

PROCEEDINGS OF SPIE

Ninth International Symposium on

Laser Metrology

Chenggen Quan
Anand Asundi
Editors

30 June–2 July 2008
Singapore

Co-organized by
School of Mechanical & Aerospace Engineering, Nanyang Technological
University (Singapore)
Department of Mechanical Engineering, National University of Singapore

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A*STAR Singapore Institute of Manufacturing Technology
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Published by
SPIE

Part One of Two Parts

Volume 7155

Proceedings of SPIE, 0277-786X, v. 7155

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

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Please use the following format to cite material from this book:

Author(s), "Title of Paper," in *Ninth International Symposium on Laser Metrology*, edited by Chenggen Quan, Anand Asundi, Proceedings of SPIE Vol. 7155 (SPIE, Bellingham, WA, 2008) Article CID Number.

ISSN 0277-786X

ISBN 9780819473981

Published by

SPIE

P.O. Box 10, Bellingham, Washington 98227-0010 USA

Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445

SPIE.org

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Printed in the United States of America.

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Contents

Part One

xv	<i>Symposium Committees</i>
xix	<i>Introduction</i>
xxi	<i>Abstracts</i>

KEYNOTE PRESENTATIONS

7155 03	Some answers to new challenges in optical metrology [7155-02] W. Osten, Univ. Stuttgart (Germany)
---------	---

INVITED PRESENTATIONS

7155 05	Hardware-based error compensation in 3D optical metrology systems [7155-04] K. Harding, GE Global Research (United States)
7155 06	Characterization of optical surfaces for the present generations of synchrotron sources [7155-05] M. Thomasset, F. Polack, Synchrotron Soleil (France)

HOLOGRAPHIC AND SPECKLE TECHNOLOGY I

7155 08	Enhanced resolution methods in shearography and holography for time-average vibration measurement [7155-07] D. N. Borza, INSA de Rouen (France)
7155 09	Characterisation of laser marks using digital holographic microscopy [7155-08] V. R. Singh, O. C. Chee, E. Sim, NACOI (Singapore); A. Asundi, Nanyang Technological Univ. (Singapore)
7155 0A	Structure measurement of phase grating on post-magnification digital micro-holography [7155-09] W. Zhou, Y. Yu, Shanghai Univ. (China); A. Asundi, Nanyang Technological Univ. (Singapore)
7155 0B	Comparison of digital holographic microscope and confocal microscope methods for characterization of micro-optical diffractive components [7155-10] H. Yan, A. Asundi, Nanyang Technological Univ. (Singapore)
7155 0C	Reduction of speckle noise by multi-kinoforms in holographic three-dimensional display [7155-11] H. Zheng, Y. Yu, Shanghai Univ. (China); H. Qian, Office of MRL Development (China); A. Asundi, Nanyang Technological Univ. (Singapore)

- 7155 0D **Deformation analysis on micro objects using multiple wavelength microscopic TV holography** [7155-12]
U. P. Kumar, N. K. Mohan, M. P. Kothiyal, Indian Institute of Technology Madras (India);
A. K. Asundi, Nanyang Technological Univ. (Singapore)

NDT EVALUATION I

- 7155 0E **Applications of laser ultrasound NDT methods on composite structures in the aerospace industry** [7155-13]
M. Kalms, O. Focke, C. v. Kopylow, Bremen Institute of Applied Beam Technology (Germany)
- 7155 0F **Experimental study of inconvenient static and dynamic deformations of piezoelectric actuators** [7155-14]
D. N. Borza, INSA de Rouen (France)
- 7155 0G **Long-term reliability measurements on MEMS using a laser-Doppler vibrometer** [7155-15]
J. De Coster, L. Haspeslagh, A. Witvrouw, IMEC (Belgium); I. De Wolf, IMEC (Belgium) and Katholieke Univ. Leuven (Belgium)
- 7155 0H **Defect inspection by an active 3D multiresolution technique** [7155-16]
J. Vargas, J. A. Quiroga, Univ. Complutense de Madrid (Spain)

MICRO-NANO METROLOGY

- 7155 0I **Development of a metrological atomic force microscope for nano-scale standards calibration** [7155-17]
S. H. Wang, G. Xu, S. L. Tan, National Metrology Ctr. (Singapore)
- 7155 0J **In-situ evaluation of nanoparticle diameter for visualizing self-assembly process** [7155-18]
S. Ota, T. Hayashi, Y. Takaya, Osaka Univ. (Japan)
- 7155 0K **Evaluation on the probing error of a micro-coordinate measuring machine** [7155-19]
Z. X. Chao, S. L. Tan, G. Xu, National Metrology Ctr. (Singapore)
- 7155 0L **High-resolution interferometry with Nd:YAG laser for local probe microscopy** [7155-20]
J. Lazar, O. Číp, M. Čížek, M. Šerý, Institute of Scientific Instruments (Czech Republic)

IMAGE PROCESSING

- 7155 0M **High throughput measurement techniques for wafer level yield inspection of MEMS devices** [7155-21]
O. Varela Pedreira, T. Lauwagie, J. De Coster, L. Haspeslagh, A. Witvrouw, IMEC (Belgium);
I. De Wolf, IMEC (Belgium) and Katholieke Univ. Leuven (Belgium)
- 7155 0N **Frequency-shifting method for phase retrieval from fringe patterns** [7155-22]
H. Wang, K. Qian, W. Gao, Nanyang Technological Univ. (Singapore)
- 7155 0O **Fast auto-focusing based on partial image characteristics** [7155-23]
J. Cui, J. Tan, Harbin Institute of Technology (China)

