THE EVOLUTION OF "ANTI-REFLECTIVE" TREATMENTS

A BUNDLE OF FEATURES AND BENEFITS THAT CONTRIBUTE TO YOUR PATIENTS' BEST VISION SOLUTIONS.

EXECUTIVE SUMMARY

The evolution of anti-reflective (AR) treatments over the past few years has been dramatic. Beginning as a way to improve the amount of light passing through the lens to offer the wearer a better visual experience, today's premium AR treatments offer an entire lens protection system. The improvements have been nothing short of revolutionary. In this paper we will review all the attributes of today's premium AR treatments and how those features positively affect the patients' visual experience and lifestyle.

TOPICS COVERED:

+ AR – What it is and how it works
+ Technology used to apply AR to a spectacle lens
+ Current AR features and benefits
+ Patient research – Attitudes towards; and value of AR
+ Practical approach to educating patients

WHAT IS ANTI-REFLECTIVE TREATMENT?

AR treaments are meant to serve two functions:

The first is to drastically reduce the amount of light reflected from the surface of the lens. According to the International Organization for Standardization (ISO), the luminous reflectance of any anti-reflective coated lens surface shall be less than 2.5%.[1] *Note ISO8980-4, Section 5.4*

The second is to increase the amount of light that passes through the lens to reach the eye.

AR treatment is a thin layer; or in the case of premium AR, a series of layers of material applied to the surface of an ophthalmic lens for the purpose of reducing unwanted reflections from its surface; thus, increasing the amount of light that passes through that lens to the eye.[2]

The proper application of these layers will not only meet the ISO definition of AR, it will also provide the top features consumers are expecting in an AR treatment:

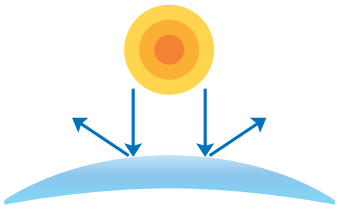
1. Increased visual clarity
2. Superior scratch resistance
3. Long term cleanability

WHY IS ANTI-REFLECTIVE TREATMENT IMPORTANT?

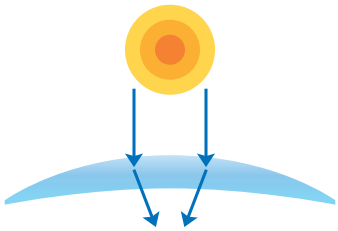
Increase available light for better vision

Corrective spectacle lenses are used to help improve the eyesight of the wearer to their best correctable vision. One of the key components of vision is light. In order to achieve the best possible vision, the wearer must be able to utilize as much of the ambient light from their environment as possible. A premium AR treatment will increase the amount of ambient light able to pass through a given spectacle lens; therefore, improving visual clarity.

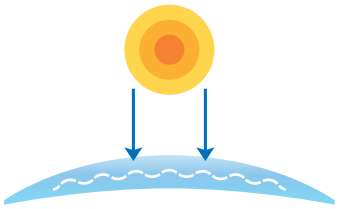
Light incident to the surface of an ophthalmic lens has one of three things happen to it. It is either reflected, refracted or absorbed.



- **Reflected** – The light that is driven back off the lens surface without being absorbed or refracted



- **Refracted** – The bending of light by a spectacle lens. Refractive power is represented in diopters, or power of the lens.



- **Absorbed** – Taking in or soaking up the energy of light as it enters the spectacle lens

If light is reflected from the front surface of a spectacle lens, then it cannot be utilized by the eyes of the wearer for optimal vision. The amount of light reflected from a specific lens substrate can be calculated and; therefore, a known value can be placed. The calculation is heavily dependent on the index of refraction and a direct correlation between the index of refraction and amount of light reflected off the lens surface can be seen in the chart **(Figure 1)**.

Lens Material	Total % Light Reflected from Both Surfaces	Total % of Light Transmitted
1.50 Plastic	7.8%	92.2%
Glass	8.4%	91.6%
1.53 Trivex	8.4%	91.6%
1.59 Polycarbonate	10.0%	90.0%
1.67 High-Index	12.0%	88.0%
1.74 High-Index	14.1%	85.9%

Figure 1

As you can see from this chart, the transmission of light in all lens materials is negatively affected by reflection. This means that if AR is not added to a spectacle lens, the amount of light able to pass through it is decreased resulting in a loss in the optimal vision that can be obtained with that lens. Furthermore, when the need for higher indices of spectacle lens materials is indicated due to prescription strength, the need for AR increases. This is a direct result of the amount of ambient light incident to the lens being reflected increasing, and the amount of light permitted to pass through, decreasing. Of special note are dimly lit areas or nighttime situations when the ambient light is already low. Spectacle lenses without AR will cause an additional reduction in the amount of light available to the visual system of the eye.

