OPTICAL DYNAMICS

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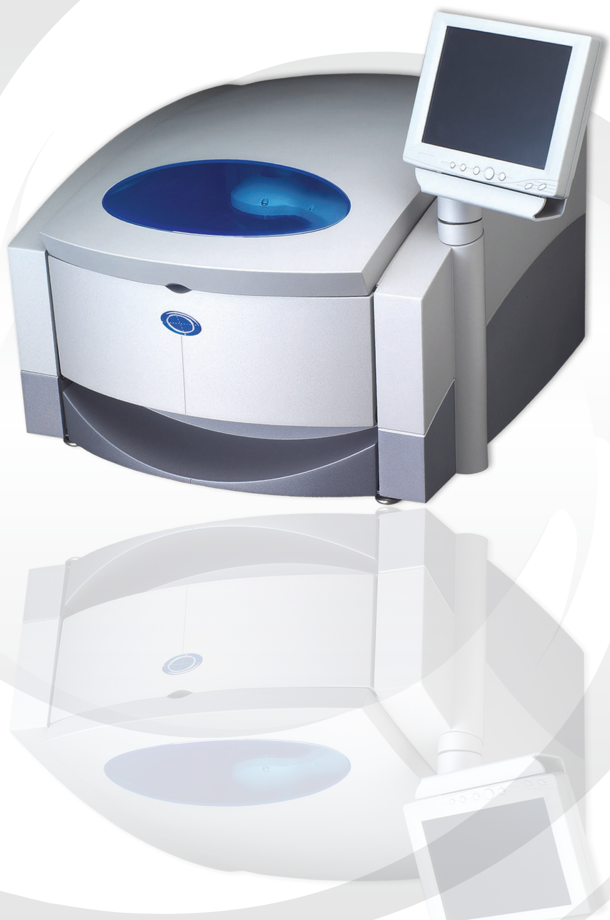
extra thin & flat | extra UV protection | extra light | extra clear | extra for rimless | extra resistant

Under the
Microscope



Side by Side Comparison of
nanoCLEAR AR & Traditional Vacuum Deposited AR

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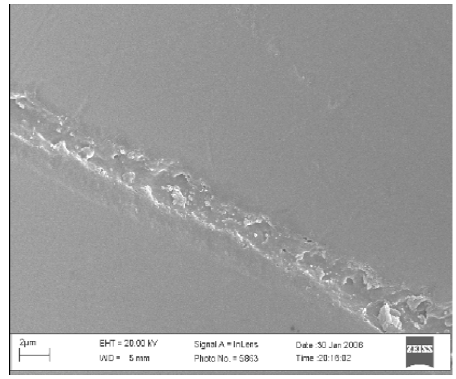
Introduction
Alternative to Glass

Traditional vacuum deposited anti-reflective coatings have been around since the 1930's and actually performed well when applied to a glass ophthalmic lens since the coatings were ceramic and, therefore, similar to the lens. During the 1970's, manufacturing improvements allowed CR-39 plastic to gain general acceptance as an alternative to glass; however, antireflective coatings did not fare well on the plastic substrate. The inherent dissimilarities between the physical properties of a vacuum deposited ceramic coating a plastic lens caused a myriad of problems. To avoid these pitfalls, Optical Dynamics (OD) researched and developed an anti-reflective technology which is plastic in nature.

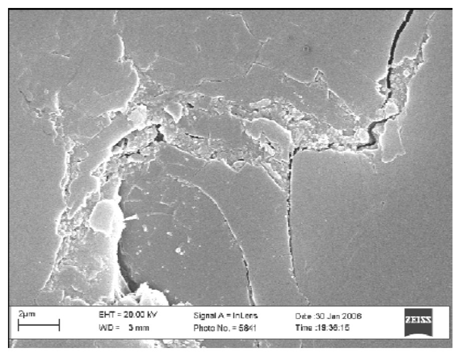
In order to study these antireflective films, the engineers and scientists at OD collaborated with the University of Kentucky and University of Louisville. The thickness of such films are on the order of a few hundred nanometers (about 100 times thinner than a human hair). Obviously, serious analysis of thin films on this scale requires the very sophisticated instruments and methods available at the Universities.