- 7155 OP **Inspection method for directional texture defects on steel strip surface** [7155-24]
J. H. Cong, Y. H. Yan, Northeastern Univ. (China)
- 7155 OQ **General structure for real-time fringe pattern preprocessing and implementation of median filter and average filter on FPGA** [7155-25]
W. Gao, K. Qian, H. Wang, F. Lin, H. S. Seah, L. S. Cheong, Nanyang Technological Univ. (Singapore)

INTERFEROMETRIC AND DIFFRACTIVE METHODS I

- 7155 OR **Phase measurement via in-line digital holographic microscopy** [7155-26]
W. Qu, Nanyang Technological Univ. (Singapore); Y. Yu, W. Zhou, Shanghai Univ. (China); H. Yan, A. Asundi, Nanyang Technological Univ. (Singapore)
- 7155 OS **Random-phase-shift Fizeau interferometer** [7155-27]
N. R. Doloca, R. Tutsch, Technische Univ. Braunschweig (Germany)
- 7155 OT **Faster window Fourier transform filters for fringe pattern analysis** [7155-28]
L. T. H. Nam, K. Qian, Nanyang Technological Univ. (Singapore)
- 7155 OU **Application of plate vibration and DSPI in evaluation of elastic modulus** [7155-29]
R. Kumar, Sant Longowal Institute of Engineering and Technology (India); C. Shakher, Indian Institute of Technology, Delhi (India)

SPECIAL SESSION: HIGH RESOLUTION METROLOGY

- 7155 OV **Optical metrology of micro- and nanostructures at PTB: status and future developments** [7155-30]
B. Bodermann, E. Buhr, G. Ehret, F. Scholze, M. Wurm, Physikalisch-Technische Bundesanstalt (Germany)
- 7155 OW **Influence of line edge roughness (LER) on angular resolved and on spectroscopic scatterometry** [7155-31]
T. Schuster, S. Rafler, K. Frenner, W. Osten, Univ. Stuttgart (Germany)
- 7155 OX **Detection and active stabilization of beams position at a high-resolution laser interferometer** [7155-32]
O. Číp, Z. Buchta, M. Čížek, R. Šmíd, J. Lazar, Institute of Scientific Instruments (Czech Republic)
- 7155 OY **Model-free and model-based methods for dimensional metrology during the lifetime of a product** [7155-33]
P. Weidner, A. Kasic, T. Hingst, C. Ehlers, S. Philipp, T. Marschner, M. Moert, Qimonda Dresden GmbH & Co. OHG (Germany)
- 7155 OZ **Determination of flatness on patterned wafer surfaces using wavefront sensing methods** [7155-34]
A. Nutsch, L. Pfitzner, Fraunhofer IISB (Germany); T. Grandin, X. Levecq, S. Bucourt, Imagine Optic (France)

PHOTOELASTICITY AND BIREFRINGENCE TECHNOLOGY

- 7155 10 **New simplified measuring method for distributed low-level birefringence** [7155-35]
K. Gomi, T. Suzuki, Y. Niitsu, K. Ichinose, Tokyo Denki Univ. (Japan)
- 7155 11 **Phase shift polarimetry for non-invasive detection of laser-induced damage** [7155-36]
P. Wang, A. Asundi, Nanyang Technological Univ. (Singapore)
- 7155 12 **Residual stress in silicon wafer using IR polariscope** [7155-37]
Z. Lu, P. Wang, A. Asundi, Nanyang Technological Univ. (Singapore)

SHAPE MEASUREMENT REVERSE ENGINEERING

- 7155 13 **Absolute and dynamic position and shape measurement of fast moving objects employing novel laser Doppler techniques** [7155-38]
T. Pfister, P. Günther, L. Büttner, J. Czarske, Technische Univ. Dresden (Germany)
- 7155 14 **An endoscopic optical system for inner cylindrical measurement using fringe projection** [7155-39]
A. Albertazzi G., Jr., A. C. Hofmann, A. V. Fantin, Univ. Federal de Santa Catarina (Brazil); J. M. C. Santos, CENPES, Petrobrás (Brazil)
- 7155 15 **Surface measurement with Shack-Hartmann wavefront sensing technology** [7155-40]
X. Li, L. P. Zhao, Z. P. Fang, Singapore Institute of Manufacturing Technology (Singapore); A. Asundi, X. M. Yin, Nanyang Technological Univ. (Singapore)
- 7155 16 **A simple method to estimate surface reflectance parameters for three light photometric stereo** [7155-41]
M. A. Younes, Alexandria Univ. (Egypt); M. A. Al-Nady, Egyptian Navy (Egypt)
- 7155 17 **A low-cost antenna reflector shape and distortion measuring system with high accuracy** [7155-42]
X. Li, H. Jiang, J. Zhou, D. Li, H. Zhao, Beijing Univ. of Aeronautics and Astronautics (China)

INTERFEROMETRIC AND DIFFRACTIVE METHODS II

- 7155 18 **The comparison of different temporal phase analysis algorithms in optical dynamic measurement** [7155-43]
H. Miao, Univ. of Science and Technology of China (China); Y. Fu, National Univ. of Singapore (Singapore)
- 7155 19 **A polarization sensitive interferometer for stress analysis** [7155-44]
M. Sarkar, S. K. Sarkar, A. Basuray, Univ. of Calcutta (India)
- 7155 1A **A double-prism lateral shear interferometer for wavefront analysis and collimation testing** [7155-45]
K. U. Hii, K. H. Kwek, Univ. of Malaya (Malaysia)

- 7155 1B **A cube splitter interferometer for phase shifting interferometry and birefringence analysis** [7155-46]
K. Bhattacharya, N. Ghosh, Univ. of Calcutta (India)
- 7155 1C **Model building and measurement of the temporal noise for thermal infrared imager** [7155-47]
X. Yu, L. Nie, Xi'an Technological Univ. (China); T. Hu, X. Jiang, F. Wang, Xi'an Institute of Applied Optics (China)

