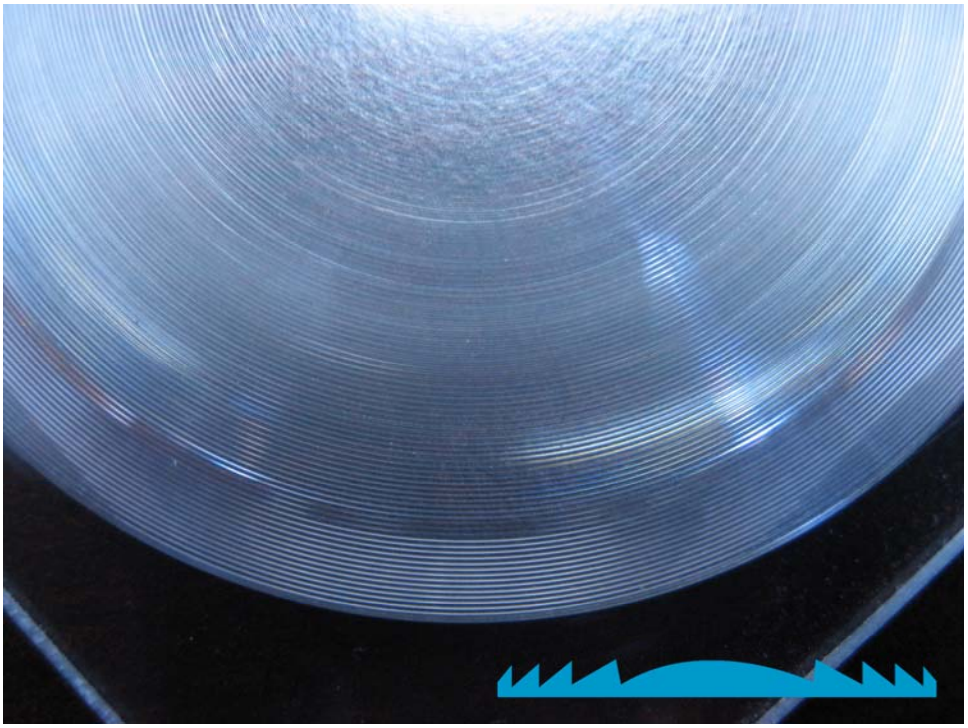
NANOVEA
A Better Measure.

FRESNEL LENS DIMENSIONS USING 3D PROFILOMETRY



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INTRO

A lens is an optical device of axial symmetry that transmits and refracts light. A simple lens consists of a single optical component for converging or diverging the light. Even though spherical surfaces are not ideal shape for making a lens, they are often used as the simplest shape which glass can be ground and polished to.

A Fresnel lens consists of a series of concentric rings, which are thin parts of a simple lens with a width as small as a few thousandths of an inch. Fresnel lenses contain a large aperture and short focal length, with a compact design that reduces the weight and volume of material required compared to conventional lenses with the same optical properties. A very small amount of light is lost by absorption because of the thin geometry of the Fresnel lens.

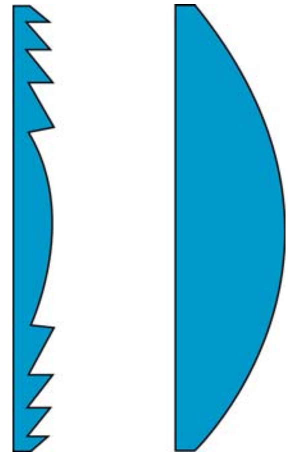


Fig. 1: Cross-section of a Fresnel Lens vs. Cross-section of a Conventional Plano-convex Lens of Equivalent Power.

IMPORTANCE OF 3D NON-CONTACT PROFILOMETER FOR FRESNEL LENS INSPECTION

Fresnel lenses are extensively employed in industry, such as automobile, lighthouses, solar energy and optical landing system for aircraft carriers. The inexpensive production of Fresnel lenses can be completed by molding or stamping them out of transparent plastic. The service quality of the Fresnel lenses mostly depends on the precision and surface quality of the concentric rings lenses. Unlike a touch probe technique, the Nanovea Profilometer performs 3D surface measurement of the sample without touching, avoiding the risk of making new scratches during the surface measurement. The chromatic confocal technique is ideal for precise scan of a complex shape, such as lenses of different geometry.

MEASUREMENT OBJECTIVE

In this application, the Nanovea ST400 is used to perform a contour analysis on a Fresnel lens. We showcases the capacity of Nanovea non-contact profilometer in providing comprehensive 3D profile analysis of optical component of a complex shape.

