SERRALUX™

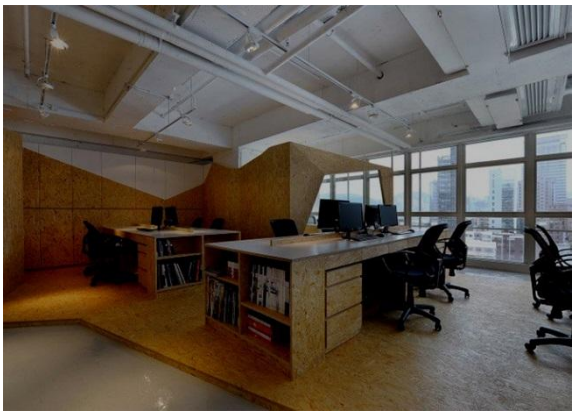
Harnessing the Power of Daylight

SerraGlaze® Q&A

SerraLux is in the business of daylighting, and our product is called SerraGlaze®. We will begin the discussion with three questions, each of which will be asked and answered twice. Here are the questions:

- **What is SerraGlaze®?**
- **Why do you want it?**
- **How does it work?**

What is SerraGlaze? It is a product that brings more natural light into a room such as an office, classroom, or home. It redistributes sunlight in such a way that the room is much brighter with it as compared to a room without it.



Why do you want it? There are a number of reasons to want SerraGlaze.

- Reduced energy costs because artificial lighting can be reduced.
- Enhances occupant health and well-being. Occupants prefer full spectrum light and reduced glare while preserving the view out the window. There is a proven correlation between natural light and human attitude when compared to artificial lighting.
- Increased rent for commercial buildings because of the increase of natural light, and the pride of having a green building.

How does it work? Because the sun is above us, most of the sunlight comes in through normal window glazing and strikes the floor of the room quite near the windows. Usually the floor is carpeted. This keeps the light from brightening the room because most of it is absorbed. On the other hand, SerraGlaze causes the light to *change direction* as it passes through the window, and it then strikes the ceiling of the room. The ceiling is almost always white or some other light color, and highly reflective, but in a diffuse kind of way. As a result, most of the sunlight is spread about the room in all directions, substantially brightening the whole room.

So, those are the general answers to our three questions. Now let's answer these same questions in greater detail.

- **What is SerraGlaze?**
- **Why do you want it?**
- **How does it work?**

What is SerraGlaze? SerraGlaze is a thin plastic film which is affixed to the inside of a window, usually, but not always at a height above eye-level. The film has a series of very small horizontal linear grooves. The material of the film is acrylic, and therefore very stable and non-yellowing in direct sunlight. The geometry of the linear grooves is carefully designed and very precise so that it accurately and efficiently changes the direction of sunlight from downwards to upwards. Figure 1 is a sketch of the grooved structure as seen in cross-section.

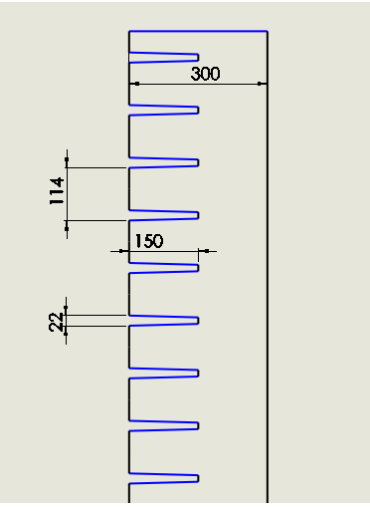


Figure 1

The dimensions are in microns, and the narrow slots are air, whereas the body of the film is clear acrylic. When this film is affixed to the window glass, the glass will be

touching, and to the left of the film. (Obviously the sun's rays will be coming from the left.)

The film is made by an extrusion process. The process begins by machining a metal cylinder on a high precision lathe. The "fins" of the mold are cut in this metal cylinder using a diamond as a cutting tool. This cylinder becomes the master mold of the product. Several generations of electroformed copies of the master may be made and then, in a carefully controlled extrusion process, the film is produced in long lengths and rolled for ease of shipping and storage.

Why do you want it?

- You want it mostly because it really works!
- Because the film is made in a mass-production process, and is very thin, the cost is kept low.
- There are installers who are already experienced in applying plastic films to windows (although this product requires some special techniques).
- Another wonderful characteristic of this film is that you can see through it clearly. (Other daylighting films obscure the view outside.)