DIMENSIONAL MEASUREMENTS

- 7155 1D **Speckle noise suppression in shape and deformation measurements by phase-shifting digital holography** [7155-48]
I. Yamaguchi, Toyo Seiki Seisaku-sho, Ltd. (Japan)
- 7155 1E **A hybrid x-ray and microscopy method for diametrical profile measurement of internal holes in steel components** [7155-49]
T. Liu, A. A. Malcolm, X. M. Yin, S. J. Liew, T. P. Prawiradiraja, Singapore Institute of Manufacturing Technology (Singapore)
- 7155 1F **Full-field swept-source optical coherence tomography with Gaussian spectral shaping** [7155-50]
S. K. Dubey, Indian Institute of Technology Delhi (India) and Central Scientific Instruments Organisation (India); G. Sheoran, T. Anna, Indian Institute of Technology Delhi (India); A. Anand, Institute for Plasma Research (India); D. S. Mehta, C. Shakher, Indian Institute of Technology Delhi (India)
- 7155 1G **Phase shifting interferograms processing for fiber point-diffraction interferometer** [7155-51]
L. Nie, J. Han, X. Yu, B. Liu, Xi'an Technological Univ. (China); X. Jiang, F. Wang, Xi'an Institute of Applied Optics (China)
- 7155 1H **Study on a new method for measuring volumetric error of CMM** [7155-52]
E. Shi, Xi'an Jiaotong Univ. (China) and Xi'an Univ. of Technology (China); J. Guo, Xi'an Jiaotong Univ. (China); Y. Huang, Xi'an Univ. of Technology (China)

HOLOGRAPHIC AND SPECKLE TECHNOLOGY II

- 7155 1I **Phase retrieval in digital holographic interferometry based on complex phasor and short time Fourier transform** [7155-53]
W. Chen, C. Quan, C. J. Tay, National Univ. of Singapore (Singapore)
- 7155 1J **Power loss due to beam splitter cascade in the simultaneous sampling of a volume speckle field for phase retrieval** [7155-54]
A. M. S. Maallo, Univ. of the Philippines (Philippines); P. F. Almoro, Univ. of the Philippines (Philippines) and DTU Fotonik (Denmark)

- 7155 1K **On-line digital holographic measurement of size and shape of microparticles for crystallization processes** [7155-55]
T. Khanam, Nanyang Technological Univ. (Singapore); E. Darakis, National Univ. of Ireland, Maynooth (Ireland) and Nanyang Technological Univ. (Singapore); A. Rajendran, V. Kariwala, A. K. Asundi, Nanyang Technological Univ. (Singapore); T. J. Naughton, National Univ. of Ireland, Maynooth (Ireland) and Univ. of Oulu (Finland)
- 7155 1L **Reduction of speckle noise in digital holographic images using wavelet transform** [7155-56]
A. Sharma, Jamia Milia Islamia Univ. (India); G. Sheoran, Indian Institute of Technology Delhi (India); Z. A. Jaffery, Moinuddin, Jamia Milia Islamia Univ. (India)

Part Two

NDT EVALUATION II

- 7155 1M **The characterization of the double fiber Bragg grating fiber ring laser and its applications in a real time fiber sensing system** [7155-57]
C. L. Ko, C. Y. Yang, K. R. Huang, M. C. Shih, National Univ. of Kaohsiung (Taiwan)
- 7155 1N **NDT detection and quantification of induced defects on composite helicopter rotor blade and UAV wing sections** [7155-58]
D. Findeis, J. Gryzagoridis, V. Musonda, Univ. of Cape Town (South Africa)
- 7155 1O **Development of an inexpensive optical method for studies of dental erosion process in vitro** [7155-59]
A. M. T. Nasution, ITS Sukolilo (Indonesia); B. Noerjanto, Univ. of Airlangga (Indonesia); L. Triwanto, ITS Sukolilo (Indonesia)
- 7155 1P **Modeling of coupling coefficient as a function of coupling ratio** [7155-60]
Saktioto, Univ. of Riau (Indonesia); J. Ali, Univ. Teknologi Malaysia (Malaysia); M. Fadhali, Ibb Univ. (Yemen); R. A. Rahman, J. Zainal, Univ. Teknologi Malaysia (Malaysia)
- 7155 1Q **3D investigation of photonics elements by means of interferometric and photoelastic tomography** [7155-61]
N. Kumar, Cochin Univ. of Science & Technology (India); M. Kujawinska, P. Kniazewski, Warsaw Univ. of Technology (Poland)
- 7155 1R **A multipoint diffraction strain sensor using micro-lens array: review on variable sensitivity** [7155-62]
J. Wang, A. K. Asundi, Nanyang Technological Univ. (Singapore)

PRECISION OPTICAL METROLOGY

- 7155 1S **Precision optical metrology for MEMS** [7155-63]
R. J. Pryputniewicz, Worcester Polytechnic Institute (United States)
- 7155 1T **A path planning method for large-scale blade profile measurement based on neural network** [7155-64]
F. Zhang, Z. Jiang, J. Ding, B. Li, L. Chen, Xi'an Jiaotong Univ. (China)

