Low-Coherence Interference Microscopy Using Switchable Achromatic Phase Shifters

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Recently Low-Coherence Interferometry (LCI) has grown in importance in a variety of applications such as in 3–D imaging for medical diagnostics using optical coherence tomography [1] and in a surface profiling technique using coherence probe microscopy [2]. One of the important characteristics of LCI is its optical sectioning property. This is due to the short coherence length of the illumination, so that the interference term is only appreciable for a short range of depths, and hence an optical section is extracted which allows three-dimensional images to be formed. In this technique the images are produced by scanning the object in height and calculating the degree of coherence (visibility peak) between corresponding pixels in the object and reference image planes. Various digital filtering techniques have been used to recover the fringe visibility curve, they tend to be numerically intensive and require additional memory space.

An alternative method is based on phase shifting. Phase shifting is traditionally performed with laser illumination, and with a broad-band source a problem is encountered in that the phase shift of the different spectral components, when reflected from a mirror, varies. This problem has been overcome by employing a phase shifter based on the geometric (Pancharatnam) phase. Since the geometric phase is the topological phenomenon it doesn’t depend on the wavelength. This type of Phase shifts is introduced by changing the state of polarisations in a cyclic manner [3]. Conventional geometric phase shifter using wave plates has the disadvantage of slower speed. However this problem can be overcome by using ferro-electric liquid crystal retarding plates. We have developed a computer-controlled low-coherence interferometric microscope based on Linnik interferometer configuration which can rapidly and accurately map the shape of micro-machined surfaces exhibiting steps and discontinuities. The novel feature of the instrument is the use of a pair of ferro-electric liquid crystal device that operate on the principle of geometric phase to evaluate the fringe visibility and the fractional phase directly for each point on the object [4, 5].