Abrasion
Resistance

One of the standard test methods developed by the optical industry to measure abrasion resistance is a test where lenses are tumbled in a barrel with abrasive media to simulate typical lens wear. The haze resulting from this accelerated wear test is then measured. The degree of haze measured correlates with the degree of damage. The following images show induced damage from a tumbler to the surface of a nanoCLEAR lens and a vacuum deposited coating. Each image is approximately 20 microns wide (about the width of a fine human hair).



nanoCLEAR AR Lens



Vacuum Deposited AR Lens

It is clear in these images that the damage to the vacuum deposited coating is more severe than that of the nanoCLEAR polymer based coating. Also of note is that the ODC lens damage is very smooth with no cracks propagating from the scratch. The cracks seen in the vacuum coating will continue to grow as the lens is further stressed (especially with cyclic changes in humidity and temperature). So, not only does the vacuum coating fair worse, it will continue to degrade over time.

Further
Testing

With this intuitive understanding of surface induced damage, the engineers at OD took the problem to the researchers at the University of Kentucky to quantify the differences in order to optimize nanoCLEAR lens performance.

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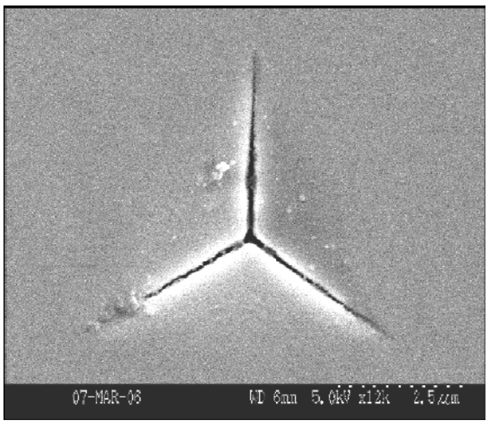
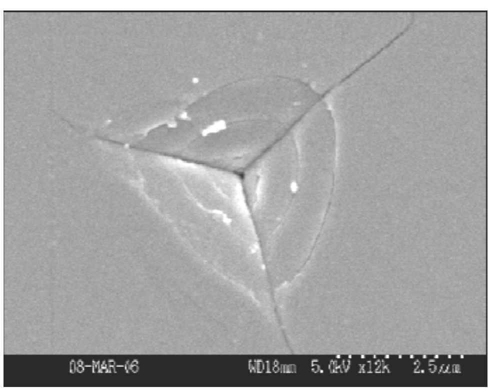
continued:

Nano-indentation and nano-scratch tests were chosen for their ability to induce quantifiable damage on a scale similar to that of the thin films. A stylus of a known geometry is used to either indent or scratch a surface in a controlled manner while measuring the response of the surface.
The following two images show the response of the lenses to a 3 sided cubic shaped indenter with an edge radius of 40 nm that was forced into the surface at 6000 JN (1/1000th of a pound). Each image is approximately 10 microns wide.



nanoCLEAR AR Lens

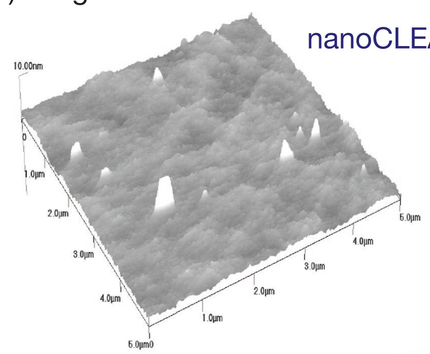


Vacuum Deposited AR Lens

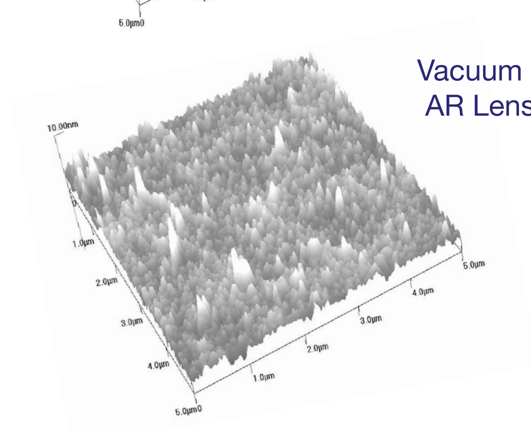
Notice that the nanoCLEAR lens does not exhibit any fractures, whereas the vacuum deposited coating exhibits fractures emanating radially from the point of indentation as well as circumferentially around the indentation. The latter cracks are indicative of delamination between the coating and the substrate.