- 7155 1U **Optical bi-sensorial measurement system for production control of extruded profiles** [7155-65]
A. Weckenmann, J. Bernstein, Friedrich-Alexander-Univ. Erlangen-Nürnberg (Germany)
- 7155 1V **Measurement of air-refractive-index fluctuation from frequency change using phase modulation homodyne interferometer and external cavity laser diode** [7155-66]
M. Aketagawa, Y. Hoshino, M. Ishige, T. Banh Quoc, Nagaoka Univ. of Technology (Japan)
- 7155 1W **Adaptive confocal system for 3-D profiling** [7155-67]
R. K. K., V. J. Shen, A. Talukdar, A. Asundi, Nanyang Technological Univ. (Singapore)
- 7155 1X **Measurement of temperature field in steady laminar free convection flow using digital holography** [7155-68]
C. Shakher, Indian Institute of Technology Delhi (India); Md. M. Hossain, Vikram Sarabhai Space Ctr. (India); D. S. Mehta, G. Sheoran, Indian Institute of Technology Delhi (India)

SPECIAL SESSION: LASER SPECTROSCOPY OF SEMICONDUCTORS

- 7155 1Y **Laser spectroscopic study of acetate-capped colloidal ZnO nanoparticles** [7155-69]
S. A. Oh, X. W. Sim, S. Tripathy, Institute of Materials Research and Engineering (Singapore)

LASERS AND LASER OPTICS

- 7155 1Z **The output characteristics of the erbium-doped fiber Bragg grating ring laser** [7155-70]
C. Y. Yang, C. L. Ko, K. R. Huang, M. C. Shih, National Univ. of Kaohsiung (Taiwan)
- 7155 20 **Active alignment and reliable pigtailling of laser diode transmitter** [7155-71]
M. Fadhal, Ibb Univ. (Yemen); Saktioto, J. Zainal, Y. Munajat, J. Ali, R. Rahman, Univ. Technology Malaysia (Malaysia)
- 7155 21 **Determination of third-order optical absorptive nonlinearity of ZnO nanoparticles by Z-scan technique** [7155-72]
R. Sreeja, R. Reshmi, G. Manu, M. K. Jayaraj, Cochin Univ. of Science and Technology (India)
- 7155 22 **Influence of iodine cell quality onto the stability and absolute frequency shifts of laser etalons** [7155-73]
J. Hrabina, J. Lazar, P. Jedlička, O. Číp, Institute of Scientific Instruments (Czech Republic)
- 7155 23 **Investigation of laser produced Fe plasma plume dynamics using time resolved imaging and snow plow model** [7155-74]
S. Mahmood, Nanyang Technological Univ. (Singapore) and Univ. of Karachi (Pakistan); L. Jiaji, S. V. Springham, T. L. Tan, R. S. Rawat, P. Lee, Nanyang Technological Univ. (Singapore)

HOLOGRAPHIC AND SPECKLE TECHNOLOGY III

- 7155 24 **Processing of digital holograms for size measurements of microparticles** [7155-75]
E. Darakis, National Univ. of Ireland, Maynooth (Ireland) and Nanyang Technological Univ. (Singapore); T. Khanam, A. Rajendran, V. Kariwala, A. K. Asundi, Nanyang Technological Univ. (Singapore); T. J. Naughton, National Univ. of Ireland, Maynooth (Ireland) and Univ. of Oulu (Finland)
- 7155 25 **A radial in-plane DSPI interferometer using diffractive optics for residual stresses measurement** [7155-76]
A. Albertazzi G., Jr., Univ. Federal de Santa Catarina (Brazil); M. R. Viotti, Photonita (Brazil); W. A. Kapp, Univ. Federal de Santa Catarina (Brazil)
- 7155 26 **Electronics speckle interferometry applications for NDE of spacecraft structural components** [7155-77]
M. V. Rao, R. Samuel, A. Ananthan, S. Dasgupta, P. S. Nair, ISRO Satellite Ctr. (India)

MOIRÉ AND STRUCTURED ILLUMINATION

- 7155 28 **Moiré fringe method for the measurement of distortions of hot-embossed polymeric substrates** [7155-79]
H. K. Taylor, Massachusetts Institute of Technology (United States); Z. Xu, Massachusetts Institute of Technology (United States), Singapore Institute of Manufacturing Technology (Singapore), and Singapore-MIT Alliance (Singapore); S. Li, Singapore Institute of Manufacturing Technology (Singapore) and Singapore-MIT Alliance (Singapore); K. Youcef-Toumi, Massachusetts Institute of Technology (United States); Y. S. Fatt, Nanyang Technological Univ. (Singapore); D. S. Boning, Massachusetts Institute of Technology (United States)
- 7155 29 **Crack displacement sensing and measurement in concrete using circular grating moiré fringes and pattern matching** [7155-80]
H. M. Chan, K. S. Yen, M. M. Ratnam, Univ. Sains Malaysia (Malaysia)
- 7155 2A **Static and dynamic 3D contouring by using structured light** [7155-81]
R. Rodriguez-Vera, D. Vasquez, Ctr. de Investigaciones en Óptica, A.C. (Mexico); K. Genovese, Univ. degli Studi della Basilicata (Italy); J. A. Rayas, F. Mendoza-Santoyo, Ctr. de Investigaciones en Óptica, A.C. (Mexico)
- 7155 2B **Temporal Paul wavelet analysis for phase retrieval using shadow moiré technique** [7155-82]
H. T. Niu, C. Quan, C. J. Tay, National Univ. of Singapore (Singapore)
- 7155 2C **Whole field residual stress measurement using computer aided reflection grating** [7155-83]
C. S. Ng, Nanyang Technological Univ. (Singapore) and Infineon Technologies Malaysia (Malaysia); Y. C. Goh, Infineon Technologies Malaysia (Malaysia); A. K. Asundi, Nanyang Technological Univ. (Singapore)