How does it work? Now things get interesting. Before we begin, you must understand that there are two broad kinds of reflectivity in optics. The most familiar kind is when light is traveling in air, strikes a surface, and is partially reflected. The reflection may be diffuse (like a rough surface), or specular (as in the case of a mirror or polished metal). Even if the surface is super-polished, chances are only 96% of the light hitting the surface will be reflected, i.e., 4% will be lost. (Most polished metal is only about 90% reflective.) The second kind of reflectivity is called Total Internal Reflectivity, or TIR. This is when light is inside a transparent liquid or solid material, and comes to an interface with air. If the angle of the light ray to the interface plane is less than a critical amount, the light will be reflected with nearly 100% efficiency. You may have seen this effect if you are swimming under calm water, and look at the water's surface at a low angle. You can't see "out" of the water, but rather will see the side of the pool or pond reflected on the underside of the water's surface. (It doesn't work if you are in air looking into the water.)

With SerraGlaze, the light enters the acrylic film and then strikes an air gap. At that interface, the light is reflected by TIR. There are two great advantages to this. First, no light is lost; but more importantly, as long as the surface of the groove is smooth, it does not have to be a reflector in the normal sense of the word, i.e., it doesn't have to be a mirror!

Figure 2 is a ray-trace of light through a window and the plastic film. The thickness of the glass is not to scale, but this thickness has no bearing on where the light goes.

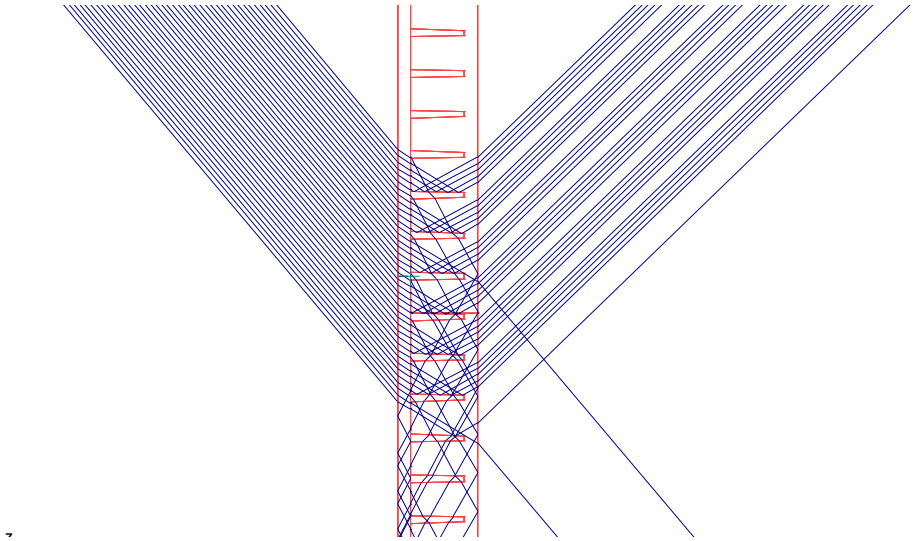


Figure 2

In Figure 2, sunlight is coming from the left, going down and to the right. As it goes through the SerraGlaze film, it strikes the air-grooves, undergoes TIR, and continues to the right, but now is going up to the ceiling, not down and absorbed.

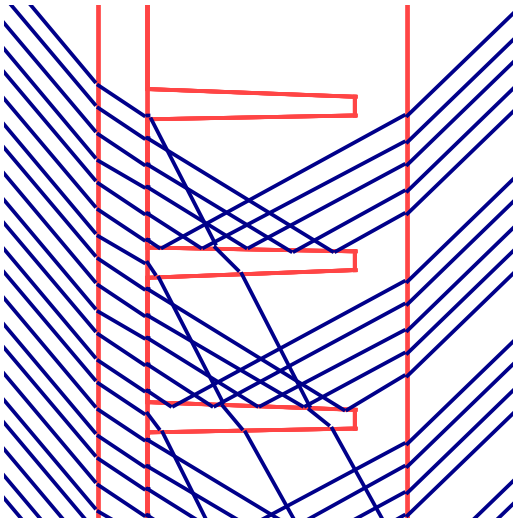


Figure 3

Figure 3 is a close-up view of the ray trace. Note that the few rays that enter into the open end of the grooves do not TIR here, but they do TIR on the back side of the film further down (see figure 2).

