ASPHERIC LENS DIMENSION
USING 3D PROFILOMETRY

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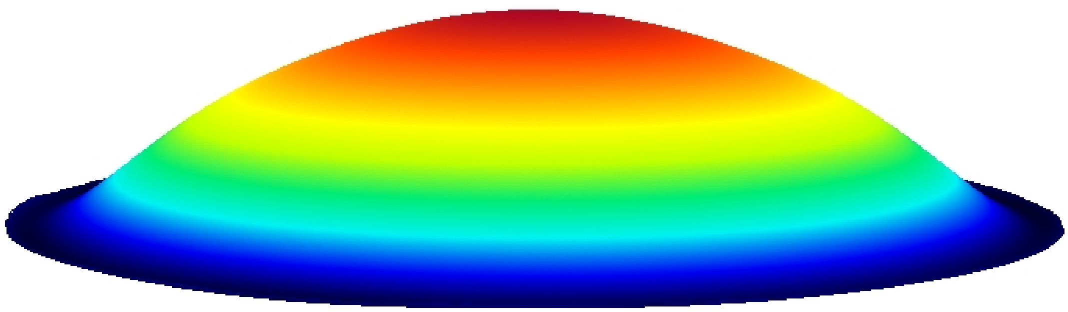
INTRO:

A lens is an optical device with perfect, or approximate, axial symmetry which transmits and refracts light (converging or diverging the light). A simple lens is a lens that consists of a single optical component. A compound lens is an array of simple lenses that share a common axis. Using multiple optical components, in a compound lens for instance, introduces more optical aberrations to correct for than with a simple lens.



3D Rendering of Aspheric Lens in Nanovea ST400 Analysis Software

Even though spherical surfaces are not ideal shape for making a lens, they are often used and the simplest shape which glass can be ground and polished to. Since lenses always contain a certain degree of distortion, they do not form perfect images. Instead, the lenses produce an imperfect replica of the object being viewed. Spherical aberration is an optical effect seen in lenses where there is an increase in the refraction of light beams that penetrate a lens near its edge, compared to light beams that penetrate close to the center of the lens (near the axis). Light rays that enter the lens close to the axis are focused farther away, on the axis, than those rays that enter the lens farther away from the axis, close to the edge of the lens. The resulting imperfect focal point produces a blurred image. In the ideal case of a perfect lens, all light beams are focused at the same point on the axis.

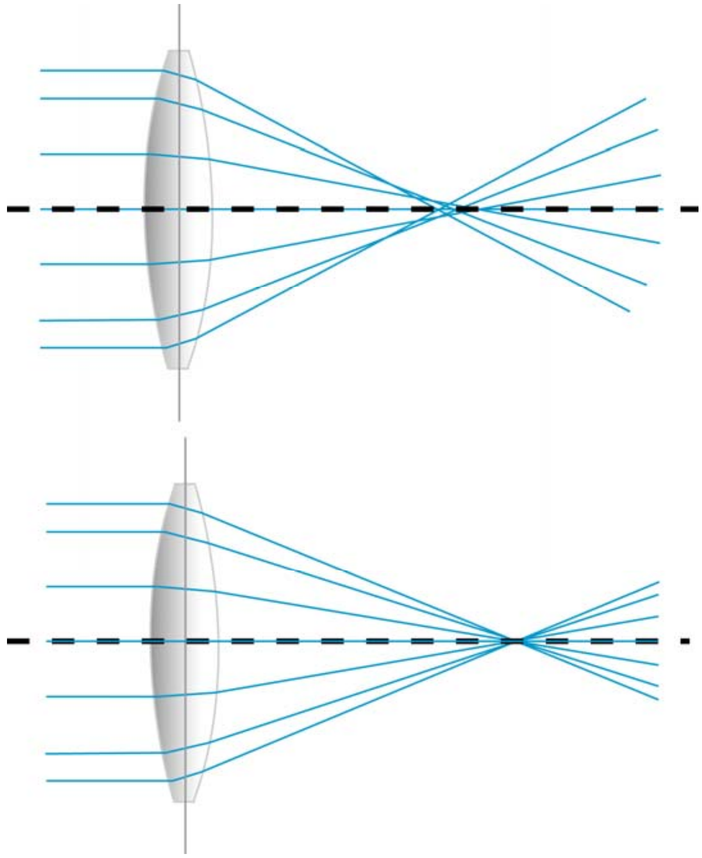


Illustration of Focal Points of Light Beams in a Real Lens (Top) vs. a Perfect Lens (Bottom)