For you to provide your patients with the best vision possible, you must give them the highest level of light transmission possible through their new lenses. That is only obtained with a premium AR like Hoya Super HiVision EX3+.

DID YOU KNOW?

Phoropter lenses utilize premium, multi-layer AR treatments for maximum transmission of light. When talking with your patients, remind them that for you to provide them with the clarity of vision they experienced while in the exam lane, a premium AR will need to be utilized on their new lenses.

HOW DOES ANTI-REFLECTIVE TREATMENT WORK?

Now that we understand what AR is and its advantages to overall vision, it is important to understand how it works.

Today's premium AR treatments are made of multiple layers; typically, 5-7, placed on top of a primer coat which adds an additional layer. This is generally referred to as the 'stack'.

First, the foundation.

As with any structure that you intend to last a significant amount of time, it must be built upon the proper foundation. Our AR process at Hoya takes this into consideration.

Although technically not part of the anti-reflection properties of the stack, the foundation of the overall AR stack is the primer coat. Hoya uses a process that matches the index of refraction of the primer coat to the index of refraction of the spectacle lens substrate it is being placed on. Unique to Hoya EX3 and EX3+, this process is performed on all materials. By doing so, the light that is refracted by the primer coat is refracted at the same rate as the substrate it has been placed on. If this step is overlooked, a phenomenon known as 'thin film reflection' (oil on water creates a thin film reflection) can occur and our efforts to eliminate reflections from light incident to the surface of the lens can be curbed. **(Figure 2)**

The primer coat is topped with a hard coat which serves two purposes. It serves as a support for the AR so that its durability is increased. It also serves as a bonding layer for maximal adhesion. Each layer is specifically engineered to work with the other layers to provide strength in the overall robustness of the AR treatment.

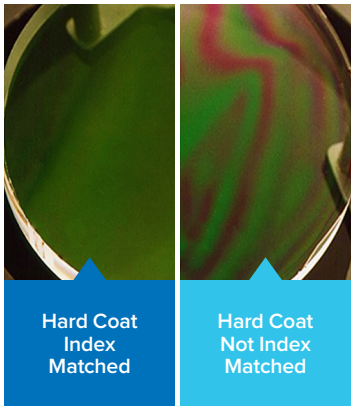


Figure 2

Next, what are we trying to accomplish?

We have already learned that AR is intended to eliminate reflections incident to the surface of a spectacle lens. The reflections can be from visible and invisible light. When referring to the front surface of the spectacle lens, the visible spectrum from 380nm to 760nm is our primary concern. **(Figure 3)**

The visible light portion of the electromagnetic spectrum is made up of component colors, each of them having a specific wavelength associated with it.

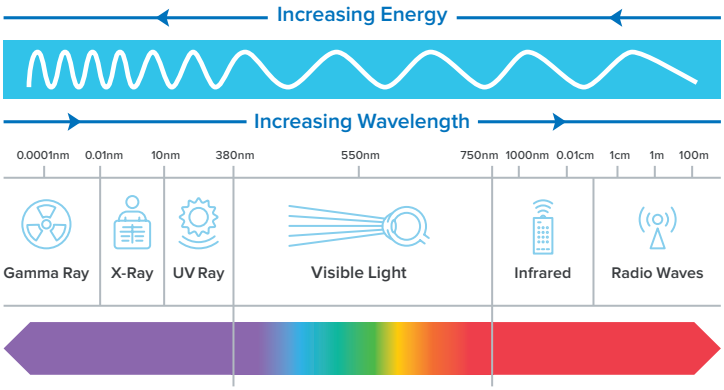


Figure 3

Each layer of the AR stack that is applied on top of the hard coat serves a distinctive purpose. Every layer is designed to eliminate reflections from a specific part of the visible spectrum. When the stack is complete, the only reflections from the visible spectrum not eliminated are those purposefully left to give the AR its distinctive color. This is also known as the 'reflex' color of the AR. Hoya employs a green hue as its reflex color of AR.

Premium AR coated lenses like Hoya EX3+ will have a consistent reflex color no matter what angle the lens is viewed from. This greatly improves the aesthetics of the finished product.