Fig. 2: Fresnel lens for the surface measurement.

RESULTS AND DISCUSSION

Fig. 3 displays the schematic of the Fresnel lens. It consists of a series of concentric rings and a complex serrated cross-section profile. The 2.3″ x 2.3″ Acrylic Fresnel lens in this study has a 1.5″ focal length, 2.0″ effective size diameter, 125 grooves per inch, and an index of refraction of 1.49.

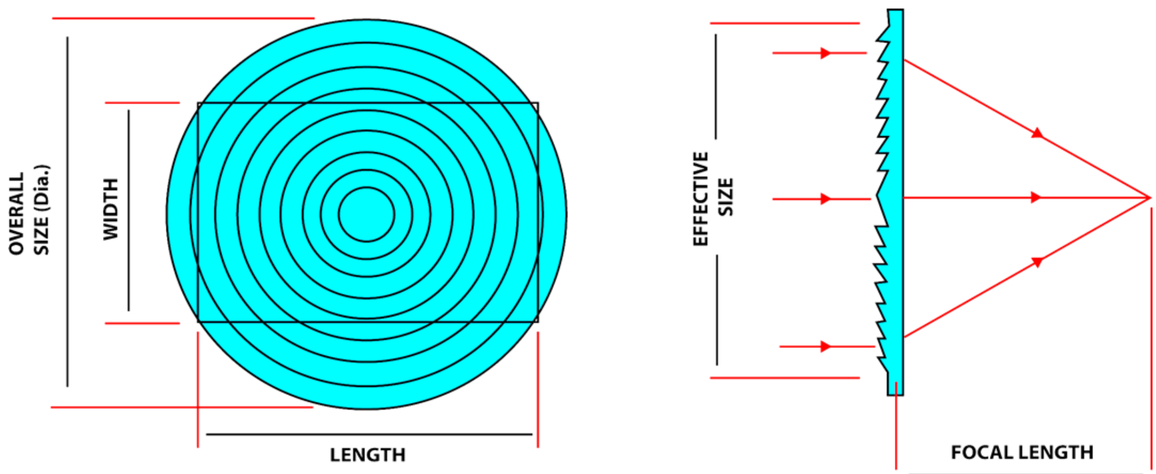


Fig. 3: Fresnel lens schematic.

The false color view and 3D view of the Fresnel lens are shown in Fig. 4 and Fig. 5, respectively. Fig. 6 and Fig. 7 show the dimensional analysis of the 2D profile of the Fresnel lens. There is a noticeable increase in height of the concentric rings, moving outward from the center of this particular Fresnel lens.

Transparent plastic Fresnel lenses can be manufactured by molding or stamping. Accurate and efficient quality control is critical to reveal defective production molds or stamps. By measuring the height and pitch of the concentric rings, production variations can be detected by comparing the measured values against the specification values given by the manufacturer of the lens.

Precise measurement of the lens profile ensures that the molds or stamps are properly machined to fit manufacturer specifications. Moreover, the stamp could progressively wear out over time, causing it to lose its initial shape. Consistent deviation from the lens manufacturer specification is a positive indication that the mold needs to be replaced.

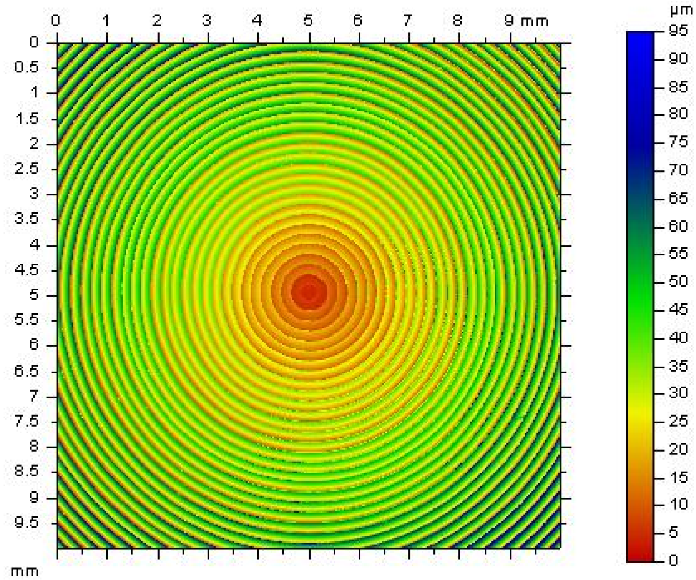


Fig. 4: 2D False Color Height Representation of a Fresnel lens in Nanovea ST400 Analysis Software.