THIN FILM METROLOGY

- 7155 2D **The effects of post-annealing on pulse laser deposition of $\text{Zr}_{0.8}\text{Sn}_{0.2}\text{TiO}_4$ thin film on Si(100)** [7155-84]
C. T. Chuang, M. C. Shih, National Univ. of Kaohsiung (Taiwan); M. H. Weng, National Nano Device Lab. (Taiwan)
- 7155 2E **Ultra-thin-film characterization with vacuum ultraviolet spectroscopic reflectometry (VUV-SR)** [7155-85]
I. Burki, C. Rivas, Metrosol, Inc. (United States)
- 7155 2F **Infrared of thin film graphene in a magnetic field and the Hall effect** [7155-86]
K. N. Shrivastava, Univ. of Malaya (Malaysia)
- 7155 2G **Inspection of electroplated gold** [7155-87]
T. W. Ng, Monash Univ. (Australia); F. Y. Yong, Interplex Singapore Pte Ltd. (Singapore)
- 7155 2H **Sub-pixel matching with consideration of lens distortion** [7155-88]
S. Dong, X. Zhao, Y. Yin, J. Tian, X. Peng, Shenzhen Univ. (China)

POSTER SESSION

- 7155 2I **The measurement of polymerization shrinkage of composite resins with ESPI** [7155-89]
Z. Zhang, G. B. Yang, Tongji Univ. (China)
- 7155 2J **Study on topography measurement of ultra-smooth surface** [7155-90]
Y. Li, X. Tong, H. Lin, H. Li, Q. Li, Tsinghua Univ. (China)
- 7155 2K **Study on measurement method for projectile location based on light screen** [7155-91]
F. Han, Q. Liu, G. Sun, Xi'an Technological Univ. (China)
- 7155 2L **Micro lens testing: an application** [7155-92]
H. L. Ng-Lee, S. C. E. Goh, C. S. N. Ranjit, Maryanto, J. Y. S. Ng, Ngee Ann Polytechnic (Singapore); A. Asundi, Nanyang Technological Univ. (Singapore)
- 7155 2M **Application of laser tracker used in the measuring and the adjusting of the workbench for SAR antenna** [7155-93]
B. Yan, J. Wang, N. Lu, W. Deng, M. Dong, X. Lou, Beijing Information Science & Technology Univ. (China)
- 7155 2N **Study on key algorithm for scanning white-light interferometry** [7155-94]
A. Tian, C. Wang, Xi'an Technological Univ. (China); Z. Jiang, Xi'an Jiaotong Univ. (China); H. Wang, B. Liu, Xi'an Technological Univ. (China)
- 7155 2O **High-power laser diode array system for optical pumping of Rb** [7155-95]
Z. Buchta, O. Číp, Institute of Scientific Instruments (Czech Republic); J. Rychnovský, Institute of Scientific Instruments (Czech Republic) and Brno Univ. of Technology (Czech Republic); J. Lazar, Institute of Scientific Instruments (Czech Republic)

- 7155 2P **Error analysis of frequency mixing on heterodyne interferometry detecting device for superfinish surface scratch** [7155-96]
H. Lin, Y. Li, D. Wang, M. Liu, Tsinghua Univ. (China)
- 7155 2Q **Error analysis and compensation of binocular-stereo-vision measurement system** [7155-97]
T. Zhang, J. Guo, Xi'an Jiaotong Univ. (China)
- 7155 2R **Research of the conical cavity high-energy laser energy meter energy loss compensation technique** [7155-98]
X. Yu, Q. Li, L. Nie, X. Shang, B. Liu, Xi'an Technological Univ. (China)
- 7155 2S **Design of laser source for fiber point diffraction interferometer** [7155-99]
X. Yu, L. Nie, J. Han, B. Liu, Xi'an Technological Univ. (China); X. Jiang, Xi'an Institute of Applied Optics (China)
- 7155 2T **Stabilization of semiconductor lasers by fiber Bragg gratings** [7155-100]
B. Mikel, Institute of Scientific Instruments (Czech Republic); R. Helan, Institute of Scientific Instruments (Czech Republic) and Univ. of Technology Brno (Czech Republic); O. Cip, P. Jedlicka, Institute of Scientific Instruments (Czech Republic)
- 7155 2U **The study of sheath flow dark zone phenomenon in dynamic individual cells scattering measurement** [7155-101]
L. Zhang, H. Zhao, X. Wang, W. Zhang, Xi'an Jiaotong Univ. (China)
- 7155 2V **Vibration influence and error compensation of aspherical surface interferometer** [7155-102]
H. Wang, Xi'an Technological Univ. (China) and Xi'an Jiaotong Univ. (China); J. Cao, Xi'an Thermal Power Research Institute (China); A. Tian, B. Liu, Xi'an Technological Univ. (China)
- 7155 2W **Investigation of light scattering for scratch detection** [7155-103]
Z. W. Zhong, Nanyang Technological Univ. (Singapore); L. P. Zhao, Singapore Institute of Manufacturing Technology (Singapore); L. J. Wang, Nanyang Technological Univ. (Singapore)
- 7155 2X **The interaction performance of white light, laser diode, and He-Ne laser with two wavefront sensing systems** [7155-104]
Z. W. Zhong, Nanyang Technological Univ. (Singapore); L. P. Zhao, Singapore Institute of Manufacturing Technology (Singapore); A. A. Hein, Nanyang Technological Univ. (Singapore)
- 7155 2Y **The high resolution actuator based on giant magnetostriction** [7155-105]
L. Wang, J. Tan, S. Zhang, Harbin Institute of Technology (China)
- 7155 2Z **Rigorous accuracy analysis of the fiber point diffraction interferometer** [7155-106]
J. Han, L. Nie, X. Yu, Xi'an Technological Univ. (China); X. Jiang, F. Wang, Xi'an Institute of Applied Optics (China)
- 7155 30 **Robust isoclinic calculation for automatic analysis of photoelastic fringe patterns** [7155-107]
J. A. Quiroga, E. Pascual, Univ. Complutense de Madrid (Spain); J. Villa-Hernandez, Univ. Autónoma de Zacatecas (Mexico)

