ARTICLE IN PRESS

Engineering xxx (xxxx) xxx

Contents lists available at ScienceDirect

Engineering

journal homepage: www.elsevier.com/locate/eng

Editorial

Editorial for the Special Issue on High-End Measuring Instruments

Jiubin Tan [a], Kenneth Thomas Victor Grattan [b]

[a] Key Laboratory of Ultra-Precision Intelligent Instrumentation, Ministry of Industry and Information Technology, Harbin Institute of Technology, Harbin 150080, China
[b] School of Science & Technology, City University of London, London EC1V 0HB, UK

Jiubin Tan   Kenneth Thomas Victor Grattan

In recent years, two major challenges have arisen in the field of measurement and instrument technology. One is the redefinition of the seven basic units in the international system of units (Système International d'Unités or SI). The SI is now based on fundamental physical constants, with full implementation having occurred in 2019. The other challenge is that a new round of scientific and technological revolution has led to breakthroughs in a new generation of information technology, biotechnology, new energy technology, new materials technology, and intelligent manufacturing technology, especially in the high-end manufacturing industry. These breakthroughs are associated with the new era of digitalization, networking, and intelligence in which we live. The two challenges will inevitably lead to further development and use of the international measurement system, the measurement systems employed in various industrialized countries, and—inevitably—a new generation of better instrument technology that is more suited to the needs of industrial users. This new generation of instrumentation will require high-end measurement instruments that are more sophisticated and have greater capabilities to support the evolution of a new generation of practical national measurement systems. Such a shift will also profoundly affect the design, technical capabilities, and integration with information technology tools of high-end measurement instruments.

Many types of high-end measuring instruments have been developed and are currently in use, including microscopes, nanoscopes, mass spectrometers, distributed optical fiber measurement systems, and heterodyne laser interferometers, to name but a few. The aim of this special issue is to report on the breadth of research and development trends for many different kinds of instruments and to discuss the detailed progress that has recently been achieved in certain specific instruments. Due to the fundamental role science plays in creating better devices for industry, we anticipate that research on high-end measuring instrument technology will lead to even greater progress in the near future.

This special issue of *Engineering* brings together a collection of recent achievements in high-end measuring instrument research that holds the potential to significantly promote the rapid development of this field. With strong support from the Chinese Academy of Engineering, it has been our great honor to invite academicians and renowned researchers to report on ideas, theories, and technologies related to high-end measuring instruments. Through a rigorous and careful peer-review process, we have selected four papers for publication—two review papers and two research papers. These papers illustrate the current situation in this dynamic field by discussing the state of the art in high-end measuring instruments in the areas described below.

Fluorescence nanoscopy has overcome the diffraction limit of light, allowing cell biologists to probe cell structures and functions in previously unattainable detail. These methodologies continue to evolve, with new improvements making it possible to tailor available techniques to a particular need and application. In the review by Prof. Min Gu group. a number of primary research articles on nanoscopy techniques and protocols are reviewed. They highlight these recent developments by exemplifying new, interesting neuroscience applications and related developments in tools for this field in the future, including machine-learning assisted nanoscopic imaging. It is evident that fluorescence nanoscopy will continue to elucidate the neuroscience-level understanding of the brain and contribute to breakthrough developments in the interface between artificial intelligence and neuroscience.

The accurate and efficient measurement of *small-molecule disease markers for clinical diagnosis* is of great importance in healthcare today. In the research article by Prof. Xiang Fang group, a home-built quadrupole-linear ion trap (Q-LIT) tandem mass spectrometer based on gas-phase ion precise-manipulation technology

https://doi.org/10.1016/j.eng.2022.07.002

is presented to reduce matrix interference, minimize space charge effects, and avoid the chromatographic separation of complex samples in order to simplify the pretreatment process. The novel instrument they describe can be expanded to be a good candidate for the measurement of biomarkers in clinical diagnosis and therapeutics.

Structural deformation monitoring of flight vehicles based on optical fiber sensing (OFS) technology has been a focus of research in the field of aerospace. A few problems are known to limit the wider application and further development of this technology, and thus urgently require solutions. In the review by Prof. Weimin Bao and Prof. Zheng You group, various aspects of OFS-based deformation monitoring are systematically analyzed, including the main varieties of OFS technology, technical advantages and disadvantages, suitability in aerospace applications, deformation reconstruction algorithms, and typical applications. They point out the key unresolved problems and main evolution paradigms of engineering applications and further discuss future development directions from the perspectives of an evolution paradigm, standardization, new materials, the inclusion of intelligent systems, and a wide range of collaborations. This work will serve as a reference for the application and development of flight vehicle structure OFS monitoring technology and will stimulate further research and discussion.

Multiphoton (mP) microscopes are essential tools for investigating live cells, thick tissues, and organs. In the research article of Prof. Yonghong Shao group, a novel mP-structured illumination microscopy by utilizing the high-order harmonics caused by the mP nonlinear effect to break the diffraction limit of mP microscopes is disclosed. A strength of this method is that the resolution is unlimited if the order in the mP excitation process is sufficient. This microscopy can be performed using typical fluorophores and the excitation light intensity of conventional two-photon (2P) microscopes. It can also be used in other coherent nonlinear optical microscopes, such as coherent anti-stokes Raman scattering and stimulated Raman scattering.

In summary, the four key papers presented in this issue of *Engineering* report on important and highly topical recent advances in high-end measuring instruments in regard to fluorescence nanoscopy in neuroscience, Q-LIT tandem mp, scanning structured illumination microscopy via harmonics, and structural deformation monitoring OFS technology.

We hope that this special issue can help researchers to further understand the related science and technology development of high-end measuring instruments. In addition, we are pleased to express our sincere thanks to the authors, reviewers, guest editors, and editorial office for their great efforts in bringing this special issue together.