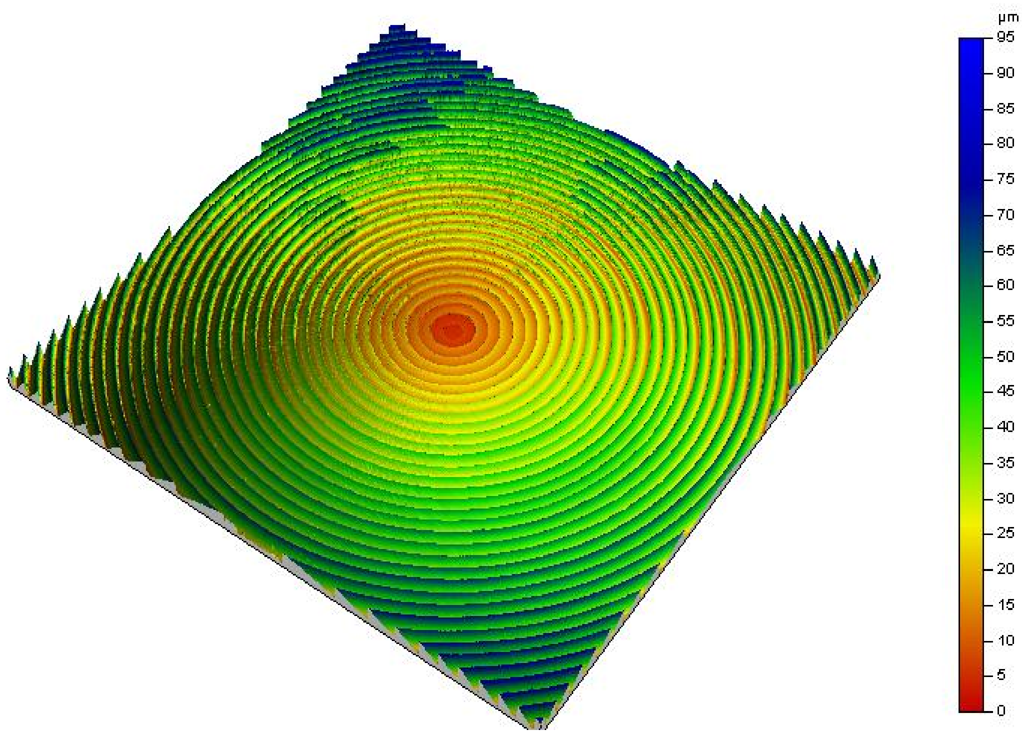


Fig. 5: 3D view of the Fresnel lens.

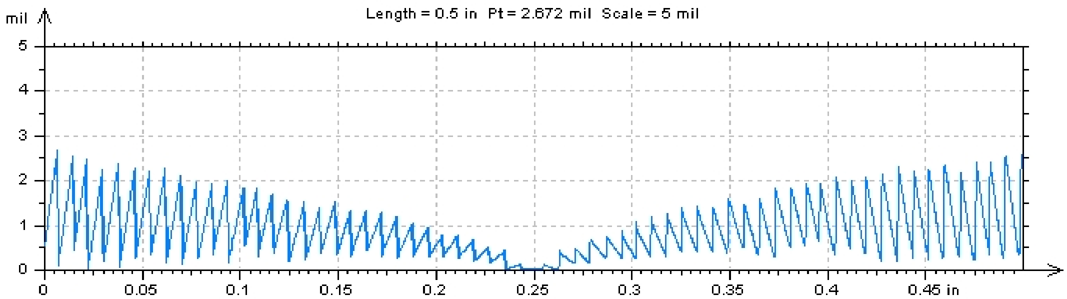
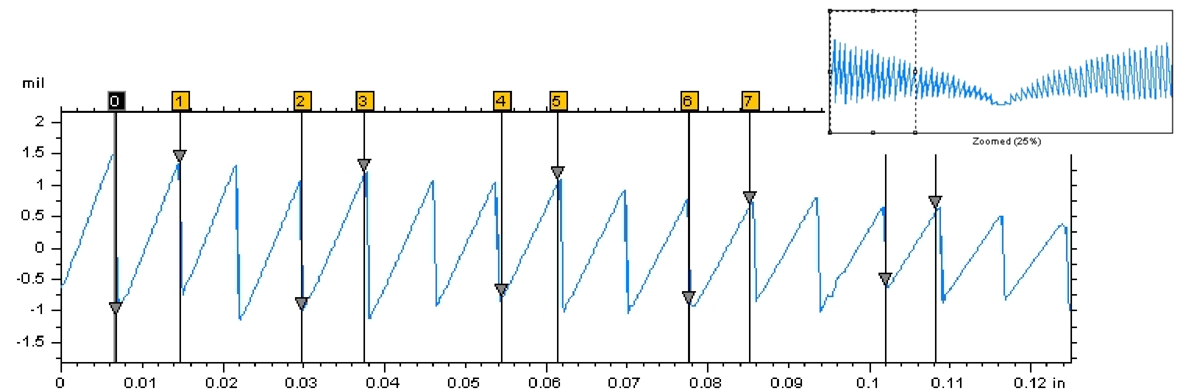