- 7155 31 **Fast wavefront estimation using multiple directional derivatives and quadrature transform** [7155-108]
R. Legarda-Saenz, Univ. Autonoma de Yucatan (Mexico)
- 7155 32 **Influence of TFT-LCD pixel structure on holographic representation** [7155-109]
H. Wang, Xi'an Jiaotong Univ. (China) and Xi'an Technological Univ. (China); Z. Wang, Xi'an Jiaotong Univ. (China); A. Tian, B. Liu, Xi'an Technological Univ. (China)
- 7155 33 **Research of the automatic imaging focusing measurement for off-axis Fresnel digital holography** [7155-110]
X. Yu, L. Nie, Xi'an Technological Univ. (China); F. Wang, X. Jiang, Xi'an Institute of Applied Optics (China)
- 7155 35 **Measurement of human embryonic stem cell in the growing cycle** [7155-112]
X. Li, L. Zhao, Singapore Institute of Manufacturing Technology (Singapore); S. K. W. Oh, Bioprocessing Technology Institute (Singapore); W. K. Chong, J. K. Ong, Singapore Institute of Manufacturing Technology (Singapore); A. K. Chen, A. B. H. Choo, Bioprocessing Technology Institute (Singapore)
- 7155 36 **Complete deformation analysis of transparent samples using digital shearography and holography** [7155-113]
F. C. I. Catalan, R. D. Santos, Univ. of the Philippines (Philippines); P. F. Almoró, Univ. of the Philippines (Philippines) and DTU Fotonik (Denmark)
- 7155 37 **The nondestructive testing research on porcelain-fused-to-metal (PFM) of oral cavity** [7155-114]
G. Yang, Z. Zhang, Y. Ding, Tongji Univ. (China)
- 7155 38 **Development of a multi-resolution measurement system based on light sectioning method** [7155-115]
W. Zhang, H. Zhao, X. Zhou, L. Zhang, Xi'an Jiaotong Univ. (China)
- 7155 39 **Three-dimensional profile measurement using a flexible new multiview connection method** [7155-116]
P. Zheng, H. Guo, Y. Yu, M. Chen, Shanghai Univ. (China)
- 7155 3A **Application research of spectrum measurement technology in thin-film thickness wideband monitoring system** [7155-117]
J. Han, Xidian Univ. (China) and Xi'an Technological Univ. (China); X. Shang, Xi'an Technological Univ. (China); Y. An, Xidian Univ. (China); X. Jiang, F. Wang, Xi'an Institute of Applied Optics (China)
- 7155 3B **Raman scattering from Zn/ZnO core-shell nanoparticles** [7155-118]
G. Bajaj, R. K. Soni, Indian Institute of Technology Delhi (India)
- 7155 3C **Inspection of thin films failure: optical shearography versus electrochemical impedance spectroscopy** [7155-119]
K. Habib, F. Al-Sabti, Kuwait Institute for Scientific Research (Kuwait)

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Spectroscopy of
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Holographic &
Speckle Tech-3

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Session D3-S17:
Moire and
Structured
Illumination

I. YAMAGUCHI

Session D3-S18:
Thin Film
Metrology

Zhong Ping FANG

Session D2-S15:
Lasers and
Laser Optics

R. S. RAWAT
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Introduction

The 9th International Symposium on Laser Metrology (LM2008) in conjunction with IMEKO TC14 – Technical Committee on the Measurement of Geometric Quantities was successfully held from 30 June to 2 July 2008 at SMU Conference Centre, Singapore. The symposium was attended by 124 delegates from 23 countries.

The symposium program included three keynote and three invited presentations given by eminent experts in their respective fields. Professor James C. Wyant of University of Arizona (USA) delivered a lecture entitled "Dynamic interferometry." Professor Wolfgang Osten of University of Stuttgart (Germany) presented the second keynote lecture, entitled "Some answers to new challenges in optical metrology." The third keynote lecture was presented by Professor Christian Depeursinge of Ecole Polytechnique Federale de Lausanne (Switzerland) on "Digital holographic microscopy: a new perspective in 3D imaging at nanoscale." Three invited presentations were given by SPIE President (2008) Kevin Harding of GE Global Research (USA), Professor Francois Polack of Synchrotron Soleil (France) and Professor Toru Yoshizawa of Saitama Medical University (Japan).

Apart from the above, 89 papers were presented in 21 oral sessions and 33 papers were presented in two poster sessions. The SPIE-sponsored best student paper competition was also held during the symposium to encourage and acknowledge excellence in oral and poster student paper presentations. The SPIE Women in Optics Lunch provided attendees with an opportunity to network with other optics professionals. Dr Rachel Won, Associate Editor of Nature Photonics presented a talk on "Communicating photonics with the public" and shared her experiences on bridging the gap between university and industry, and science publishing and editing. Students with Experts Lunch provided a chance to promote personal and professional growth through networking and encourage students to choose optics as a career. This symposium covered topics ranging from dimensional measurements to precision metrology as well as high resolution metrology with applications ranging from shape measurement to laser spectroscopy for semiconductor applications to thin film metrology.

We take this opportunity to thank all speakers and authors for contributing to the success of the symposium, to members of the international advisory committee for their assistance and enthusiastic support, to the session chairs, to our sponsors, and to the organizing committee for ensuring the efficient execution of the symposium program.

Chenggen Quan

Abstract Only

Dynamic Interferometry

James C. WYANT

Dean, College of Optical Sciences

Professor of Optical Sciences

University of Arizona

A major limitation of precision interferometry is the sensitivity to the environment. This talk discusses different techniques for reducing the effects of vibration and atmospheric turbulence on interferometric measurements enabling precision interferometric measurements in uncontrolled environments. The application of these techniques for the measurement of surface vibration, the testing of optical components, the phasing of segmented optical components, and the measurement of deformations of diffuse structures will be described.

