Application of Micro Devices for DVD-like Pickup

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Abstract

Optical data storage industries are continually growing with rapid progress of computer, multimedia, and network markets. In this trend, technologies capable of recording more information thus become increasingly demanded. Optical pickups are key component of the recording system. To develop high-spatial-resolution, high-optical-efficiency, and small-sized optical pickup is essential to enable the system more competitive in price and performance.

Among these optical devices in the optical pickup, the objective lens is the most important device. From DVD specification, such as the cover layer thickness and the three beam tracking, the minimum size of objective lens was discussed. Moreover, to fabricate the micro lens applied to objective lens, the mature processes to for micro devices are reflow process and gray-scale mask. The spherical lens made by using the reflow processes causes the spherical aberrations. Therefore, the reflow process is not feasible to make the lenses satisfied the DVD specification.

The other approach to make the micro objective lenses is the gray-scale mask.

By well-adjusted aperture ratio of the mask, the aspheric surface which has eliminated geometrical aberration is feasible. Therefore, we suggest using gray-scale mask to fabricate micro lenses. With this process, three kinds of lenses, namely aspheric lens, Fresnel lens, and harmonic lens are feasible. By utilizing proper optimization variables, the aspheric lenses with thickness of 97.5 μm meet the requirement of DVD-like objective lens. However, the thickness of the aspheric lens is too thick to be fabricated. Next, the Fresnel lens was proposed to overcome the thickness. Nevertheless, the 1um line width of the Fresnel lens is too fine to make the refractive profile for a lens of high NA. Thus, we propose the harmonic lens for objective lens purpose.

The conventional design steps of harmonic lens include three parts. First, the refractive profile was designed. Next, the refractive profile was sliced. Finally, the sliced layers were compressed into one layer. The focal shift of slicing induces the aberrations. We proposed a novel method to overcome this issue. When slicing the lens, we employed the aspheric profile to redesign the surface of each segment and choice the outmost part with eliminated geometrical aberration. The redesigned harmonic lens obtained is the combination of several segments with aspheric profiles. The thickness of the redesigned harmonic lens is 19.5 μm. The diameter of designed harmonic lens is 260 μm to couple three-beams tracking with beam width of 210 μm. The volume of the objective lens is highly reduced to 1.91×10^{-6} cm^3. A harmonic diffractive objective lens has been designed to be fabricated with gray-scale mask photolithography and will be integrated onto a free space optical module for a MEMS-type DVD-like pickup. The modeling and analysis show that the aberration of objective lens is negligible and the size of focused spot meets DVD specification of 1.08 μm.