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Measuring Miniature Lens Radius of Curvature and Refractive Index with White Light Optical Profiler

Introduction

For miniature lenses with size of few millimeters or sub-millimeter, it is difficult to measure their parameters, radius of curvature (ROC) and refractive index (N), with conventional methods. iOptron's advanced optical profiler can be used to precisely measure both parameters. Because of its unique design, applicable surface reflective coefficient of the lens can be ranged from 0.1% to 100%, that include almost any surfaces such as that of antireflection coated. Large range of ROC, convex or concave, can be measured less than 1% error. In addition, this white-light interferometer based instrument can also used to measure refractive index of lenses directly.

Measuring Radius of Curvature

iOptron optical profilers provide real time, vibration insensitive, user-friendly ROC measurement with high resolution.

The steps to measure ROC of lens using iOptron Optical Profiler, is as follow:

1. Place the lens under the 3D on the sample holder;.
2. Adjust the light source intensity, find the interference fringe;
3. Adjust fringe contrast for maximum contrast for varies surface reflectivity;
4. For convex surface, adjust the lens start-position so that the fringes on screen move outward direction and stop when fringes just disappear. (This will make fringe movement out to in, when software module is run.)

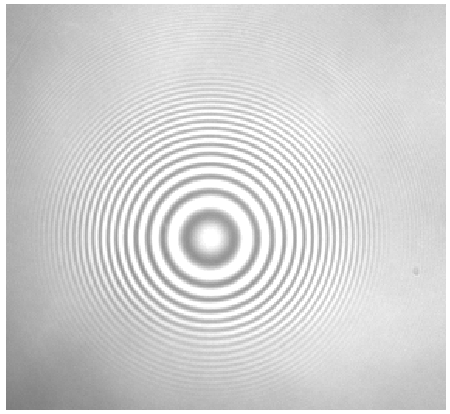

Figure 1 Fringe movement from outward towards center for convex surface.

5. For concave surface, adjust the lens position such that the fringes on screen moves inward direction and stop when fringes intensity is maximum in center and disappear. (This will make fringe movement in to out, when software module is run)

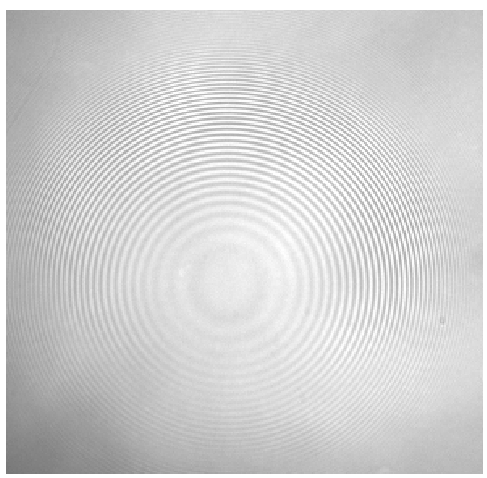

Figure 2 Fringe movement from out to center for concave surface.

6. Once the lens position is set, run the module, the module will create a 2D intensity image showing in Figure 3. Draw a line passing through center on the lens cross-section image created. Values of Radius of Curvature and center position will be cur-fitted and displayed on the screen.

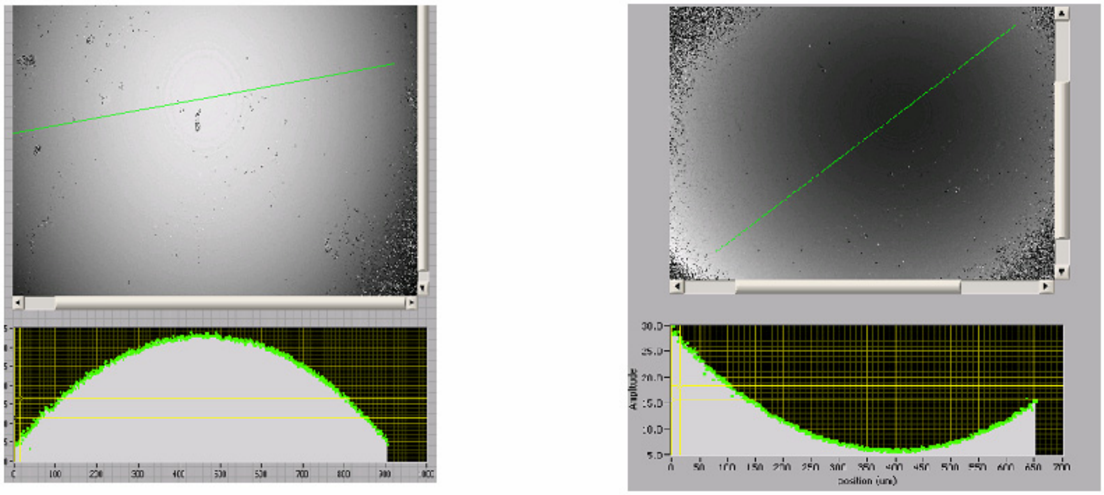

Figure 3: 2D intensity and cross-section images for a convex surface (left) and a concave surface (right)

7. The module also generates 3D image of the lens surface and also the curve-fitting graph to monitor surface profiling and noise along with ROC measurement.