An aspheric lens is a lens whose surface profile resembles that of a bell curve, where the curvature of the lens flattens toward the edge of the lens. This complex surface curvature can remove spherical aberration and decrease other optical aberrations seen with a simple lens. In many instances, a single aspheric lens can replace a more highly complex multi-lens system. Choosing this replacement lens can result in a lighter, smaller, and probably less expensive system, or device.

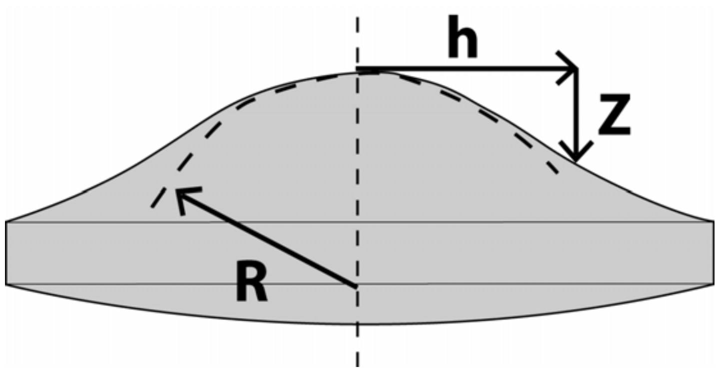
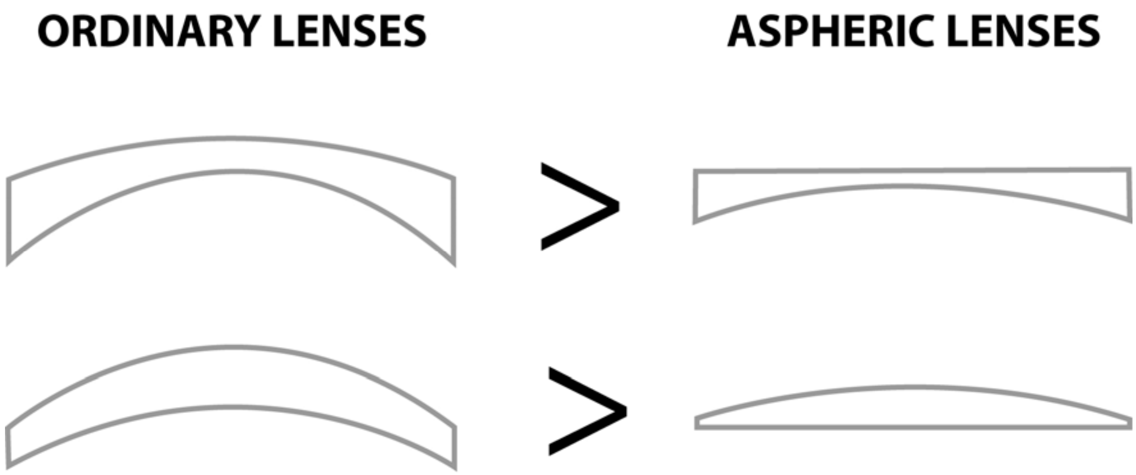


Illustration of an Aspheric Biconvex Lens

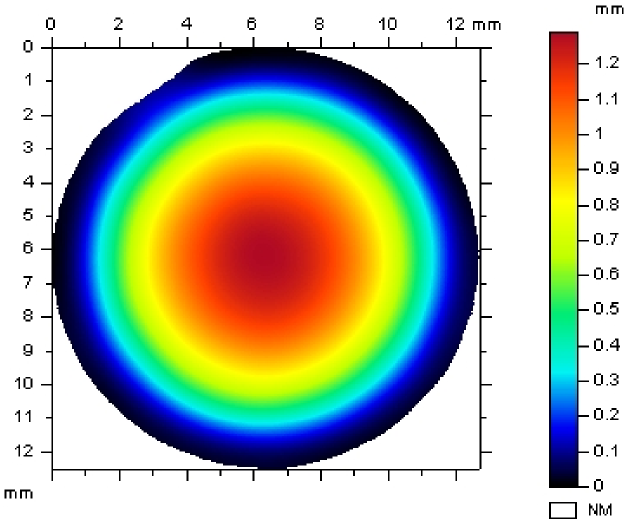
Certain eyeglasses have aspheric lenses. These eyeglasses typically have thinner lenses that provide less distortion of the eye, as seen by other people, thus generating a nicer aesthetic appearance (both eyes will look more natural to other people). Eyeglasses that have conventional spherical lenses contain a distortion when looking away from the center (axis) of the lens. However, aspheric lenses reduce, and sometimes remove, these aberrations to provide a wider field of view and enhanced peripheral vision.