So, how does the AR stack eliminate reflections?

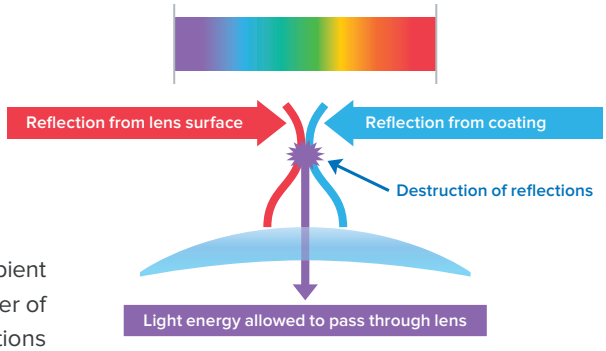
As mentioned above, when dealing with a reflection as a result of light incident to the front of a spectacle lens, our primary concern is visible light. Visible light is made up of component colors. Generally speaking; Red, Orange, Yellow, Green, Blue, Indigo and Violet, each of which have their own index of refraction and wavelength.

Each of these layers will produce a reflection once it strikes the lens surface and these reflections will have their own wavelength. As we discussed earlier, these reflections can be calculated and therefore known.

To eliminate the reflections, each layer in the stack must be formulated to eliminate a specific portion of the visible spectrum. This is done with destructive interference.

Destructive interference is the process of producing a reflection that is out of phase with the incoming ambient light. For example:

- Ambient light strikes the front of the lens
- The red component portion of the white light contacts the layer in the AR stack for red
- From that layer, a reflection is produced out of phase with the light reflecting off the lens itself
- The crest of one reflection strikes the trough of the other, collide into each other and destruct



This destroys the reflection and allows the light energy from the incoming ambient light to pass through the lens to the eye. The process is repeated at each layer of the stack for the remainder of the component colors until 98.5% of the reflections are destroyed. Thus, 98.5% of the light striking the front of the lens is now allowed to pass through the lens to the eye for increased visual clarity.

BUT WHAT ABOUT THE BACK OF THE LENS?

When dealing with the back of a spectacle lens, the concern for reflections of the electromagnetic spectrum are slightly different. The concern for eliminating reflections of the visible portion of the spectrum remains, and the process for eliminating them on the rear surface is the same as when dealing with the front surface.

However, when dealing with the back of a spectacle lens we are also concerned with the reflections of ultra violet radiation or UV, being reflected onto the exposed structures of the eye; the cornea and sclera, as well as the sensitive para-orbital skin, or eye lids.

HOYA EX3+ ALSO PROVIDES ULTRA VIOLET PROTECTION

Ultra Violet (UV) Protection

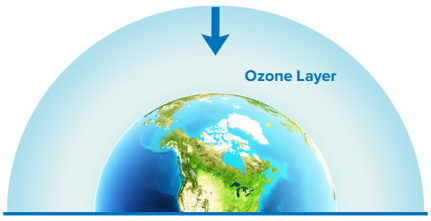
It has long been known that protection of the eye and surrounding sensitive skin tissue from UV radiation is imperative. Not only can UV damage the structures of the eye; both internally and externally, it can also damage the surrounding sensitive para-orbital skin. In this section, we will discuss the UV protection of Hoya EX3+ and how it provides complete UV protection for the eye.

What is UV Radiation?

UV Radiation is short wavelength radiation emitted by both natural and artificial sources. It is measured from 200nm to 400nm in the electromagnetic spectrum. Visible light begins at 380nm; therefore, UV is invisible to the human eye.

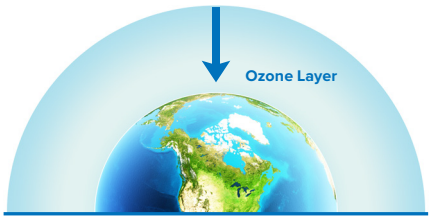
UV is divided into three segments:

UVC - 200nm to 280nm



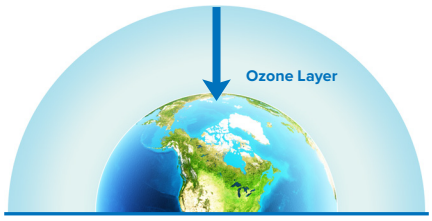
UVC is absorbed by the ozone layer and does not reach the surface of the earth.

