Laser Metrology Developments and Applications in the Automotive Industry

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Laser metrology has experienced escalating research, development, and application within the automotive industry since its inception. The development of digital imaging devices, evolution in computer technologies, electro-optical components, image analysis/processing algorithms, and laser capabilities have paved the way for increased utilization of laser metrology techniques as standardized experimental tools. Worldwide customer expectations and increasing regulatory mandates for vehicles with quality performance and value are being met by laser metrology as one key enabling technology applied throughout the vehicle design, development, and manufacturing stages. High standards and performance targets are being set in areas such as noise and vibration, durability, fuel economy, safety, and quality.

This special section provides a variety of development examples from many aspects of laser metrology and interferometry such as TV holography, laser vibrometers, shearography, and moiré interferometry. In the order presented, the first two papers are concerned with the development and application of TV holography and electro-optic holography systems.

The first paper develops speckle averaging, phase shifting, and phase reconstruction iteration procedures to provide a high-quality noise-free fringe pattern; presents a single setup for measuring both vibration deformation and geometric shape; and demonstrates how powerful this tool is for whole vehicle modal survey and how it can be used in interactive design optimization, CAE model correlation, and nondestructive testing. The second paper innovatively combines an optical microscope with an electro-optic holography system. The measurement range has been extended into the nanometer and 2 MHz range. It illustrates how it can be employed to measure and analyze the microbeam vibration behavior. The microbeam is an essential element for many types of sensors that are being used in automotive applications.

In the second group, the papers deal with the challenging problems in electronic packaging and the failure mechanism of multi-layered material structures. The third paper develops a novel technique using shearography to rapidly detect the leakage of a hermetically sealed microelectronic package. One possible failure of microelectronic devices is due to the leakage resulting from imperfect hermetical seals in microelectronic packages such as microchips. The fourth paper presents an innovative phase shifting moiré interferometry for measuring and analyzing the thermal strain concentration, delamination, and shear deformation of a power plastic package and a flip-chip package. The measurement range has been extended into the nanometer range. The fifth paper develops a holography interferometric technique to investigate in detail the behavior of edge deliminations in multi-layered material and establishes an analytical model to study the failure mode in two-dimensional delaminated structural plates.

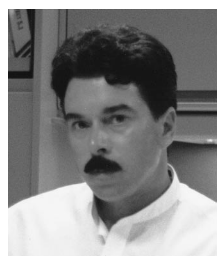
The third category regards the development of techniques to measure and analyze the surface roughness of engine cylinders. The sixth paper develops a white light optical interferometer for nondestructive and *in situ* measurement of engine cylinder surfaces. The system produces a three-dimensional measurement, and the novelty resulted in a U.S. patent. The seventh paper presents a scatterometry of honed surfaces. A linear model has been generated to calculate the surface parameters out of the angular distribution of the scattered light. It may be used to measure deviations from rated values and to detect deviations in the machining process.

The following paper represents the development and application of a laser vibrometer. In a laser vibrometer application, the pose (position and orientation) information is required. This paper establishes a new nonlinear regressive model for the pose determination of the laser vibrometer with respect to a structural coordinate system. It provides highly accurate results over conventional methods. Two examples are given using a laser vibrometer to measure automotive body panel velocity.

The last two papers present the integration methodologies of CAE with experimental techniques. Computer simulation permits fast parametric studies and determination of critical engineering design directions while experimental investigations, especially those using optical techniques, provide detail in thousands of points of qualitative and quantitative information on the actual response of the structure of interest to the applied load and boundary conditions. The innovative integration of CAE with experimental techniques makes it a unique tool for fast and accurate design optimization. The ninth paper provides CAE and experiment integration in the form of computational, noninvasive optical techniques and fringe predication analysis tools. The last paper serves as a closing mark and presents a complete and detailed methodology on how to use CAE and experimental integration tools to achieve the noise and weight reduction of a simulated vehicle cavity. The paper develops a new procedure for panel acoustic contribution analysis (PACA) using a laser vibrometer and boundary element method.

We would like to thank all of the authors, from the pioneers in this field to the outstanding researchers who have received various awards such as the U.S. President Award, for their high-quality contributions; the reviewers for their comments and efforts; and Dr. Brian Thompson and the SPIE staff for providing the opportunity for a special section on this subject, which we believe will promote laser metrology applied research and application in the automotive industry.

Fang Chen received BS and MS degrees in engineering mechanics from Dalian Technology University in China and a PhD degree in mechanical system engineering from Oakland University, Rochester Hills, Michigan. He was an assistant professor with Tongji University, Shanghai, China, from 1985 to 1989 and was an instructor of applied optics for university professors and college teachers sponsored by the U.S. National Science Foundation in 1997. He is currently a research engineer with Advanced Vehicle Technology Division, Ford Motor Co., an adjunct professor with Oakland University, and a PhD advisor with the University of Michigan. He was the recipient of the Science and Technology Significant Contribution Award and the Science and Technology Achievement Award of the National Education Committee of China in 1988 and 1989, respectively, and the Ford Customer Driven Quality Award and Ford Innovation Award in 1995 and 1997, respectively. He holds one patent and has three patents pending. He has published more than 45 papers in the fields of applied optics and automotive engineering. He is a chapter co-author of *Advanced Photomechanics*, published in 1992 by Academic Press, China. He has been included in America Marquis Who's Who in Science and Engineering.



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