Digital Holographic Microscopy: A New Perspective In 3D Imaging at the Nanoscale

Christian DEPEURSINGE

Professeur titulaire

Laboratoire d'Optique Appliquée

Ecole Polytechnique Federale de Lausanne

DHM belongs to the larger family of "Coherent Imaging (CI) techniques in microscopy" (CIM), which includes also Interferometric Microscopy (IM). By the recourse to reduced coherence lengths, the so-called "Optical Coherence Microscopy" OCM imaging technique has been proposed, which is traditionally based on the exploitation of the coherence in the time domain (coherence gating), whereas DHM exploits coherence in the space domain, by providing a simple mean to reconstruct from the hologram data the wavefront scattered by the specimen. It is demonstrated in this talk how the new concept of "Digital Optics" (DO) can be useful by opening the way to a new kind of microscopy performing well down to the nanoscale. The DO concept can be applied to Digital Holographic Microscopy (DHM) in order to provide aberration- and distortion-free amplitude and phase images: Ultimately, wavefronts corrected by DO techniques can be combined to provide the reconstructed scattering potential by diffraction tomography (synthetic aperture). The 3D arrangement of the dielectric properties of the specimen can be directly derived from these data. Many new applications of DHM can be found in biology where longitudinal accuracies of a few nanometers and resolutions of a few hundreds of nanometers are achievable, provided that optical signals diffracted by the object are or can be made sufficiently large, eventually by tagging. Living biological cells in culture, including their intracellular structures, have been observed with accuracies far beyond that of confocal microscopy. New developments permit now to exploit fully the measurement of absolute phase contrast, and to derive quantitatively physiological parameters with DHM such as cell refractive index and morphology. DHM offers real time observations of very small movements and deformations (nanometers), which are produced, in particular, by stimulation of excitable cells like neurons or occurring naturally in red blood cells in connection with their metabolic activities. Direct imaging of living cells and tissues by DHM is deemed to offer henceforth unique investigation means in biology and medicine.

Banknote Verification Using Optical Techniques

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Saitama Medical University
Japan

Today, in the high-technology world, one of the crucial social problems is counterfeiting of currency. The situation is the same with a high-tech country such as Japan. Counterfeit currency of all kinds of notes found in 1998 was 807, but more than 20,000 notes were detected in 2002, and 25,000 notes in 2004. This means total amount of detected banknotes increased 32 times during these six years. The main reason is attributed to the rapid widespread use of color copying and printing machines. At the same time, the fact that vending machines and bill validators are too popular in Japan caused this result. Consequently, the Bank of Japan issued the three new bank notes in November 2004. Some of the former features were 1) Watermark, 2) Ultrafine-line printing, 3) Intaglio printing, 4) Microprinting, 5) Luminescent ink. In addition, the following security features have been added: 1) Hologram, 2) Watermark-bar-pattern, 3) Latent image, 4) Pearl ink, 5) Luminescent ink, 6) Intaglio printing. Because of newly incorporated techniques, the amount of forged bills of new type notes seems to have reduced. Most of the false notes found recently are old type of notes still in circulation. However, measures have to be taken to meet the demand for discrimination of a legitimate bill from a fake because forging techniques are becoming more skillful. Moreover, most of false notes are found in the vending machines or bill validators for drinks and game machines such as "Pachinko" which are counted to be more than 5.5 million in Japan. To cope with the situation, a project team was set up two years ago by members from two universities, an institute and an industrial company. This team succeeded in developing sensors for checking hologram pattern, fluorescence of ink, microprinting pattern, and watermark. One group focused on checking the microprinting. Microprinting technique has been adopted to draw a portrait on the front surface using fine and thin lines. When the reference pattern is overlapped on the note, distinct moire pattern is produced, whereas, in the case of a copied note, blurred poor pattern appears. Another group weighed three-dimensional information as well as two-dimensional pattern. In printing banknotes higher technique such as intaglio printing has been used. In this case, the ink is raised much higher than by conventional anastatic printing. Such high raise is impossible to duplicate or produce by using letter press, an office printer or a copying machine. To detect this raising of ink, they applied newly improved structured-light-method which has been used in industrial applications to car industry and/or semiconductor industry for measurement of 3D profile of bodies, dies, bumps, etc. The proto-type apparatus incorporating these detection principles is now under testing, and a bill validator equipped with new sensors is expected to be commercialized.

Abstract Only

Multi-Sensor Target Recognition Fusion Based On Fuzzy Evidence Theory

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It is important to situation and threat assessment that targets in battle field are identified timely and exactly, which is the key element of victory in the war. D-S evidence theory is an important method and is widely used in automatic target recognition system. However, modern wars have the trait of air-surface integration and electronic counter measures are taken by both hostile sides, which makes battlefield more complex increasingly. As a result, the data measured by different sensors are imprecise, half-baked, fallibility and the attributes of targets in the model database may be fuzzy too. So, multi-sensor target recognition is not carried off in a state of normal in this condition. In this situation, how to finish multi-sensor target recognition is an open issue. In order to solve this problem, a multi-sensor target recognition fusion model based on fuzzy evidence theory was set up. Firstly, each factor that has influence on target recognition was analyzed in the model, and then different weights are selected in each sensor according to the fuzzy membership function. The degree of membership of the measured target relative to the reference target in the target-base is gained, and then the decision results are sent to the fusion center. In the fusion center, D-S evidence theory was used to implement data fusion, and the target recognition decision results were obtained finally. The simulation experiment shows that it can identify the target accurately and is an effective and feasible multi-sensors target recognition fusion method.