UVB - 280nm to 315nm

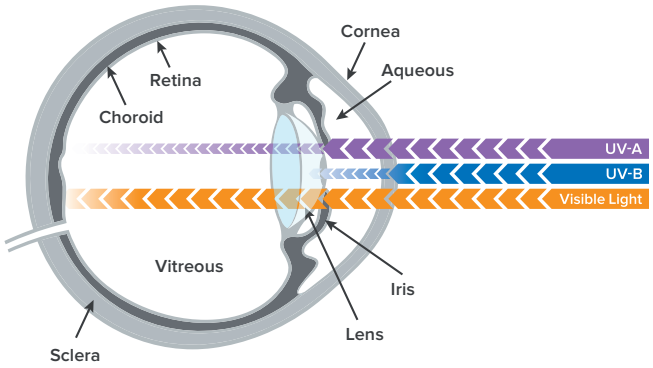


UVB does reach the earth's surface; however, is partially absorbed by the cornea and crystalline lens.

UVA - 315nm to 400nm



UVA also reaches the surface of the earth and accounts for approximately 95% of our total exposure. UVA penetrates human tissues most deeply.



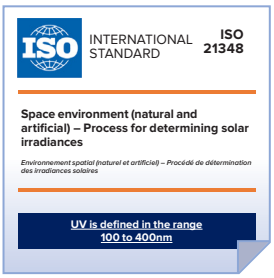
Therefore, we should be concerned with the exposure level of UVB and UVA; with a bias toward UVA, for all our patients when prescribing spectacle lenses.

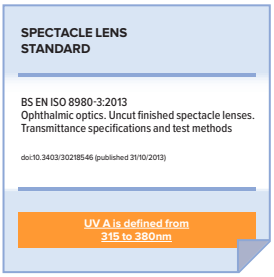
How much protection is needed?

The International Organization for Standardization (ISO) has standards regarding UV protection. For Space Environment (natural and artificial) the upper limit of UV is determined to be 400nm. However, the ISO standard for spectacle lenses determines the upper limit of UV to be 380nm[3,4]. Therefore, all spectacle lenses should provide UV protection up to and including 380nm to provide 100% UV protection.

Although some benefits to UV exposure exist such as vitamin D synthesis, there are no known benefits of UV ocular exposure. The eye and para-orbital skin should be protected from both incident and reflected UV up to and including 380nm.

While many spectacle lenses offer inherent 100% UV protection from light incident to the front surface, we should be concerned with the reflection of UV incident to the back of those spectacle lenses. According to a study conducted by Pacific University[5], 10% - 50% of UV incident to the back surface of an anti-reflective treated spectacle lens (without backside UV protection) is reflected onto the eye and surrounding skin. The average rate of ocular surface reflectance = 20%. Although these lenses protect against UV incident to the front of the lens, there is risk of UV exposure from back surface reflections of about 20%.





Lenses that do not offer inherent UV protection incident to the front such as 1.50 plastic offer an additional concern. 1.50 plastic spectacle lenses allow UV incident to the front above 340nm to pass through the lens. This does not meet the ISO recommended 380nm protection standard, allowing harmful UV light incident to the front of the spectacle lens to pass through the substrate onto the eye and para-orbital skin. Remember that we are also permitting approx. 20% of the harmful UV light incident to the back surface of the spectacle lens to be reflected onto those same structures, compounding the exposure.

UV Benefits of Super HiVision EX3+

Super HiVision EX3+ provides complete UV protection. Hoya EX3+ provides protection to the eye and the sensitive para-orbital skin from UV radiation reflected off the back surface of the lens. Since anti-reflective treated spectacle lenses reflect 20% of the light incident to the back surface, a decrease in UV exposure of approximately 20% can be realized.

It is important to note that all Hoya spectacle lens materials except 1.50 plastic provide protection from UV incident to the front of the lens up to and including 390nm. Hoya utilizes a special hard coat that will absorb UV from light incident to the front of spectacle lenses without inherent UV protection, such as 1.50 plastic. Therefore, a 1.50 plastic spectacle lens with Hoya EX3+ and UV absorbing hard coat will have 100% UV protection from light incident to the front and reflections from the back surfaces of the lens.

DID YOU KNOW?

As will be discussed in the next section, your patients believe that an inherent benefit of AR is UV Protection. You should incorporate the added UV protection of EX3+ into the bundle of benefits that EX3+ offers.

