B－2－4 In-Line Holographic Lenses of High Numerical Aperture

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Recently holographic optical elements including holographic lenses(HLs) come to be interesting and potentially useful in the optoelectronics.[1-5] HLs are very attractive compared with conventional lenses because they can be thin film structures of lightweight and be easily fabricated photochemically. One of the important applications of them is an use for optical players of video and audio disks to make them simple and low-cost. This requires NA higher than 0.4 of HLs but there seems to be no report on an accomplishment of such one.

In this report we will describe in-line HLs of NA up to 0.55 which were successfully fabricated using specially designed optics and processing recording materials carefully. The reason why we have not adopted off-axis HLs, but in-line ones, is that the latter have an uniaxial symmetry to be easily handled in practical optical systems.

We constructed recording opics schematically illustrated in Fig. 1: the carefully aligned off-axis HL, which was recorded from the original objective lens previously, was reconstructed by the obliquely incident plane wave to provide the spherical wave necessary for recording in-line HLs, and the another plane wave passed through this HL to interfere with the above wave on the recording material; both waves were just in-line.

Methylene-blue sensitized dichromated gelatins[6] were used for recording materials at 6471Å (Kr laser). The careful processings of the materials before and after recordings were demanded and we improved the published procedures[5-7] especially to suppress the thickness change of gelatin films as well as to obtain the diffraction efficiencies enough for our purpose.

Fig. 2 shows fabricated in-line HLs with the effective aperture of about 2 mm diameter and an original lens. The modulation transfer function (MTF) characteristics were measured to evaluate HLs and a typical result for NA=0.4 at 6328 Å is shown in Fig. 3. In-line HLs of NA =0.55 were made with another improved recording optics and were found to focus laser beams as narrow as illustrated in Fig. 4. A measured MTF for NA=0.55 is also shown in Fig. 3.

Reliability of HLs is also an important requirement for practical optical elements because gelatin holograms are well known to be destroyed under high humidity. We sealded HLs with carefully processed glass plates, photocurable adhesives and epoxy resins. Such sealded HLs were found to be not affected even when they were kept at 70°C and 90 % R. H. for several hours.

We applied these HLs to a disk-player with a I mW He-Ne laser and succeeded in playing back video and audio signals from optical disks. This application will be reported elsewhere in the near future.

References

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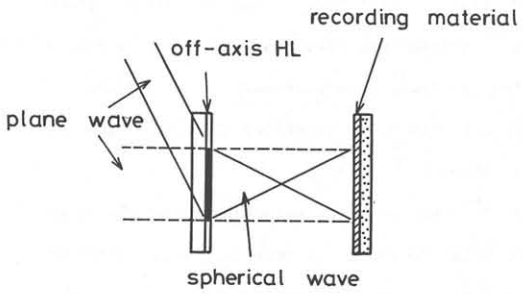

Fig.1 Recording optics for in-line HLs using an off-axis HL

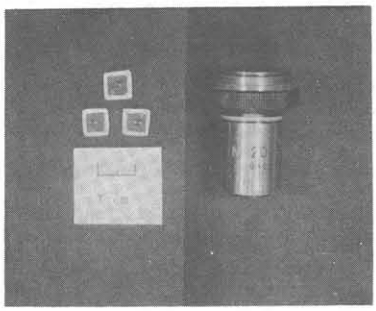

Fig.2 Photograph of fabricated in-line HLs (left) and an original lens (right)

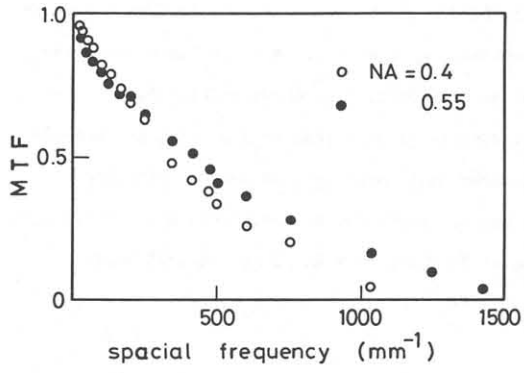

Fig.3 Measured MTF at 6328 Å

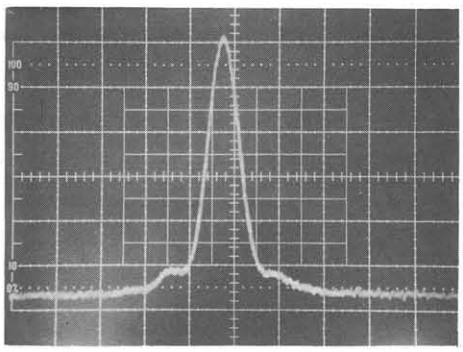

Fig.4 Beam profile focused by a HL of NA=0.55, measured with the knife-edge scanning method at 6328 Å, abscissa 0.8 μm/div.