Asphere Manufacturing Considerations for the Designer

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This paper will present designers with topics to consider during aspheric lens design. There are geometrical restrictions that hinder producing particular aspheric shapes. Understanding these restrictions will help drive cost out of the design.

1. Specifying a clear aperture

Independent of the aspheric surface shape (convex and or concave) the clear aperture diameter is smaller than the full diameter of the part. The behavior of the aspheric profile within both of these diameters and the associated actual edge thickness influences the manufacturing options as well as the price of the optic. The need to produce an over sized in-process mechanical diameter is, in most all cases, critical to successfully yielding the final product. It is common to process parts oversized by 4mm or more beyond the final clear aperture. Once polished the lens is then edged to the final diameter.

2. Aspheric Lens Edge Thickness

When producing an aspheric lens with the previously mentioned over-sized condition the manufacturer has to account for resultant edge thickness. There are conditions that present challenges, such as negative edge thickness, where the intersections of both lens surfaces occur inside of a processing diameter. Another is asymptotic edge thickness, where the lens diameter cannot mathematically go beyond a given diameter. Either case requires the manufacturer to create tooling or alter the surface geometry beyond the clear aperture. This is done to provide the required working sub aperture. During the design phase, inspecting the general shape of the aspheric surface 4mm beyond the actual clear aperture is recommended.

3. Cost-drivers when specifying aspheric surfaces

A well-behaved aspheric surface is one without inflections (sharp direction changes). This form has a continuously increasing or decreasing radius from center to edge. In general the fewer the inflections the lower the manufacturing cost.

For a convex aspheric surface, the vertex radius can range from less than 3mm to infinity. The vertex radius is the base radius that the aspheric surface is applied to. The opportunity to produce these shapes have the fewest manufacturing limitations over a larger range of diameters. The measurement of convex surfaces can be achieved using either contact profilometry or, in certain cases, interferometry. This type of asphere is generally the least expensive to produce.

Concave aspheric surfaces have radius restrictions that can pose challenges. An example is the actual sag of the surface verses the vertex radius. Interference during sub aperture processing can result in a compromised condition. The grinding and polishing tools need to “fit” within the concave work space. Therefore, a vertex radius that is larger than 13mm provides better opportunity for the manufacturer. The measurement of concave surfaces can be achieved using either contact profilometry or, in many more cases, interferometry. The concave geometry poses a cost factor that should be considered.

4. Aspheric Departure and Measurement

Qualifying the aspheric surface during the entire process of grinding and polishing is a specific requirement that is again shape dependant. The use of a contact profilometer offers the greatest flexibility in the process, and can accommodate the greatest amount of departure. The precision achievable using the profilometer provides the manufacturer with accurate two dimensional measurements. Multiple measurements can be synthetically joined to produce a surface map and create a correction file [1, 2]. This process commonly yields final results as precise as two waves peak to valley, depending on all previously mentioned considerations.

The use of interferometry provides the manufacturer with a true three dimensional surface map which can be used to correct the aspheric form to exacting tolerances. The fringe density over any given zone of the associated aspheric surface will limit what interferometry solutions are available for the manufacturer. This is where the aspheric departure can become a limitation, designing a null test or CGH to use interferometry increases cost dramatically. Designing surfaces that can be tested with commercially available interferometers [3, 4] will contain cost and provide fractional wave peak to valley precision.

For more details on aspheric manufacturing [5] refer to cited references.

5. References

[1] Taylor Hobson, 1725 Western Drive West Chicago, IL 60185, (http://www.Taylor-Hobson.com)

[2] Zeeko Ltd, 4 Vulcan Court, Vulcan Way, Coalville, Leicestershire LE67 3FW, (http://www.zeeko.co.uk/)

[3] Zygo Corporation, Laurel Brook Rd Middlefield, CT 06455, (http://www.zygo.com)

[4] QED Technologies Inc., 1040 University Avenue Rochester, NY 14607-1282, (http://qedmrf.com)

[5] Optimax Systems Inc., 6367 Dean Parkway, Ontario, N.Y. 14519, (http://www.optimaxsi.com)