CURRENT AR FEATURES AND A PRACTICAL APPROACH TO COMBINE THEM WITH PATIENT RESEARCH

Features That Provide Investment Protection

In addition to offering the two basic functions needed to meet the requirements of the definition of AR; cancel reflections created by the surface of a spectacle lens and increase the amount of light that reaches the eye, AR treatments should also protect the surface it is placed on. Hoya lenses offer industry leading technology and are an investment in your patient's optimal visual comfort and should be protected. For that reason, Hoya EX3+ AR treatment also offers a series of benefits that protect the spectacle lens.

Hoya is a technology company. Our research is primarily dedicated to optical clarity utilizing industry leading free form lens designs. We also make a significant investment in understanding the end user – your patients. Our purpose is to understand the value of our products and provide your practice insight into the market.

Hoya conducted a consumer survey in 2019 focused on AR through VisionWatch, which is the Vision Council's consumer survey study of the U.S. ophthalmic market. The results of the study indicated the benefits most desirable to consumers when it comes to AR are:

+ Being able to see more clearly
+ Protection against UV
+ Scratch resistance

And when it comes to the top drawbacks concerning not purchasing AR, consumers are most concerned with:

+ AR scratching too easily
+ Lenses being too hard to clean

You can see that the benefits most desirable and the drawbacks to not purchasing play hand in hand. Since we have already discussed the benefits of seeing more clearly and UV protection, this section will focus on the increased scratch resistance and long term clean-ability of Hoya EX3+ AR treatment in these two categories.

Scratch Resistance

As discussed earlier, Hoya uses a hard coat and primer coat specific to each lens substrate it is being placed upon. In addition to its optical benefits we covered already, it also permits superior scratch resistance on EX3+ AR treatment.

EX3+ makes use of a thermal curing process of the hard coat that improves the scratch resistance above that of other Hoya HiVision AR treatments. This extra step places the lenses in a thermal unit for curing. The thermal process improves the hardness of the foundation for the AR stack. This improvement in the foundation of the AR stack translates into the scratch resistance of Hoya EX3+ being more resistant to scratches than other Hoya HiVision AR treatments. So much so that when Bayer tested, EX3+ treated lenses are more resistant to scratches than what was once the most scratch resistant lens product, crown glass, and three to six times more scratch resistant than competitors.

Having the most scratch resistant lens treatment in the optical market today will help you in two ways:

- It will allow you to combat the common misconception that AR scratches too easily with the utmost confidence
- It will provide you with one of your patient's most desirable benefits – superior scratch resistance

SCRIPT TIP

When talking with patients, you can offer a benefit that they expect and meet a top objection in one statement. "The AR treatment I am recommending is the most scratch resistant lens treatment on the market today."

DID YOU KNOW?

Remember that children are exceptionally tough on their lenses. Having the most scratch resistant lens treatment available today will give parents a high level of confidence that they are choosing the best protection for their child's new lenses.

Cleanability

Another common misconception of AR treatment is that it will make the lenses too hard to clean. This could not be further from the truth. Hoya EX3+ AR treatment offers the benefits of being easier to clean and staying cleaner longer by using hydrophobic and oleophobic that is specifically engineered to work with the other layers of the AR stack. Let's look at each element.

Hydrophobic

Hydrophobic properties allow the lens surface to repel water. When water contacts a hydrophobic surface, it forms into a droplet rather than spreading out over the surface. The formation of the droplet allows the water to easily run off the surface, keeping the spectacle lens surface void of accumulated water when in wet environments such as rain.

Oleophobic

Oleophobic properties help the lens surface repel oil in much the same way it repels water. The oleophobic treatment forces oil that contacts the spectacle lens to stay on the surface and not permeate into the AR stack. With the oil on the surface of the lens, it can be cleaned away easily and not interfere with the wearer's vision by causing cloudiness or smearing.

Oleophobic treatment serves to keep body oil from fingerprints making the lenses difficult to clean.

By choosing only premium AR treatments, you will be offering your patients a better all-around experience. Your patient's new spectacle lenses will be easier to clean and the need to clean them will be less often. By cleaning the lenses less often, the chances for scratching will inherently decrease.

SCRIPT TIP

When talking about premium AR, simply state to the patient that "Your new lenses will be easier to clean and stay cleaner longer." If more explanation is requested by the patient, then use the information provided in this paper to explain the cleanability attributes you are offering.