The Difference between a Slimmer, Thinner and Lighter Aspheric Lens vs. Conventional Glass or Plastic Lens.

PRODUCTION

The inexpensive, mass production of small plastic and glass aspheric lenses is accomplished by molding them. These aspheric lenses are commonly used in certain types of consumer cameras, camera phones, and CD players because of their good performance and low production costs. Other applications in which the molded aspheres are frequently used are laser diode collimation and coupling light into and out of optical fibers. Large aspheric lenses are created by grinding and polishing. These large aspheres are used in projection TVs, scientific research instruments, telescopes, and missile guidance systems.



False Color Height Representation of an Aspheric Lens in Nanovea ST400 Analysis Software

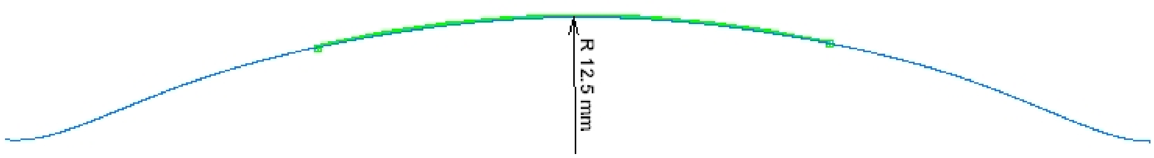
MEASUREMENT OBJECTIVE

In this application, the ST400 is used to measure the surface topography of an aspheric lens. The aspheric lens measured is a 0.5" (12.7mm) diameter, molded, acrylic plastic lens manufactured by Edmund Optics. The radius specification for this lens is 12.45 mm.

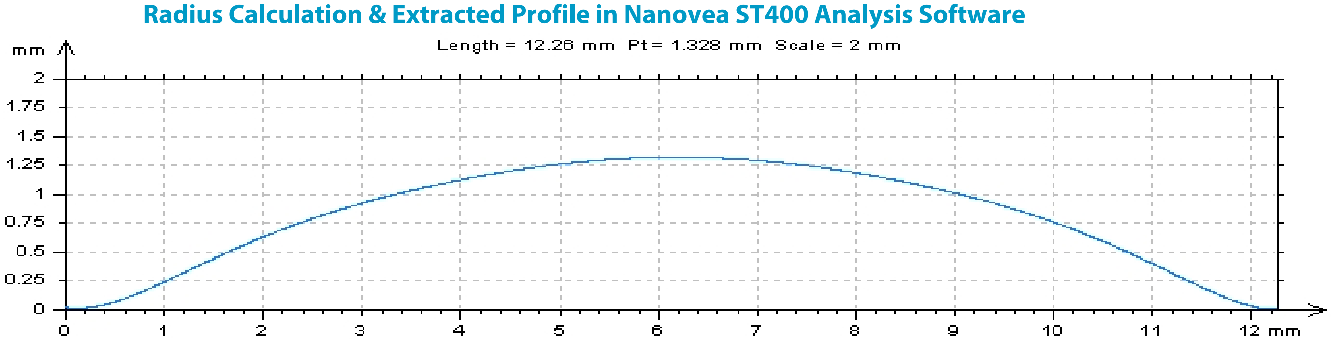
By measuring the radius of the lens, production variations can be detected by comparing the measured radius value against the radius specification value given by the manufacturer of the lens. Quality control by these means could reveal defective production molds. For instance, the mold could be wearing over time, causing it to lose its initial shape, or curvature. Consistent deviation from the radius specification could be a positive indication that the mold needs to be replaced.

