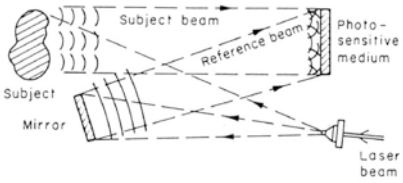
INTRODUCTION TO HOLOGRAPHY

Introduction to Holography

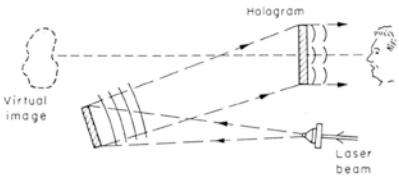
Holography is based on the recording of phase information of light wave. As shown below, the subject is shined with a coherent reference light, ex., a laser. The scattered light from the subject then interferes with the same reference light to form an interference pattern on the photo-sensitive plate, hologram. For a plane reference beam incident on the plate at an angle, the phase varies linearly along coordinates x. The plate is a square-law detector and records the interference pattern. In such way, the hologram records the complete information on the amplitude and phase of the scattered wave reaching the hologram.

The subject wave can be reconstructed by illuminating the hologram with the same reference beam as in the hologram-forming state.

The diffraction of light by the interference pattern in the hologram reconstructs the original light wave. The original light wave corresponding to the virtual image, travels at right angles to the hologram plane. The recording and reconstruction processes are complete, i.e., the phase information contained in a light wave u(x, y) is not lost.



Hologram forming

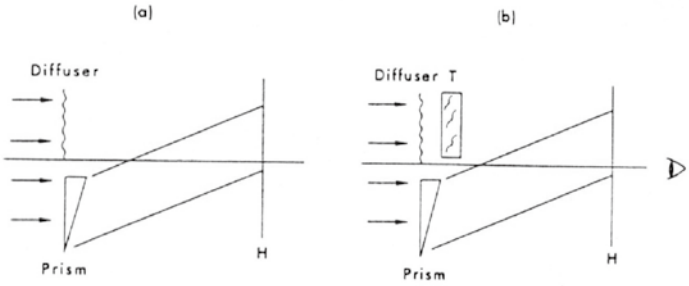


Reconstruction of original light wave

Applications of holography

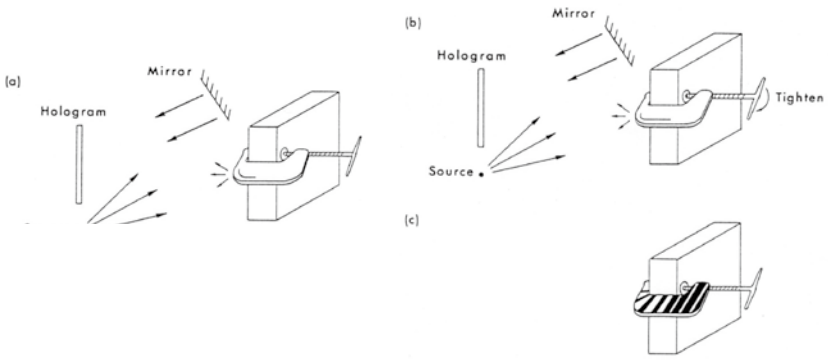
- Holographic interferometer

A hologram of a diffuser is recorded, (a). The hologram is placed exactly in its original position so that both the reconstructed and actual object wave are superposed. When the test plate T is inserted, any optical inhomogeneities will distort the actual object wave so that interference fringes appear, (b).



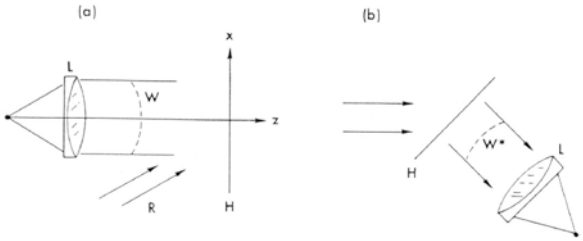
- Holographic strain interferometry

A hologram is recorded of an object, (a). The hologram is replaced in its exact original position and the object is strained, (b). Light from the strained object passes directly through the hologram and interferes with the reconstructed wave of the unstrained object, (c).



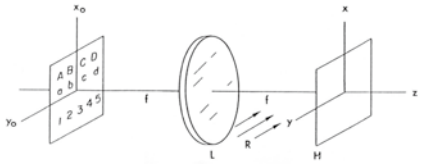
• Holographic correction of lens aberrations.

Recording the aberration, (a). The hologram produces a wave that is phase conjugate to the aberrated wave. When the lens L images this wave, the errors will cancel, (b).

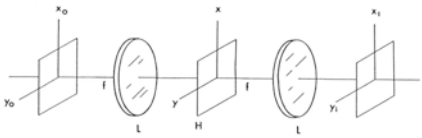


• Holographic character recognition

The master hologram consists of a large number of Fourier transform holograms of a set of characters to be stored.



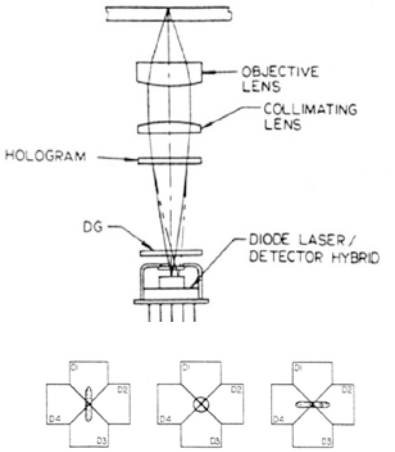
The completed hologram is replaced as indicated below. When an unknown character is placed in the window in the x-y plane, the lens L produces its Fourier transform at the hologram. A second lens L produces a Fourier transform of this product in the xi-yi plane, and therefore the cross-correlations of the unknown character and all of the stored characters are displayed in this plane.



A bright spot will appear in the xi-yi plane when the unknown character is correlated with a stored character of similar shape.

• Optical pick head

The spatial frequency of the hologram is designed to diffract the returned light to the center of the detector. The hologram also serves as a cylindrical lens introduces astigmatism to the returned beam. The focusing condition of the laser beam on the disk surface can be detected from the signal generated by the astigmatic beam on the detector.



When the spot is in focus, the beam on the detector is round. If the point of focus is above or below the disk's surface, the beam on the detector is either a vertical elliptical beam or a horizontal elliptical beam. The focus error is then simply given by (D1+D3)-(D2+D4).

• Photographic emulsions

High-resolution photographic plates and films are the most widely employed recording materials for holographic interferometry because of their relatively high sensitivity.

• Photothermoplastics

A hologram can also be recorded in a multiplayer structure consisting of a glass or Mylar substrate coated with a thin, transparent, conducting layer of indium oxide, a photoconductor, and a thermoplastic. Photothermoplastics have a reasonably high sensitivity and yield a thin phase hologram with good diffraction. They have the advantage that they can be processed rapidly in situ; in addition, with a glass substrate, the hologram can be erased by heating the substrate, and the material reused.

Holographic Recording Materials

• Photorefractive(PR) crystals

PR crystals feature excellent resolution, readout efficiency, reversibility, storage capacity, and sensitivity. They are highly flexible, being useful in both read/write and read-only systems. The advantages include the improvement of techniques for hologram fixing, the storage of many thick holograms at different angles within the same volume of a crystal, and electronic means for storage and readout enhancement.