Optical Fiber Sensors Analysis By In-Line Digital Holographic Microscopy

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^bIndian Institute of Science, India

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In this paper in-line digital holographic microscopy is presented to study splicing point of optical fiber sensors. A diverging beam is used to illuminate the object to get desired magnification. The amplitude and phase information of the object is recorded digitally and then numerically reconstruct. The amplitude contrast image shows the amplitude distribution of the object however the phase image shows the information about refractive index. The profile of the refractive index distribution of optical fibers is studied by reconstructed phase contrast image. This method is extended for the analysis of splicing point of optical fibers. Two optical fibers are spliced together and their refractive index distribution is studied. The fibers are joined together by heat created by an electrical spark. We conclude that this analysis helps to calculate the loss in the light during in spliced optical fibers and can found promising applications in optical MEMS.

Micro-Raman Mapping Of Ge Rich Sige-On-Insulator And Ge-On-Insulator Templates

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In this study, we report on the micro-Raman mapping studies on high Ge-content SiGe-on-insulator (SGOI) and Ge-on-insulator (GeOI) templates. These templates are prepared by Ge condensation techniques and we have successfully produced nearly-relaxed SGOI and GeOI layers of good crystalline quality. SGOI layers with varying Ge contents (20 to 100% Ge) are chosen for micro-Raman probing of in-plane strain distribution on the surface. Thick GeOI templates formed by thermal intermixing and subsequent condensation of epitaxially grown high Ge-content SiGe on Si-on-insulator (SOI) substrate reveal that phonon peak associated with the Ge-Ge optical vibration approaches the bulk Ge optical phonon peak. An additional cyclic annealing step has led to the reduction of the compressive strain on GeOI surface, which is confirmed by two-dimensional visible Raman mapping. The distribution of layer strain and the relaxation mechanism in thick GeOI templates are discussed based on the Raman mapping data.

Optical Properties Of AlGaIn/GaN Multiple Quantum Wells Grown On Nano-Epitaxial GaN

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AlGaIn/GaN multiple quantum wells (MQWs) were grown on nano-epitaxial GaN template by metalorganic chemical vapor deposition. Hexagonal nanopore arrays in SiO₂ film are fabricated on the underlying GaN using anodic alumina (AAO) as etch masks, resulting in a nanoporous SiO₂ mask layer with an average nanopore diameter and interpore distance of 60 and 110nm, respectively. The photoluminescence measurement shows great increase in intensity on nano-epitaxy GaN compared to that of the MQWs grown on planar GaN. The improvement in photoluminescence of the AlGaIn MQWs is benefited from the reduction of threading dislocation density in the nano-epitaxial GaN layer, revealed from cross-sectional transmission electron microscopy. It is also attributed to the improvement of light extraction efficiency by the periodic arrangement at the nanoporous SiO₂ mask. The nanoporous SiO₂ mask acts as both a threading dislocation reduction layer and a 2-dimensional (2D) photonic crystal layer to enhance both internal quantum efficiency and external light extraction efficiency. The use of nano-epitaxy method improves both internal quantum efficiency and external quantum efficiency for III-nitrides based optoelectronic devices.

CARS Spectra Measurements Of CO₂ In Nanopores

Sergey DUBYANSKIY

Lomonosov Moscow State Univ., Russia

Nonlinear optics are widely used for investigations of nanocomposite objects spectral properties. These properties are defined by individual contributions of both nano-porous matrix and filling molecular matter. The mechanism of molecular vibrations can be essentially modified due to molecular interaction with the wall surface of nanoporous matrix in comparison with the case of liquid in bulk volume. Therefore, the molecular spectra can be essentially deformed in comparison with molecular spectra in bulk volume and also they depend on pores size and topology. We studied the influence of nanoporous glass walls on spectral broadening of carbon dioxide Fermi dyad $\nu_1/2\nu_2$ Q-branches with CARS spectra measurements. The nanoporous glass sample with nanoporous average diameter about 40 nm and void-solid ratio ~30% was filled with liquid carbon dioxide in high-pressure cell. Spectral linewidth was investigated as a function of liquid density comparatively in a bulk volume and in nanoporous glass sample. Measurements were fulfilled at room (25 °C) and near-critical (30.5°C) temperatures at density range 340÷450 Amagat. Non-resonant signal in the case of carbon dioxide in a bulk volume was negligible, whereas nano-porous glass cell provided considerable non-resonant contribution and special fitting procedure was used in order to separate resonant part.

An Application Of Stereo Vision In 3D Measurement Of Microstructures

Tao ZHANG and J J GUO

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This paper attempts to apply the stereo vision system into 3D coordinates measurement of microstructures. A conventional bridge-type coordinate measuring machine (CMM) with an opto-tactile fiber probe for the measurement of microstructures has been equipped with dual-camera vision system. Image of the fiber probe sphere during probing of the measured surface is captured by the cameras. Then, based on the principle of stereo vision measurement, the center of fiber probe sphere is deduced and the three-dimensional coordinates of the probing point are obtained. The arrangement of the dual cameras and the global calibration of the system are discussed in this paper.

Partial Differential Equation Based Denosing In Electronic Speckle Pattern Interferometry Fringe Patterns

Haixia WANG, Kemao QIAN and Wenjing GAO
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Fringe pattern produced by electronic speckle pattern interferometry (ESPI) are evaluated to measure the deformations on object surfaces. Noise in the fringe pattern is one of the key problems affecting the unwrapping result. This paper presents a partial differential equations (PDEs) based denoising filter to reduce the noise and improve the fringe pattern image quality. Experimental results show that this filter is flexible, fast and capable of removing most of the noise in ESPI fringe image.