TEST RESULTS:

RADIUS CALCULATION

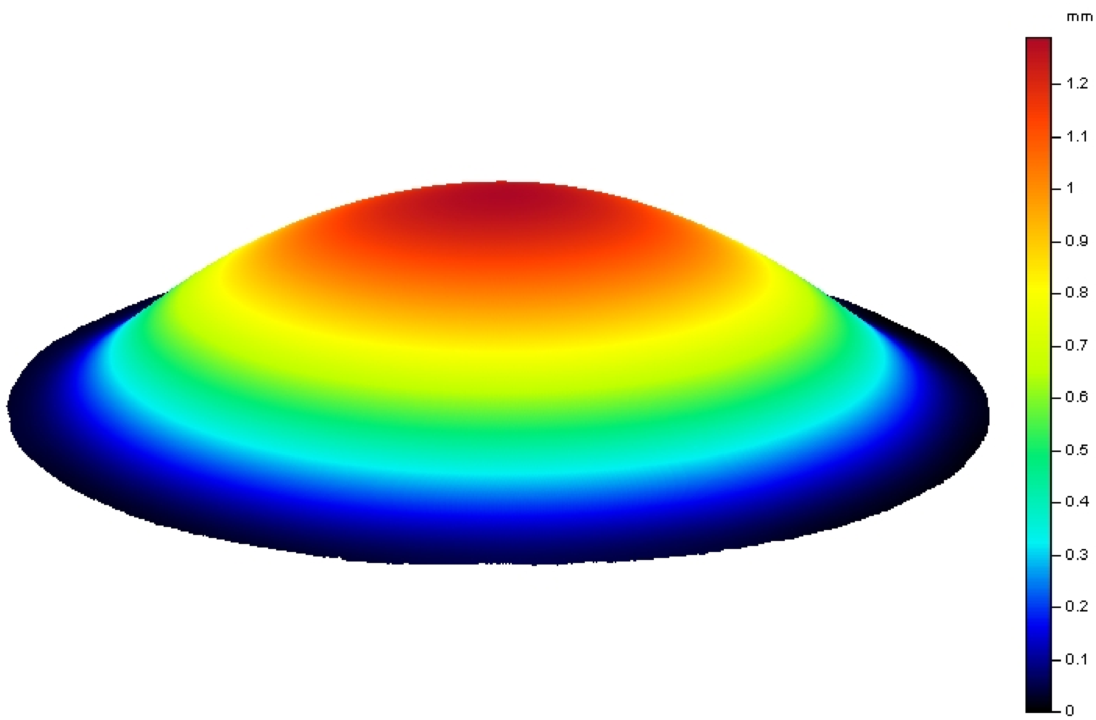


Radius Calculation & Extracted Profile in Nanovea ST400 Analysis Software

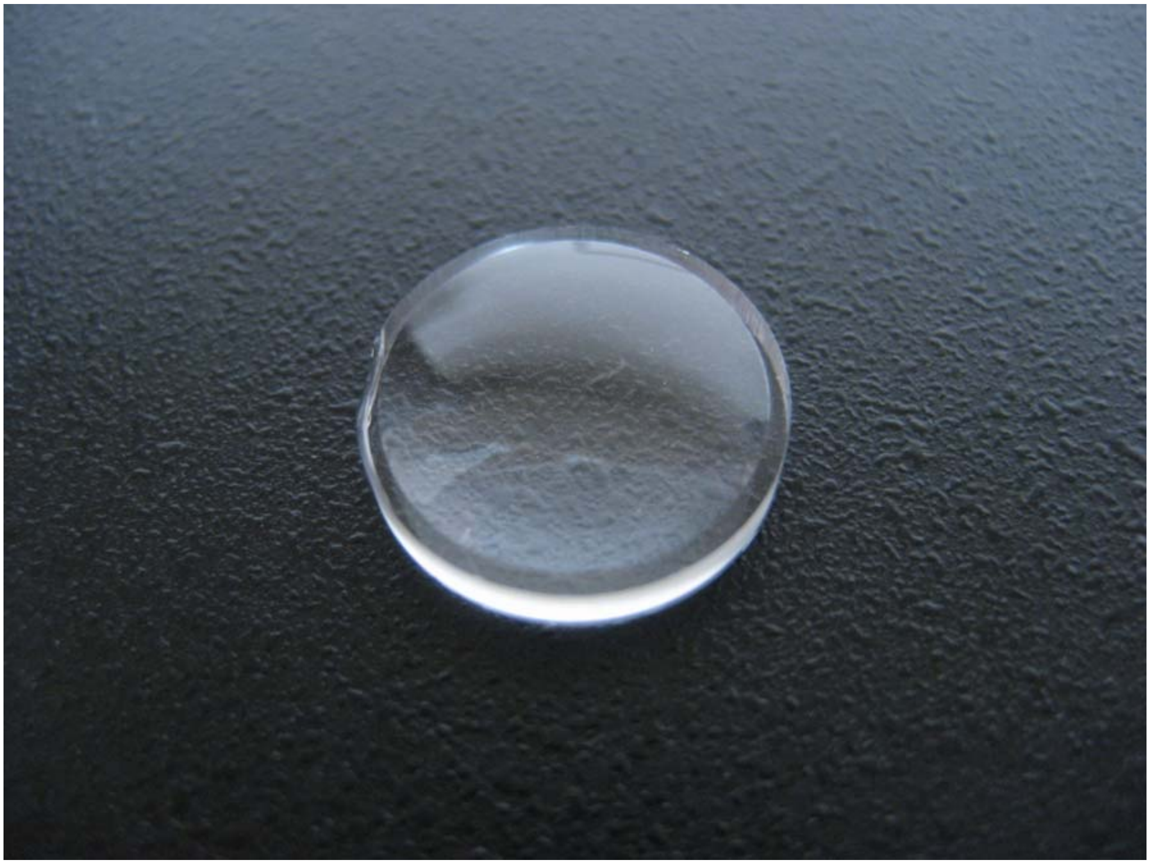


TEST DISCUSSION:

The radius of the aspheric lens, used in this study, was calculated to have a radius of 12.5 mm. From the radius calculation, it can be observed that the radius of the aspheric lens that was measured by the Nanovea ST400 is approximately the same as the radius specification provided by the manufacturer of the lens, Edmund Optics, which is 12.45 mm. Due to this observation, it can be assumed that the production mold that was used to form this aspheric lens is retaining the necessary shape. Maintaining production mold shape is essential for the manufacturer to produce lenses that fall in line with radius specifications.



3D Rendering of Aspheric Lens with Height Color Scale in Nanovea ST400 Analysis Software

