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## **Instrumentation and Techniques for Geometrical and Mechanical Quantity Measurement**

Liandong Yu  
Peter Ott  
Lianqing Zhu  
Benyong Chen  
Lianxiang Yang

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## Instrumentation and Techniques for Geometrical and Mechanical Quantity Measurement

### Liandong Yu

Hefei University of Technology  
School of Instrument Science and Optoelectronic Engineering  
Hefei, Anhui 230009, China  
E-mail: [liandongyu@hfut.edu.cn](mailto:liandongyu@hfut.edu.cn)

### Peter Ott

Heilbronn University  
Institute of Automotive Engineering and Mechatronics  
Max Planck Str. 39, D-74081  
Heilbronn, Germany  
E-mail: [peter.ott@hs-heilbronn.de](mailto:peter.ott@hs-heilbronn.de)

### Lianqing Zhu

Beijing Information Science and Technology University  
School of Instrument Science and Opto-Electronic Engineering  
12 E. Xiaoyin Road, Qinghe of Haidian District  
Beijing 100192, China  
E-mail: [zhulianqing@bistu.edu.cn](mailto:zhulianqing@bistu.edu.cn)

### Benyong Chen

Zhejiang Sci-Tech University  
School of Mechanical Engineering and Automation  
2 Avenue Development District, Campus Xiasha  
310018 Huangzhou, China  
E-mail: [chenby@zstu.edu.cn](mailto:chenby@zstu.edu.cn)

### Lianxiang Yang

Oakland University  
Department of Mechanical Engineering  
220 North Squirrel Road  
Rochester, Michigan 48309  
E-mail: [yang2@oakland.edu](mailto:yang2@oakland.edu)

The fast development of new and improved high-precision production and manufacturing, and the demands for greater product quality and reliability generate new challenges for measurement techniques. Precision optical measurement is the most active research area in the precision metrology field. The advances of optical measurements enable noncontact measurement with high precision. The measurement accuracy has been honed into micrometer and even nanometer range, regardless of the scale of the measurement range. In this special section, we present a collection of selective papers that represent some recent advances in precision optical measurements and instrumentation and related technologies.

The paper entitled "Optimal design of the laser synthetic wavelength interferometer" by [L. P. Yang and B. Y. Chen](#) presents a method for improving the zero-crossing position errors of the two interference signals. The standard deviation of the experimental results has reached 0.7 nm.

A correlation dimension locating method for phase-sensitive optical time domain reflectometry is presented by [Y. Shi et al.](#) to solve the coherent fading problem in "Correlation dimension locating method for phase-sensitive optical time domain reflectometry." The proposed method is sensitive

to the weak vibration and immune to coherent fading. This method is suitable to find out the vibration response section and even the location of the vibration source.

The paper entitled "Invariant Hough random ferns for RGB-D-based object detection" by [X. P. Lou et al.](#) studies the object detection problem using rich image and depth features. An invariant Hough random ferns framework is proposed, which consists of a rotation-invariant RGB-D local binary feature, random ferns classifier training. The research shows that the method is robust against rotation, scale variations, and part occlusions.

[C. Y. Lee et al.](#) from KAIST, Korea, investigated the technical possibility of near-infrared low-coherence interferometry for nondestructive geometrical inspection of the complex camera module to examine the inside packaging stats in their paper entitled "Optical inspection of smartphone camera modules by near-infrared low-coherence interferometry." The packaging requirements of the smartphone's camera module are developing fast and their research allows for the comprehensive three-dimensional quality assurance of the whole camera module during the packaging process.

The application of a dynamic laser goniometer (DG) system for the rotary encoders' calibration is presented in the paper "Dynamic goniometer for industrial applications" by [E. Ivaschenko, P. A. Pavlov, and V. Pukhova](#). The calibration

procedure allows reducing the level of DG uncertainty to 0.2 arcsec, which ensures the uncertainty of the rotary encoder metrological control to 0.05 arcsec.

Dynamic measurement, especially vibration measurement, by optical methods is receiving lots of research interest due to the strict quality requirements of modern consumers. [B. Zhang, Q. Feng, and Y. F. Liang](#) describe an interferometer for small-amplitude and high-frequency vibration measurement in their paper "Interferometer with bismuth silicon oxide crystal for vibration measurement." The system is based on the reflective holographic grating in a crystal of bismuth silicon oxide without applying an external electric field. The nanometer vibrations of a piezoelectric transducer can be detected by the proposed system in optimal conditions.

Lacking traceability in nanometrology inhibits the comparison of tools from different manufacturers and limits knowledge about the real geometrical information of the fabricated features. In the paper "Two approaches for realizing traceability in nanoscale dimensional metrology," [G. L. Dai et al.](#) from Physikalisch-Technische Bundesanstalt (PTB), Germany, develop top-down and bottom-up approaches for realizing traceability by using metrological atomic force microscopes, laser interferometers, and silicon crystal lattice.

The paper entitled "Synchronous measurement of three-dimensional deformations by multi-camera digital speckle patterns interferometry" by [Y. H. Wang et al.](#) describes a spatial phase-shift digital speckle patterns interferometry (SPS-DSPI) system for three-dimensional deformation measurement using multiple cameras. The SPS-DSPI is combined with a digital image correlation method to achieve deformation measurement under dynamic loading.

A transferable force calibration standard based on a silicon microelectromechanical sensor is proposed in the paper

"Double-meander spring silicon piezoresistive sensors as microforce calibration standards," by [G. Hamdana et al.](#) Piezoresistive silicon microforce sensors as a transferable calibration standard are developed by optimizing the mechanical and electrical readout elements. The stability and characteristics experiments are carried out by repeated mechanical force measurements.

The optical vibration measurement method is developing fast, but high-accuracy reconstruction for vibration motion is a significant challenge. The paper entitled "High-accuracy three-dimensional reconstruction of vibration based on stereo vision," by [J. Zhang et al.](#) systematically investigates the factors that affect the accuracy of stereo vibration measurement methods. The influences of camera parameters and vibration properties on the reconstruction are studied, and the sinusoidal motion is reconstructed by stereo vision achieving the accuracy of 0.1 RMSE.

The final paper in the special section is authored by [M. Sakah and B. Chebbi](#), titled "Measuring solid surface velocity and detection of particle movement by laser Bessel beams." The paper presents a technology to measure solid surface velocity and detect particle movement. The technology is based on the measurements of the frequency change of scattered light of particles crossing the fringes of a nearly Bessel beam formed by an axicon. The presented system is simple and compact, which can have an extended depth of focus, allowing measurements at different locations and eliminating the need for traversing. The system can also be used to detect and measure the movement of particles, which has the advantage of a better ability to detect different shapes and orientation.