Developments of Optical Holography

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Abstract

Optical holography is a rapidly developing branch of Optics. In recent years, more and more attentions were paied to the optical holography technique, and it has been widely used in the fields of measurement, optical communication, medicine, art, massive message storage and so on. This paper reviewed the developing history of optical holography and described the current research status of optical holography. It also introduced the applications of the technique, e.g. holographic display technology, holographic storage technology, holographic interferometry method, embossing holography and computer-generated holography. At the end of the article, the development trend of optical holography is summarized.

Keywords

Optical Holography, Holographic Display, Holographic Storage, Holographic Interferometry, Embossing Holography, Computer-Generated Holograph.

1. Introduction

Optical holography uses the principle of interference to record the wave amplitude and phase in the form of interference fringes, using the diffraction effect to reproduce it in a certain condition to form a three-dimensional image which contains all the information of the original object. This process is called holography because all the information (amplitude and phase) of the object is recorded[1]. With it's unique advantages, this technology has been widely used in the fields of measurement, optical communication, medicine, art, storage and so on in the recent years.

2. Research status of optical holography

In recent years, with the development of computer, CCD, CMOS, spatial light modulator, holographic technology has developed rapidly. Holographic display, holographic storage, holographic interferometry and computer generated holography are the most promising areas of optical holography. In 1960s, Stetson and Powell proposed holographic interferometry technique, this technique uses the spatial wave front reconstruction to realize non-contact three-dimensional measurement of objects, no matter how smoothness of the surface of the object, it is possible to measure the wavelength level. In 1990s, Germany's Ulf Schnars and Juptner[2] used CCD to record holograms and reproduce the 3D image of objects by computer, this makes holographic imaging more convenient and greatly improves the imaging quality.

3. Application and development of optical holography

The following is an overview of the status and development of holographic technology in some applications.

3.1 Holographic display technology

Three-dimensional display technology is one of the most expected technologies by of the public, while holographic technology has its unique advantage in principle which could regenerate the "real" three-dimensional image of the original object. So holographic 3D display is developing rapidly, however, this technology is not mature enough in real color, seismic, recording speed and capacity. Holographic 3D display technology is the use of multi view image processing or image processing

methods to synthesize holograms, then displays by a suitable device. Digital holographic 3D display technology is to use CCD or CMOS, instead of holographic, to record holographic information. Digital holography has the advantages of fast imaging speed, flexible method and so on. With the development of CCD and CMOS devices, more and more people focus on digital holography.

3.2 Holographic storage technology

Holographic storage is the use of two laser beams interference to achieve information storage. Holographic storage has many advantages, such as high storage density, high dispersion and strong fault tolerance, this is unmatched by other storage technologies. The key to holographic storage is to find the appropriate storage medium. At present, the most used materials are photopolymer, photorefractive crystal, photorefractive polymer and photochromic material. Japan OPTWARE company in 2006 launched a capacity of 200 GB holographic versatile disc and drive. This company will also introduce a holographic card with a capacity of 30 GB.

3.3 Holographic interferometry technology

Holographic interferometry was first proposed by R. Powell and K. Stetson in 1965[3]. Holographic interferometry is the use of wavefront reconstruction of the object without contact with three-dimensional observation, analysis of the order of magnitude can reach the wavelength. The basis of interferometry is wavefront comparison. Holographic interferometry is the only technique that can record and reproduce wavefront, which can be measured by a standard wavefront and wavefront generated by a deformed object [4]. The most commonly used holographic interferometry techniques are single exposure, double exposure, dynamic time averaging, and dual wavelength method and so on. This technique is widely used in the fields of micro stress analysis, micro displacement measurement, nondestructive testing, vibration analysis and so on.

3.4 Embossing holography

Embossing holography is a method to make the information layer to be permanently deformed at a certain temperature to achieve the purpose of reproducing holograms[5]. In 80s, embossed holograms entered the commodity market, it has the characteristics of rich color and vivid stereoscopic vision and it plays an important role in the field of anti fake labels, packaging, trademarks, advertising, securities, identity documents and so on. So far, the embossing holography has gone through four stages, including the holographic grating, the encrypted hologram, the pixel hologram and the combined hologram.

3.5 Computer-generated holograph

Computer generated hologram is a new technology of making holograms. In 1966, Roman combined the sampling theorem with the optical field, which laid the theoretical foundation of computer-generated holograph. He uses computer plotters to create the world's first computer-generated hologram. In 2011, Turkey bilkent University[6] has developed many spatial modulator annular holographic display system. The system combines many spatial light modulators to overcome the defects of the observation angle and the small imaging size when the single spatial light modulator reconstructs. At home, Zhejiang Normal University has done a lot of research in the field of Computer-generated holograph. In 2010, they used the phase spatial light modulator to realize the three-dimensional display of the hologram, and achieved good results[7].

4. Conclusion

With the development of half a century, the development of optical holography is in the direction of digitalization and opto mechatronics. With the development of computer technology, CCD, spatial light modulator and other optoelectronic devices, the systematic, intelligent and miniaturization holographic technology is the main development trend in the future.

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