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Digital Holographic Interferometric Microscopy for the Testing of Micro-Optics

Authors : Varun Kumar, Chandra Shakher

Abstract : Micro-optical components such as microlenses and microlens array have numerous engineering and industrial applications for collimation of laser diodes, imaging devices for sensor system (CCD/CMOS, document copier machines etc.), for making beam homogeneous for high power lasers, a critical component in Shack-Hartmann sensor, fiber optic coupling and optical switching in communication technology. Also micro-optical components have become an alternative for applications where miniaturization, reduction of alignment and packaging cost are necessary. The compliance with high-quality standards in the manufacturing of micro-optical components is a precondition to be compatible on worldwide markets. Therefore, high demands are put on quality assurance. For quality assurance of these lenses, an economical measurement technique is needed. For cost and time reason, technique should be fast, simple (for production reason), and robust with high resolution. The technique should provide non contact, non-invasive and full field information about the shape of micro- optical component under test. The interferometric techniques are noncontact type and non invasive and provide full field information about the shape of the optical components. The conventional interferometric technique such as holographic interferometry or Mach-Zehnder interferometry is available for characterization of micro-lenses. However, these techniques need more experimental efforts and are also time consuming. Digital holography (DH) overcomes the above described problems. Digital holographic microscopy (DHM) allows one to extract both the amplitude and phase information of a wavefront transmitted through the transparent object (microlens or microlens array) from a single recorded digital hologram by using numerical methods. Also one can reconstruct the complex object wavefront at different depths due to numerical reconstruction. Digital holography provides axial resolution in nanometer range while lateral resolution is limited by diffraction and the size of the sensor. In this paper, Mach-Zehnder based digital holographic interferometric microscope (DHIM) system is used for the testing of transparent microlenses. The advantage of using the DHIM is that the distortions due to aberrations in the optical system are avoided by the interferometric comparison of reconstructed phase with and without the object (microlens array). In the experiment, first a digital hologram is recorded in the absence of sample (microlens array) as a reference hologram. Second hologram is recorded in the presence of microlens array. The presence of transparent microlens array will induce a phase change in the transmitted laser light. Complex amplitude of object wavefront in presence and absence of microlens array is reconstructed by using Fresnel reconstruction method. From the reconstructed complex amplitude, one can evaluate the phase of object wave in presence and absence of microlens array. Phase difference between the two states of object wave will provide the information about the optical path length change due to the shape of the microlens. By the knowledge of the value of the refractive index of microlens array material and air, the surface profile of microlens array is evaluated. The Sag of microlens and radius of curvature of microlens are evaluated and reported. The sag of microlens agrees well within the experimental limit as provided in the specification by the manufacturer.

Keywords : micro-optics, microlens array, phase map, digital holographic interferometric microscopy
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