Evolution and Development of In-situ Automated Optical Inspection Applied to the Macro-, Micro- and Nano-scale

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Abstract

The application of automated optical inspection to manufacturing processes with tight geometric tolerances and specifications is critical to assure success in today's globally competitive manufacturing industries, such as 3C (computer, communication and consumer electronics), nanotechnology, biotechnology, broadband communications and opto-electronics. In the past decades, much effort had been devoted to developing novel solutions for on-line optical inspection of surfaces and the dynamic characteristics of objects. For macro-scale 3D profilometry, the traditional laser triangulation scanning strategy, though restrained by speckle noise and line sectioning, is still widely employed because of its high adaptability to various surface characteristics. So far, the major challenging issues in macro-level detection are the lack of optimal measuring strategies for integrating large depth ranges with very high resolution, as well as the need for innovative optical design of detectors for various measurement scenarios, such as spectacular, transparent or low-reflection light conditions. Meanwhile, conventional approaches to micro-scale 3D profilometry have adopted novel concepts in chromatic confocal microscopy, coherence scanning interferometry, or spectrally resolved white light interferometry for measuring 3D surface characteristics with high speed and high precision. The one-shot measurement characteristic of these methods is effective in minimizing measured uncertainty caused by environmental vibration. Nevertheless, extremely high-speed microscopic 3D profilometric methodologies for 100 % full-field inspection are yet to be developed. For the next significant move in 3D profilometry, the lateral resolution is impeded by the optical diffraction limit. Novel manufacturing technologies, such as roll-to-roll nano-imprinting or nano-scale

semiconductor lithography processes, require accurate reconstruction of surface relief with lateral resolutions of less than 100 nm and axial resolutions of 1 nm - ten times better than can be achieved by current technologies. Therefore, innovative far-field optical measurement methods for solving the detection limit are not only of academic interest, but of great significance to manufacturing.