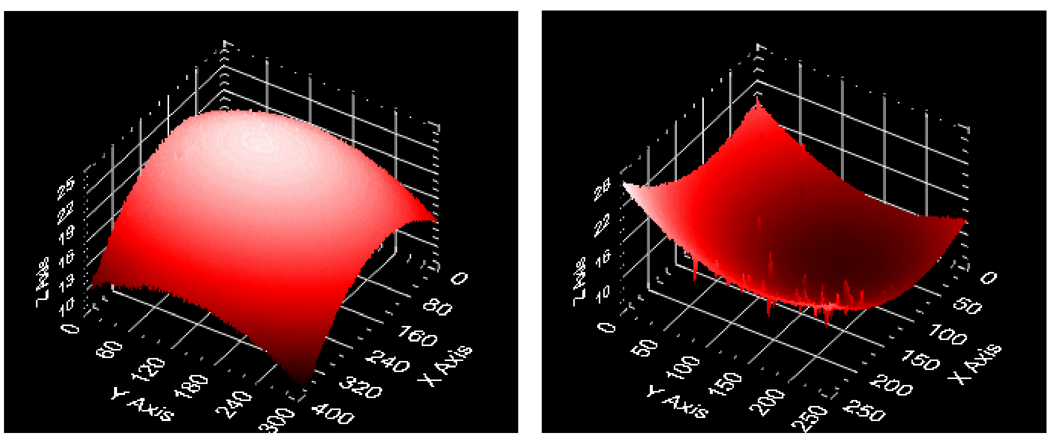

Figure 4: 3D Sphere surface image generated by software module (a) Convex lens (b) Concave lens

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Measure the reflective index of a lens

Refractive index measurement is another attractive feature of iOptron optical profiler. It can provide straightforward measurement of lens refractive index without any cutting and with reasonable accuracy (< 1%).

The measurement principle is based on finding out optical-path difference between two surfaces and comparing with the physical thickness of the lens. These surfaces position can be determined from series of "interfering" z-scan positions. A program to monitor whole field "coherency" has been developed for easy finding these interfering positions.

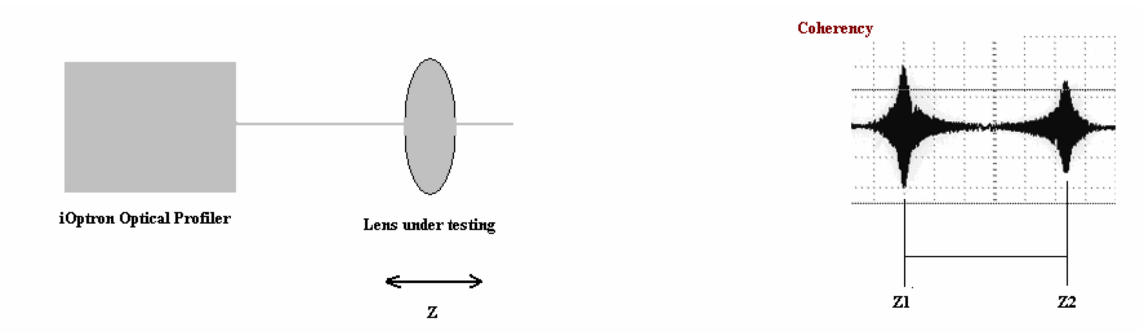

Figure 5 Principle of measuring refractive index of a lens

The steps to measure ROC of lens using iOptron Optical Profiler, is as follow:

1. Place the lens and run the program;
2. Record z positions when the "coherency" window turns to brightest (peak coherency); displacement of two peaks is the optical-path difference between two surfaces;
3. The refractive index then can be calculated from the optical-path difference divided by the thickness.

For example, Figure 6 and Figure 7 show the coherency image and corresponding fringe image of front and back surfaces of a lens under testing. We can calculate the refractive index of that BK7 lens was 1.515 at 635nm wavelength.

