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Jiubin Tan
Xianfang Wen
Editors

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Plenary Presentations Abstracts

Challenges in dimensional metrology resulting from possible further development of the International System of Units (SI)

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Reliable and comparable dimensional measurements have been of great importance for the functioning of societies and the quality of manufacturing goods from the very beginning in ancient cultures until the globally networked economy of today. A necessary prerequisite of a globally accepted system of units was laid down with the Convention of the Metre, an international treaty which was signed in Paris in 1875 by representatives of 17 nations. Twelve years later, in 1887, the first national metrology institute worldwide was founded in Berlin, the so-called PTR, and predecessor of the PTB.

This 125th anniversary will be taken as an opportunity to discuss in this contribution some examples of the relation between precise measurements and the progress of science. In particular the contributions of and the remaining challenges for dimensional metrology to support a further development of the International System of Units (SI), possibly redefined in terms of invariants of nature will be addressed.

Precision interferometric measurements in non-ideal environments

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Precision optical components are essential for modern optics/photonics systems. Modern electronics, computers, and software have made it possible to greatly improve the fabrication and testing of optical components and optical systems and the resulting improvements in the new optical instruments and devices we use are evident. Once the data obtained testing an optical system is in the computer it is possible to do sophisticated computer analysis to determine what is wrong with the optical system and what needs to be done to correct the system, and how well the system will perform if it is not improved. It is now practical to test optical systems much better than

the reference optics used in the optical test setup. Until recently, a major limitation of interferometry for precision metrology was the sensitivity to the environment. In recent years many techniques for performing high quality interferometric measurements in non-ideal environments have been developed and new techniques are being introduced all the time. This talk discusses some of the different techniques for reducing the effects of vibration and atmospheric turbulence on interferometric measurements. The application of these techniques for the measurement of surface vibration, the testing of optical components including large astronomical optics, the phasing of segmented optical components, and the measurement of deformations of diffuse structures will be described.

Some critical factors easy to be overlooked in precision instrumentation and characterisation

Liangchi Zhang

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With the advance in precision engineering and nanoscience and nanotechnology, the requirement on the accuracy and reliability of characterisation and measurement means and devices have become more stringent. This has posed new challenges in the further development of metrology theories and techniques, of which the majority is interdisciplinary. This presentation will not discuss anything in a traditional way of precision metrology research, but raise some open questions from a different angle to emphasise the importance of interdisciplinary considerations in the design and application of a piece of ultra-precision instrument. The presentation will use the characterisation of a nano-indentation/nano-probing system as an example to discuss some critical factors that govern the accuracy and reliability of the results but are easily to be overlooked in the measurement practice in a research laboratory.

Calibration for surface topography measurement: How close are we?

Richard Leach

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The function of a component part can be profoundly affected by its surface topography. There are many examples in nature of surfaces that have a well-controlled topography to affect their function. Examples include the hydrophobic effect of the lotus leaf, the reduction of fluid drag due to the riblet structure of shark skin, the directional adhesion of the gecko foot and the angular sensitivity of the multi-faceted fly eye. Surface structuring is also being used extensively in modern manufacturing industry. In this way many properties can be altered, for example optical, tribological, biological and fluidic.

The measurement of surfaces has been carried out for over 100 years using a stylus instrument to trace a profile across the surface. Whereas a profile measurement may allow the investigation of process changes during manufacture, to gain an understanding of the functional nature of a structured surface, an areal measurement is usually required. For areal surface topography measurement a range of instruments, both tactile and optical, has been developed. However, a traceability infrastructure for areal surface topography measurements is not yet in place. This paper will discuss the philosophy behind such a traceability infrastructure and will describe the latest developments at the National Physical Laboratory, UK to develop primary instrumentation and calibration artefacts. The concept of a surface will be addressed from first principles and novel approaches to remove common systematic errors when using areal surface topography measuring instrumentation will be presented.

State of the art and challenges of tactile micro coordinate metrology

Dr. Rudolf Thalmann

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Miniaturization in modern industrial products leads to larger functionality in a smaller volume. Today, small components with complex geometry are found in a variety of products in different sectors, e.g. in micro-sensors or injection systems for the automotive industry, in small gears for drug delivery in medical applications, or in components for the next generation RF technology. These micro parts have feature sizes in the meso scale, i.e. in the sub-millimetre to micrometre range, and are difficult to measure by means of classical dimensional metrology and often too complex and too large for microscopic techniques.

The challenges for the measurement of microparts are the small structure size, the complexity of the geometrical features, the sensibility of the surfaces, and the requirements for traceability and reduced uncertainty. In the recent years, several micro coordinate measuring machines with innovative probe designs were developed in research laboratories and in industry.

