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Speckle Metrology

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Once considered as noise arising from the use of coherent light sources, and in particular the laser, the speckle phenomenon has shown unique potentialities as a tool in many optical metrology applications. Many techniques have emerged over the past 50 years that use speckles as their underlying carrier of information such as amplitude and phase of a sample under study. These data can be displayed on a map with millions of points of valuable information from which scientists and engineers may obtain physical and mechanical parameters without the need to interact destructively with the sample. Today most of these laser-based techniques have reached maturity and are being used in a broad range of applications to perform metrology from meters to subnanometers.

Thus, the objective for this special section is to gather a collection of papers that show recent advances extending the state-of-the-art of speckle fundamentals and their applications in metrology.

Twenty papers deal with metrology based on the speckle effect related to objects or scenes of interest. A first range of techniques is based on interferometry: speckle interferometry, shearing speckle interferometry (also known as shearography), and digital holographic interferometry. A total of 12 papers present either research works in new fringe/phase processing in interferometry or applications in a wide variety of domains: from nanoscale to large-scale objects, at various optical wavelengths. A second category comprising 9 papers makes use of noninterferometric techniques, where correlation between two speckle fields at different instants/positions of the object or processing of a series of speckle images for extracting features in a scene is used. Data fusion between interferometric and noninterferometric methods is discussed in one paper.

For some cases when speckle is noise it can compromise imaging or process information: four papers are devoted to novel strategies for limitation or suppression of speckle in imaging, holographic reconstruction, or metrology.

One paper addresses the change of speckle after transmission through a fiber as a measurement sensor.

The remaining papers present various applications where speckle is present in images and its effect is discussed. They concern observation through turbid media, high-speed velocimetry, wavefront sensing, deformations by coordinate measurement methods, and modulation transfer function measurements.

No doubt, this collection of papers impressively demonstrates that, although known for half a century, the speckle phenomenon is still an area of active research in a wide variety of fields ranging from fundamental optics to industrial applications of optical metrology. We hope that this special section will encourage researchers to dedicate their future activities to achieve further progress in this fascinating field of optics.

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Fernando Mendoza Santoyo was former general director of Centro de Investigaciones en Optica, A.C., (CIO), León, México. He has held positions in the USA and Europe as visiting professor conducting research in electron holography and optical nondestructive techniques applied to novel nanomaterials and a wide variety of biomaterials. He is currently on the board of editors of the Mexican *Journal of Physics* (*Revista Mexicana de Física*) and *Optics and Lasers in Engineering* (Elsevier), and a topical editor for *Applied Optics*. He is an SPIE Fellow and a member of its board of directors.

Marc Georges holds a master in physics from the Université Catholique de Louvain since 1989. He joined The Centre Spatial de Liège (Univ. de Liege, Belgium) in 1990 where he received his PhD in 1998. Since 2006, he is responsible for the CSL Laser and NDT Laboratory. He leads research in optical metrology by analog and digital holography and NDT with thermography and laser ultrasonics. He is member of SPIE, OSA, and SFO.

Peter Lehmann studied physics at the University of Karlsruhe, Germany. He received his PhD degree at the University of Bremen in 1994 and finished his Habilitation in 2002. In 2001 he joined the company Mahr in Goettingen, Germany, where he coordinated research activities in optical metrology until 2008. Since then he is a full professor and holds the chair in measurement technology at the department of electrical engineering and computer science of the University of Kassel, Germany.

Wolfgang Osten received the diploma in physics from the Friedrich-Schiller-University Jena in 1979, and in 1983 the PhD degree from the Martin-Luther-University Halle-Wittenberg. From 1984 to 1991 he was at the Central Institute of Cybernetics and Information Processes in Berlin making investigations in digital image processing and computer vision. In 1991 he joined the Bremen Institute of Applied Beam Technology to establish the Department of Optical 3D-Metrology. Since September 2002 he has been a full professor at the University of Stuttgart.

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