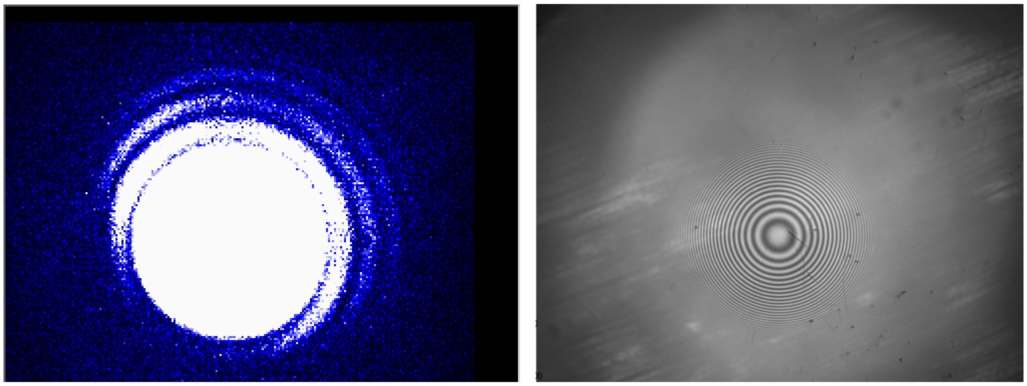

Figure 6 Front surface "coherency" image and fringe image of a lens under testing.

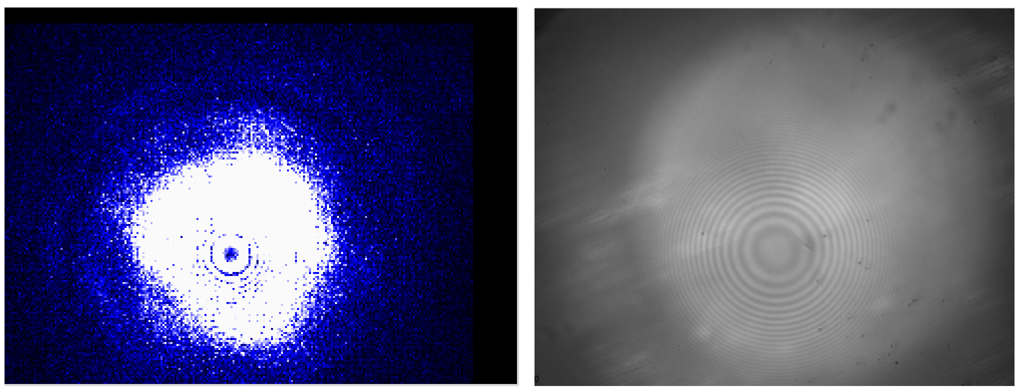

Figure 7 Back surface "coherency" image and fringe image of the lens under testing.

At certain circumstance, the fringe will be difficulty to find from ordinary fringe imaging. However, it is much easier to find in the "coherency" image. Figure 8 shows an example of when measuring a special lens, which the image of the surface under testing was very small. It was still easy to find the interference peak from "coherency" image.

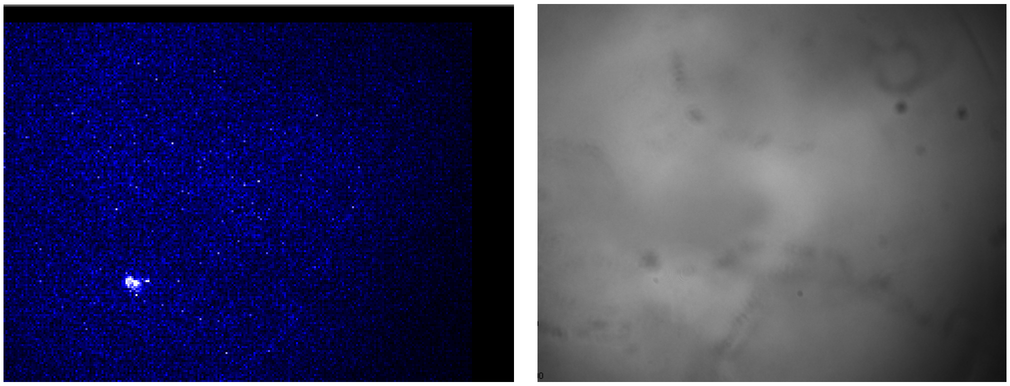

Figure 8 It is much easier to find interfering fringe from "coherency" image than from ordinary fringe image.

Conclusion

The ROC and refractive index measurement is an important advancement in 3D measurement techniques. This has given scientists, engineers, quality control and process engineers a significantly improved tool for production control and new product design.

3D optical measurement system from iOptron corporation is a versatile, economic and easy-to-use instrument to measure both important parameters of a lens, radius of curvature and refractive index.