.uniri.hr) of the University of Rijeka, Croatia. In this context, the activities relating to precision positioning, one of the key factors in the development of precision mechanics, are first presented. Two main mechanical engineering design approaches can hence be followed. Conventional sliding and rolling mechanisms, allowing extended motions and load capacities, can be used, but they are characterised by stochastic nonlinearities such as friction. Modelling using state-of-the-art integrative heuristic approaches, coupled with advanced mechatronics-based compensation, which is increasingly based on adaptive and machine-learning predictive control methods, must therefore be used. A valid alternative is the use of compliant mechanisms that are free of friction, backlash and wear, but have a complex kinematics with parasitic motions. Therefore, advanced nonlinear numerical modelling must be used, which enables the development of design configurations with minimised parasitic displacements and maximised stable working ranges. The developed ultrahigh-precision devices are generally based on suitable sensing elements, which are, in turn, increasingly autonomous and founded on energy harvesting principles. A section on our research on the potential applications of energy harvesting in the development of autonomous wearable devices, aimed at applications in telemedicine, patient monitoring or IoT, and based on innovative geometrical and dynamical excitation strategies applied to piezoelectric energy harvesting devices, and/or on thermogenerators, is illustrative of these trends. Many of these technological advances are based on materials technologies and the respective multidomain and multiscale effects. As an example of these advances, our activities in characterising the concurrent influence of multiple process parameters on fundamental frictional effects in the nanometric domain, is also given. State-of-the-art single asperity nanotechnological experimental technologies, coupled to the most advanced machine learning and artificial intelligence-based modelling methods, have thus to be used to obtain the functional description of the dependence of nanoscale friction on the studied variables, i.e., for nanoscale friction prediction.

All research results presented are achieved by networking our capacities at the national as well as on the European and international levels. One of the main goals of these activities is also to enhance the competencies of the early-stage researchers in our research group. In addition, the described activities are intensely disseminated via a broad range of science outreach activities.

Guest-Editor
Saša Zelenika, University of Rijeka, Faculty of Engineering & Centre for Micro- and Nanosciences and Technologies