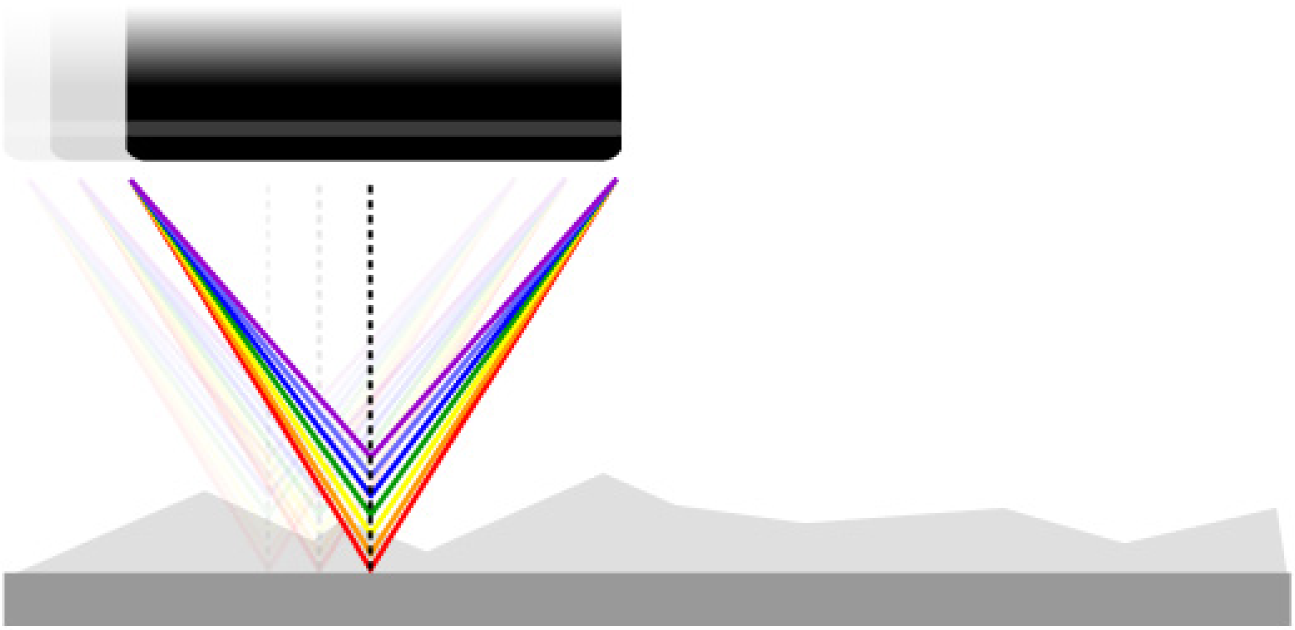


CONCLUSION:

The Nanovea ST400 can be used to accurately measure the surface dimension of aspheric lenses, from which radius calculations can be made. The complex profile curvature of an aspheric lens can be measured because of the versatile measurement technique used by the ST400. Using the measurement data, the analysis software provided with the ST400 can quickly and precisely calculate the radius of the lens. Comparing radius values of manufactured lenses against the ideal radius specification is an extremely useful quality control tool to verify that production molds are maintaining their proper shape.

MEASUREMENT PRINCIPLE:

The Chromatic Confocal 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.



Unlike the errors caused by probe contact or the manipulative Interferometry technique, Chromatic Confocal technology measures height directly from the detection of the wavelength that hits the surface of the sample in focus. It is a direct measurement with no mathematical software manipulation. This provides unmatched accuracy on the surface measured because a data point is either measured accurately without software interpretation or not at all. The software completes the unmeasured point but the user is fully aware of it and can have confidence that there are no hidden artifacts created by software guessing.

Nanovea optical pens have zero influence from sample reflectivity or absorption. Variations require no sample preparation and have advanced ability to measure high surface angles. Capable of large Z measurement ranges. Measure any material: transparent or opaque, specular or diffusive, polished or rough. Measurement includes: Profile Dimension, Roughness Finish Texture, Shape Form Topography, Flatness Warpage Planarity, Volume Area, Step-Height Depth Thickness and many others.

DEFINITION OF HEIGHT PARAMETERS

	Height Parameter	Definition
Sa	Arithmetical Mean Height	Mean surface roughness. $Sa = \frac{1}{A}\iint_A \lvert z(x,y)\rvert dxdy$
Sq	Root Mean Square Height	Standard deviation of the height distribution, or RMS surface roughness. $Sq = \sqrt{\frac{1}{A}\iint_A z^2(x,y)dxdy}$ Computes the standard deviation for the amplitudes of the surface (RMS).
Sp	Maximum Peak Height	Height between the highest peak and the mean plane.
Sv	Maximum Pit Height	Depth between the mean plane and the deepest valley.
Sz	Maximum Height	Height between the highest peak and the deepest valley.
Ssk	Skewness	Skewness of the height distribution. $Ssk = \frac{1}{Sq^3}\left[\frac{1}{A}\iint_A z^3(x,y)dxdy\right]$ Skewness qualifies the symmetry of the height distribution. A negative Ssk indicates that the surface is composed of mainly one plateau and deep and fine valleys. In this case, the distribution is sloping to the top. A positive Ssk indicates a surface with a lot of peaks on a plane. Therefore, the distribution is sloping to the bottom. Due to the large exponent used, this parameter is very sensitive to the sampling and noise of the measurement.
Sku	Kurtosis	Kurtosis of the height distribution. $Sku = \frac{1}{Sq^4}\left[\frac{1}{A}\iint_A z^4(x,y)dxdy\right]$ Kurtosis qualifies the flatness of the height distribution. Due to the large exponent used, this parameter is very sensitive to the sampling and noise of the measurement.
Spar	Projected Area	Projected surface area.
Sdar	Developed Area	Developed surface area.