Fig. 6: Fresnel Lens Extracted Profile in Nanovea ST400 Analysis Software.



	0-1	2-3	4-5	6-7	8-9
Horizontal distance :	0.007795 in	0.00766 in	0.007023 in	0.007409 in	0.00625 in
Height difference :	2.445 mil	2.193 mil	1.853 mil	1.589 mil	1.248 mil
Slope :	313.6 mil/in	286.3 mil/in	263.8 mil/in	214.5 mil/in	199.8 mil/in
Angle :	17.41°	15.98°	14.78°	12.11°	11.3°

Fig. 7: Peak and Valley Dimensional Analysis of the Extracted Profile.

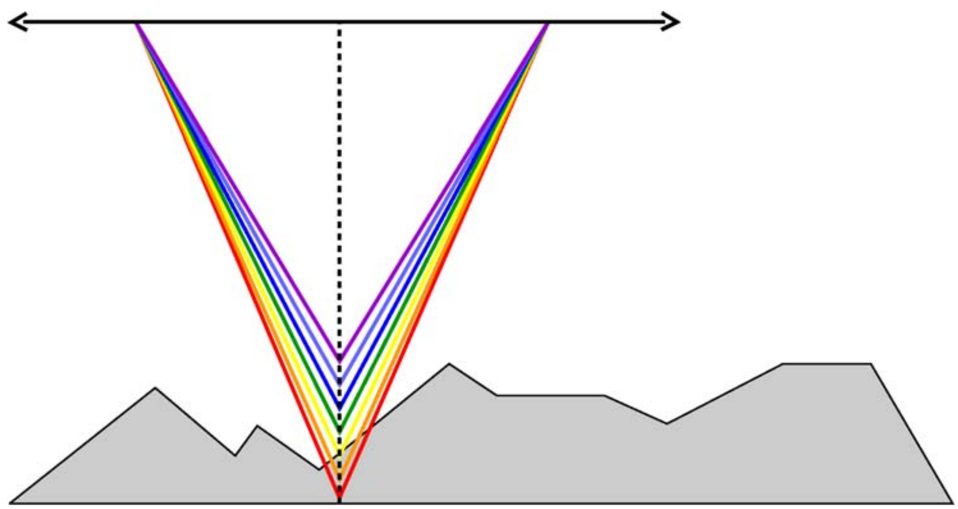
CONCLUSION

In this application, we have showcased that the Nanovea ST400 non-contact profilometer accurately measures the surface topography of Fresnel lenses. The dimension of the height and pitch can be accurately determined from the complex serrated profile using Nanovea analysis software. Users can effectively inspect the quality of the production molds or stamps by comparing the ring height and pitch dimensions of manufactured lenses against the ideal ring specification.

The data shown here represents only a portion of the calculations available in the analysis software. Nanovea Profilometers measure virtually any surface in fields including Semiconductor, Microelectronics, Solar, Fiber Optics, Automotive, Aerospace, Metallurgy, Machining, Coatings, Pharmaceutical, Biomedical, Environmental and many others.

APPENDIX: MEASUREMENT PRINCIPLE

The axial chromatism technique uses a white light source, where light passes through an objective lens with a high degree of chromatic aberration. The refractive index of the objective lens will vary in relation to the wavelength of the light. In effect, each separate wavelength of the incident white light will re-focus at a different distance from the lens (different height). When the measured sample is within the range of possible heights, a single monochromatic point will be focalized to form the image. Due to the confocal configuration of the system, only the focused wavelength will pass through the spatial filter with high efficiency, thus causing all other wavelengths to be out of focus.



The spectral analysis is done using a diffraction grating. This technique deviates each wavelength at a different position, intercepting a line of CCD, which in turn indicates the position of the maximum intensity and allows direct correspondence to the Z height position.