Null CGH를 이용한 비구면 형상 측정

Interferometeric measurement of deep aspheres with null CGH

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A lenses used in large screen projection television system require more aspheric and more accuratley figured in order to achieve the high image quality. A Interfoerometric optical testing with null CGH is used for measuring aspheric surfaces to high accuracy.

The surfaces under test are 71 mm f/0.30 aspheric concave surface deviated from the best-fit surface by 1000 μm and 88 mm f/4.1 aspheric convex surface deviated from the best-fit surface by 1600 μm. Both of these tests require a surface measurement accuracy of $\pm 1.6\lambda$ rms. A phase-shifting Fizeau interferometer with He-Ne laser operating at 632.8 nm is used.

The phase CGHs for testing aspheric surface are designed to be used in the 1-st order transmission mode. These are designed for all rays to coincide with the normal of asherical surface after diffraction as shown in Figs. 1(a) and (b). The chrome-on-glass CGH for aligning CGH is designed to be used in the 3-rd order reflection mode. These are designed for all rays to exactly retroreflect into object point after diffraction as shown in Fig. 2. The CGHs will give interferometer systems an autocollimation optical scheme.

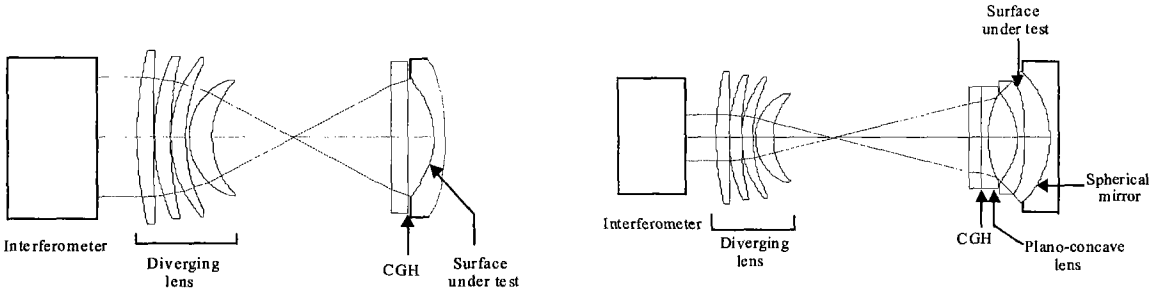

Fig. 1. Layout of phase CGH for (a) concave surface and (b) convex surface.

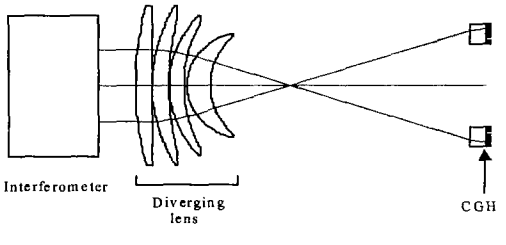

Fig. 2. Layout of chrome-on-glass CGH for convex surface

We have found that the cubic spline phase surface model is useful for describing the null CGHs located near ray caustics. Near a ray caustic, the behavior of the rays is highly nonlinear. The standard phase polynomial fitting can't properly describe the null CGH even if many polynomial terms are used. We know if the Optical Path Length(OPL) from an object point to the image point along any ray is constant, then all the field-independent aberrations are corrected. So Optical Path Difference(OPD) across CGH is expressed by $OPD_i = OPL_{center} - OPL_i$, choosing the arbitrary reference point as the center. We can properly describe the null CGH using the spline phase polynomial fitting with a total of 1000 OPDs as spline points. This work use the cubic spline phase surface in the single-pass configuration in which the refractive index of object plane is 0. Thus, the normals of surface easily generate if parallel rays from asphere to image point are traced.

We have found that the concave lens is useful for correcting the spacing between adjacent rings on hologram. In the grating equation, the ring spacing depends on the angle of incident ray, so the incident ray with fast slope cause the small for ring spacing. This tell concave lens can be putted in front of the CGH to increase the ring spacing. Applying the concave lens to the system in which ring spacing decrease with increasing ring radius, we can get the reasonable improvement that the ring spacing of 1μm is increased to 3μm, making the part easier to fabricate.

Wavefront tilt and power terms from the raw phase map in order to reduce alignment errors during the interferometeric measurements are removed. And then the data are low pass filtered to reduced high frequency noise. The processed 2-D and 3-D phase maps are shown in Figs. 3 and 4, respectively.

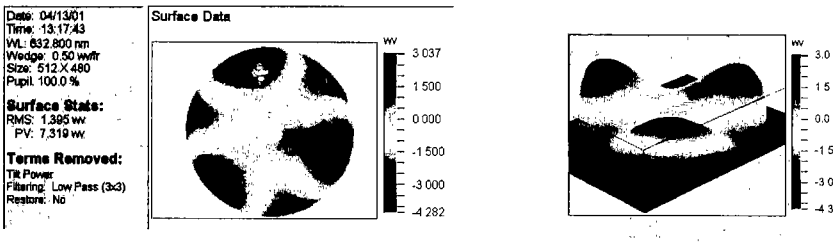

Fig. 3. 2-D and 3-D phase map of concave aspherical surface acquired through the null CGH

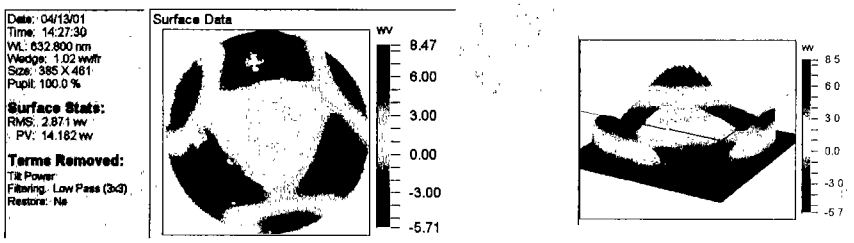

Fig. 4. 2-D and 3-D phase map of convex aspherical surface acquired through the null CGH.