PRACTICAL APPROACH TO APPLYING YOUR KNOWLEDGE

Now that you have learned about the technical features that make today's premium AR a total protection system, let's discuss how to put that knowledge to meaningful conversation with your patients. In order to do that, you need to know what your patients expect from you and what their perception of AR is so that you can educate the benefits in a manner that is valuable to them. This section will focus on this area.

Additionally, our VisionWatch survey uncovered three valuable lessons when it comes to why consumers - your patients - are not purchasing AR. They are:

1. **Confusion – Consumers don't know what AR is or what it does; therefore, don't understand why they should buy it**
2. **Bundling – Consumers want simple easy to understand pricing**
3. **Education – Consumers want to be educated about how AR improves their everyday life, not sold to**

Let's look at each point more closely.

Confusion

Our study showed that consumers are confused about what AR is, what it does and how it works. This confusion leads to hesitancy when asked to purchase based on features alone. When confusion about AR is present, and that patient has gotten by without AR in the past, they cannot justify spending the additional money to purchase it.

SCRIPT TIP

Instead of presenting AR to the patient assuming they know what it is, or worse yet, only explaining that it helps them see better at night, present it as a total protection system. Speak to patients in terms of benefits rather than features. An example would be, "You mentioned you want your lenses to be easily cleaned and scratch resistant. We can do that for your lenses." Accurately answer any questions they may have with information from this paper. As explained below, education is key.

Bundling

Respondents in our study were more likely to purchase AR if it were presented as part of the lens package. They want one price that includes all they are receiving. However, they still want to know what they are getting for that price. This creates value and decreases confusion.

In addition, when you bundle the lens material, design and AR into one price, it helps your patient understand that AR is a necessary part of the lens system.

SCRIPT TIP

Present the price of the lenses in totality. Then state everything that they are receiving for that price. Ex. 'Your lenses today will be $X which includes state-of-the-art optics with best in class AR protection. Your lens design will help with the complaints you mentioned on your pre-exam questionnaire and the AR will provide optical clarity, cleanability, and superior scratch resistance.' If you passed on any part of the manufacturer's warranty, this is a great time to include that element of peace of mind to your script.

HOYA

Education

Consumers aren't being educated on the benefits of AR and how it can benefit them. They are being sold a suite of features rather than a bundle of benefits. When you present AR in this manner, you are not creating value, you are creating confusion. Remember, consumers in general do not know what AR is or what it does. Therefore, cannot understand how it brings value.

Instead, find out what attribute of the total protection system Hoya EX3+ will appeal to the patient and educate them on that feature, turning it into a benefit that the patient will find value in. Your patients will not purchase something if they do not see the value.

DID YOU KNOW?

Keep this paper and review it regularly with your team. Make notes of anything that you think you might use or things you learned by reading it. By continually reviewing your information and staying informed, you will be viewed as the expert and your recommendations welcomed.

Now its your turn to evolve

By now you may be thinking, AR is no longer just AR. And you would be correct. It has evolved into a total system, with many components working in harmony to create a better visual experience along with a better user experience and durability.

Gone are the days of presenting this crucial piece of the total lens system as simply a way to reduce reflections. Your approach to educating your patients needs to be as up to date as the technology used to create Hoya Super HiVision EX3+.

As your ally, Hoya Vision Care is dedicated to bringing you and your patients the best vision solutions through innovative lens designs, materials and treatments. This paper was designed to share with you the technological evolution of AR, patient attitudes towards AR, and strategies for you to best communicate the benefits. More resources are available on our web site, blog, online training portal, and from your local Hoya Territory Sales Manager.

References:

[1]International Organization for Standardization. (2006). *Specifications and test methods for anti-reflective coatings* (ISO Standard No. 89804). Retrieved from: https://www.iso.org/standard/40122.html

[2]*System for Ophthalmic Dispensing. Glossary pg. 620*

[3]International Organization for Standardization. (2007). *Space environment (natural and artificial) – Process for determining solar irradiances* (ISO Standard No. 21348). Retrieved from: https://www.iso.org/standard/39911.html

[4]International Organization for Standardization. (2013). Ophthalmic optics – Uncut finished spectacle lenses (ISO Standard No. 89804-3). Retrieved from: https://www.iso.org/standard/51052.html

[5]K.Citek, Pacific University. Anti-reflective coating reflect ultraviolet radiation. Optometry 79(3), March 2008

[6]Interactive VisionWatch Market Research Dashboard (n.d.)
Retrieved from: https://www.thevisioncouncil.org/interactive-visionwatch-market-research-dashboard