The paper will give an overview on state of the art machine and probe developments in Europe. The accuracy limitations for the geometrical errors of the axes, the probe head as well as for the probing element will be outlined. It will be shown, that tactile probes are the ultimate reference for geometrical measurements of micro components, since they can give a complete 3D picture of even complex objects and are unsurpassed in terms of accuracy, whereas optical sensors are often preferred for their fast and non contact measurement capability without risk to mechanically damage the surface. By means of exemplary applications and comparison results, the achieved performance will be illustrated and the challenges for further research are addressed.

High-accuracy self-correction of air refractive index variation using wavelength-stabilized combs

Kaoru Minoshima

National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), 1-1-1 Umezono, Tsukuba, Ibaraki 305-8563, Japan

We developed a wavelength-stabilized optical frequency comb using a pulse-to-pulse interferometer for high-accuracy self-correction of the air refractive index by two-color method. Two-color combs were generated with fundamental and second harmonic generation (SHG) of an Er-doped mode-locked fiber laser. The fundamental interference signal was stabilized by feedback control of the comb frequency and so that environmental variation in air refractive index was cancelled. Therefore all the wavelengths in air of the comb modes were stabilized accordingly if the dispersion of the air refractive index is negligible (wavelength-stabilized comb). In this case, we can precisely and directly measure the effect of dispersion, and then two-color optical path-length difference was measured with a stability of 10^{-10} for 1000 s for the path length 5.6m. In long-term measurements for 10h, experimental and calculated results were highly consistent with an accuracy of 10^{-10}. The measured optical distances of two-color difference and the one-color were applied to the two color method; high-accuracy self-correction of the air refractive index fluctuation was performed with an uncertainty of 5×10^{-8} for 10-h. In this method, the correction can be realized without additional precise measurements of the environmental parameters, therefore the method is attractive to various practical applications.

xxx

Introduction

The International Symposium on Precision Engineering Measurements and Instrumentation (ISPEMI) is an international symposium held every other year in different cities of China with English as its working language. It originated from the International Symposium on Instrumentation Science and Technology (ISIST), which has been held for a total of 5 sessions. ISIST 1999, the first session, was held in Luoyang, Henan Province, ISIST 2002, the second session, in Jinan, Shandong Province, ISIST 2004, the third session, in Xi'an, Shanxi Province, ISIST 2006, the fourth session, in Harbin, Heilongjiang Province, and ISIST 2008, the fifth session, in Shenyang, Liaoning Province. In order to efficiently use the resources available to run one important international symposium, the International Symposium on Instrumentation Science and Technology (ISIST) and International Symposium precision mechanical measurements (ISPMM) merged in 2010 into ISPEMI as suggested by National Natural Science Foundation of China (NSFC), Chinese Society for Measurements (CSM), and China Instrument and Control Society (CIS). The emerging of ISIST and ISPMM, and the use of ISPEMI means the establishment of a more efficient platform for academic exchange amongst well-accomplished scientists and postgraduates both inside and outside China in order to facilitate in-depth discussion and cooperation in the field of precision engineering measurements and instrumentation.

ISPEMI 2012, the 8th ISPEMI, was held August 8-11, 2012, in Chengdu, Sichuan Province. The theme of ISPEMI 2012 is "metrology by quantum, measurement of extremity, innovative instrument and precision engineering". We want to make this meeting an international technical forum for scientists, researchers and students working in the field of precision engineering measurements, and instrumentation inside and outside of China to present their work and to broaded their knowledge on recent advances in this particular field.

More than 240 delegates attended the meeting. Plenary speakers from the U.S., Germany, U.K., Russia, Switzerland, Japan, Australia and China made excellent presentations on their work. A wide range of subjects were covered during session discussions. From the 380 manuscripts received, we accepted only 230 papers for oral and poster presentation at the meeting. After the meeting, we worked further with the authors to make sure the 189 papers included in the proceedings of ISPEMI 2012 are good in both technical quality and English.

While the proceedings of ISPEMI 2012 are now ready for distribution to the authors, we would like to thank National Natural Science Foundation of China (NSFC), International Committee on Measurements and Instrumentation (ICMI), Chinese Society for Measurement (CSM), China Instrument and Control Society (CIS), Harbin Institute of Technology (HIT), SPIE, Institute of Optics and Electronics under Chinese Academy of Sciences, Beijing Information Science and

Technology University, and Hefei University of Technology for their funds and assistance provided. Our thanks go to the procedure and organizing committee members, especially honorary chairman, cochairmen, and plenary speakers, Prof. Jie Gao, Prof. Wenhan Jiang, Prof. Abou-Zeid, Prof. Dr. Harald Bosse, Prof. Gao Wei, Prof. James Wyant, Prof. Liangchi Zhang, Prof. Tony Wilison, Prof. Richard Leach, Dr. Rudolf Thalmann and Prof. Kaoru Minoshima for their efforts in making the meeting fruitful and successful. Finally, our special thanks go to SPIE for its efforts to enable us to do all these thing so well.

Jiubin Tan

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Challenges in dimensional metrology resulting from possible further development of the International System of Units (SI)

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