METHOD FOR REPLICATING HOLOGRAPHIC OPTICAL ELEMENTS

This is a continuation of U.S. patent application Ser. No. 07/466,935 filed Jan. 18, 1990 (now abandoned) which was a continuation-in-part application of U.S. patent application Ser. No. 07/375,100 filed Jun. 30, 1989 (now abandoned).

FIELD OF THE INVENTION

The invention is directed to a method for making embossed optical elements and particularly for making embossed holograms.

BACKGROUND OF THE INVENTION

Holographic optical elements are a specialized class of surface relief holograms which are used to replace conventional optical components in laser scanning devices such as rotating mirrors, galvanometers, and other such beam-deflecting devices and their associated optics. Various types of holographic optical elements are described in "Holographic Laser Scanners For Nonimpact Printing" by C. J. Kramer; Laser Focus, pp 70–82, June 1981. European Patent Application 86308641.9, published as 0 223 508 on May 27, 1987, discloses a scanner system using rotating, high efficiency holograms to deflect a light beam achieving a linear scan. The hologram thus allows high system efficiency without requiring the input polarization to be aligned to the fringe pattern. The high efficiency, deep groove, phase hologram required for such a system is obtained by using a photoresist as the recording medium. While photoresist recording media are satisfactory for making individual deep groove, phase holograms, a method is needed to replicate faithfully the holographic optical elements to maintain the high aspect ratio needed for each duplicate element. The term "high aspect ratio" means that the depth of a groove is substantially greater, i.e., 2, 3 or more times greater, than the width of the groove.

Conventional relief holograms used in graphic arts applications, e.g., on bank cards, packaging, and book covers such as the December, 1988 (Vol. 174, No. 6) issue of National Geographic, etc., typically are lower aspect ratio reliefs having a reflective backing. Such holograms may be manufactured by a number of replicating processes including thermal embossing of thermoplastic films having a reflective surface and molding of UV-curable liquid resin layers.

Schlesinger et al. in U.S. Pat. No. 4,054,635 discloses an embossing process for replicating holograms wherein, instead of a nickel master, the hologram or photoresist image is employed directly to replicate impressed images on various thermoplastic materials by heating the hologram or photoresist image and pressing it into the surface of the thermoplastic material to produce replicated impressions of the hologram or photoresist image therein.

Japanese Patent Publication 58144879 discloses the production of hologram copies by irradiation of a curable liquid resin layer sandwiched between a relief hologram and a support. The relief hologram master is prepared conventionally and the liquid resin may consist of monomers, oligomers or prepolymers. In the process, the sandwiched liquid layer is cured by light, e.g., UV light, passing through the transparent support.

Japanese Patent Publication 58144878 discloses the production of hologram copies by coating a relief mold with UV- or electron beam-curable liquid resin, curing the resin and removing the relief mold. Holograms produced include Fresnel, Fourier transformation and Fraunhofer types.

Japanese Patent Publication 58144877 discloses the production of hologram copies by coating a thermoplastic resin mold with a UV-curable liquid resin, curing the resin and then removing the mold.

Although the conventional methods of replicating holograms meet many of the needs of the graphic arts industry, they have been unsatisfactory for replicating the high efficiency, deep groove, phase holograms required for laser scanner systems. In the case of thermal embossing, the deep groove, high aspect ratio relief hologram is not faithfully reproduced and in the case of molded UV-curable liquid resins, a residue of UV-cured resin remains entrapped in the deep grooves of the mold.

SUMMARY OF THE INVENTION

The invention is directed to

1. A method for making an optical image clement having a high aspect ratio relief hologram comprising the sequential steps of

(a) applying a dry photohardenable film to a surface of a dimensionally stable optically transparent substrate;

(b) embossing the exposed surface of the photohardenable film with the relief holographic image by applying thereto under pressure a stamper containing a reverse relief image of the hologram having an aspect ratio of at least 3:1;

(c) passing actinic radiation through the transparent substrate and the photohardenable film to effect hardening of the photohardenable film while it is in contact with the stamper; and

(d) separating the stamper from the embossed photohardened film.

BRIEF DESCRIPTION OF THE DRAWINGS

The Drawing consists of three figures.

FIG. 1 depicts schematically the steps of this invention used for preparing a holographic optical element.

FIGS. 2A–2F is a more detailed schematic description of the holographic element and the process steps used in this invention; and

FIG. 3 depicts schematically an in-line manufacturing embodiment of the invention using blank sheet substrates wherein discs are cut from the sheet after the lamination step.

DETAILED DESCRIPTION OF THE INVENTION.

A. Substrate

The substrate functions primarily as a dimensionally stable support for the photohardened information-carrying layer. It may be either rigid or flexible. To function as a suitable substrate, the disc or sheet should (1) be substantially transparent to radiation of the scanner system or end use contemplated, (2) be uniformly thick across the entire surface area, (3) have minimum birefringence, (4) have a refractive index matched to the photohardened layer, and (5) have a disc geometry suitable for the end use contemplated.

The blank substrate can be formulated from a variety of polymeric materials provided that suitable optical