Cleanability of the Lens

Another issue that plagues vacuum deposited antireflective coatings is the cleanability of the lens. A vacuum deposited AR coating leaves a columnar structure that traps oils and dirt and is difficult to clean. In response to this problem the industry developed hydrophobic coatings to fill in the valleys and produce a smooth surface. The nanoCLEAR product is inherently smooth. The two surfaces are shown in the following Atomic Force Microscope (AFM) images.



nanoCLEAR AR Lens



Vacuum Deposited AR Lens

Conclusion

ODC has developed a unique, plastic based antireflective technology that is suitably matched to the substrate, improving the durability of the final product. Optical Dynamics Corporation continually strives to bring the best in cutting edge technology to our customers so they can improve the bottom line.

nano

technology

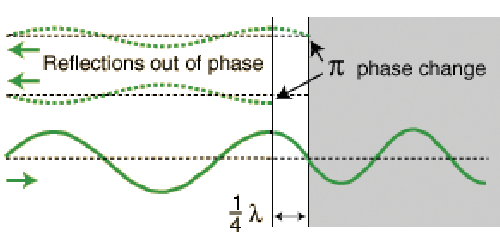
Nanotechnology refers to the engineering of structures that are less than 100 nm, (this piece of paper is approximately 150,000 nm thick). Obviously, working at these dimensions presents serious challenges. As of March 2006 there were only 212 consumer products that were identified as nano-tech based, which included both particles and films of less than100 nm.

Optical Dynamics (OD) has been involved in nanotechnology research since 2000 and successfully launched a consumer product in 2005 utilizing nanoparticles incorporated into thin films less than 100 nm thick. The nanoCLEAR product is a polymer based anti-reflective coating that is targeted at the ophthalmic industry.

Because of the research complexities and the sophisticated tools that are required to develop products at these dimensions, ODC teamed up with the University of Louisville and The University of Kentucky.

nanoCLEAR AR

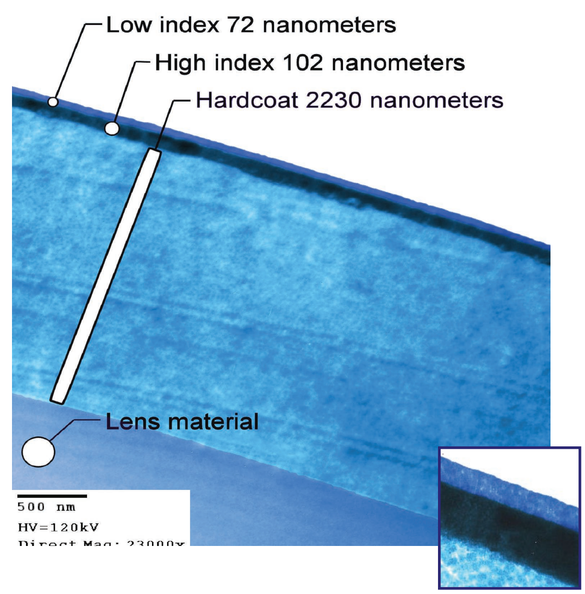
The nanoCLEAR product reduces the reflections from the surface of a clear lens by shifting the phase of the reflected light waves such that they are cancelled. The phase changes require manipulating the speed of light over distances smaller than the wavelengths of the visible spectrum (380-780 nm).



interference phenomena of an antirlective film from http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/antiref.html#c1

Controlling the speed of the light requires exact engineering of the refractive index of a clear material. Normal UV-curable polymers do not allow much control over refractive index (from 1.48-1.56), but they have advantages in cost, ease of use, and curing speed. Incorporating nanoparticles into the polymer matrix allows for the engineering of the refractive index and the mechanical properties of the thin films, without affecting the clarity of the lens. By utilizing metal oxides with refractive indices ranging from 1.46 to 2.7 (with Mohs hardness of up to 9) we have been able to engineer the refractive ndex over a broader range.

Using UV-curing technology and nanoparticles, OD was able to develop thin films that reduce the reflections from a lens surface. The method allows for the production of a premium ophthalmic lens in about one hour at an affordable cost.



Transmission electron microscope image of the thin film cross-section showing the thickness of the individual films at approximately 100nm. A close-up of the image shows the nanoparticles.

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