The above "ray traces" are simulations, i.e., they are done with computer models. The ray trace software used for this is very sophisticated and accurate, but it is still a simulation. So, is there any reality check on the simulation? There are two:

- The film has been made and it works!
- A physical sample of the film was sent to an accredited laboratory where detailed measurements were made. A result called a Bi-directional Transmittance Distribution Function (BTDF) was obtained. Meanwhile, we developed a simulated goniometer. This is a computer model of a device that measures the energy of reflected optical rays as a function of input and output angles. The correlation between our simulation and the lab's measured results are excellent. See figures 4 and 5.

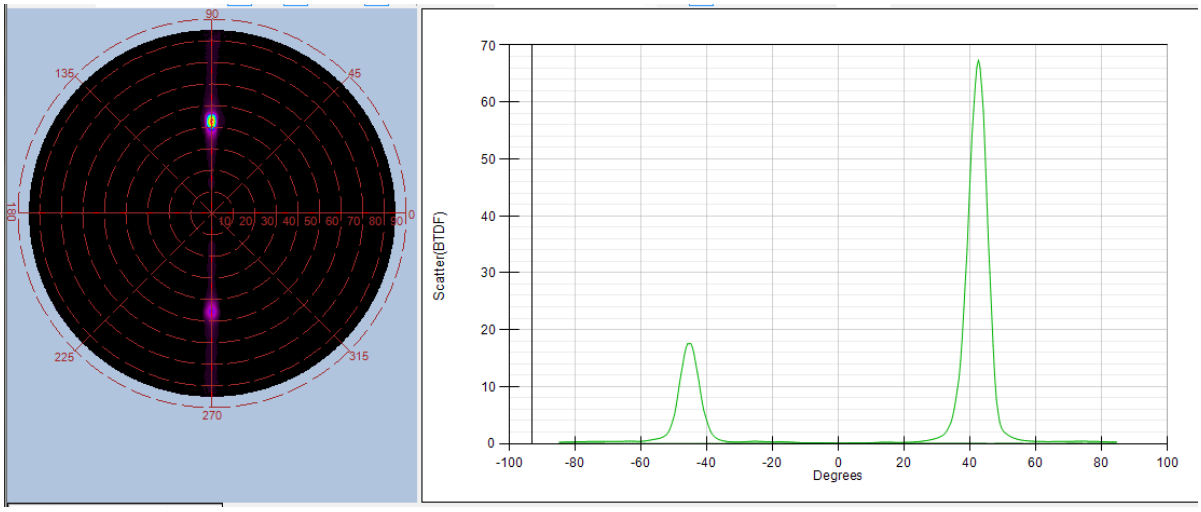


Figure 4, Measured BTDF SerraGlaze sample above.

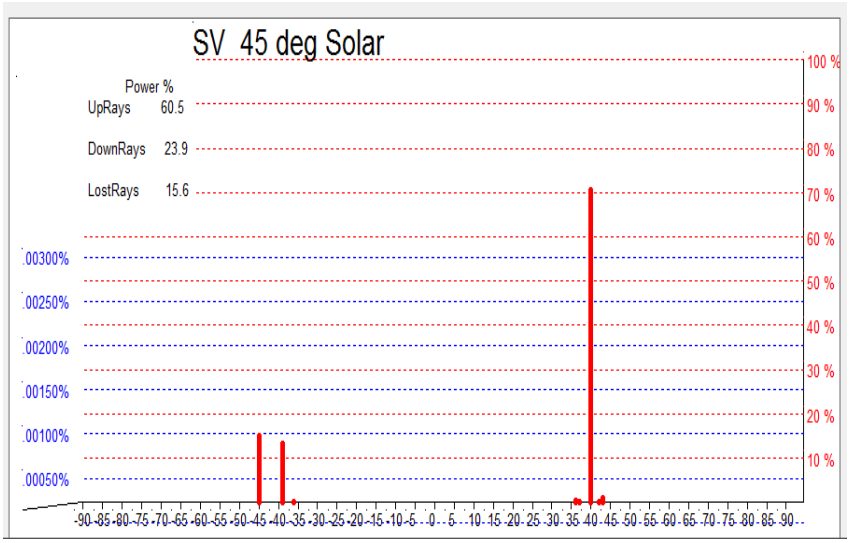


Figure 5, Simulated Goniometer Results above

Our product, SerraGlaze, is protected by a family of broad and strong patents, but we aren't resting on our laurels. Our Research and Development personnel are developing new products for the future that should broaden our intellectual property position and better serve our customers.

Remember that for most cities in the Northern hemisphere, the sun spends most of its time in the Southern sky. Figure 6 shows a typical path of the sun 9in this representation, North is to the right).

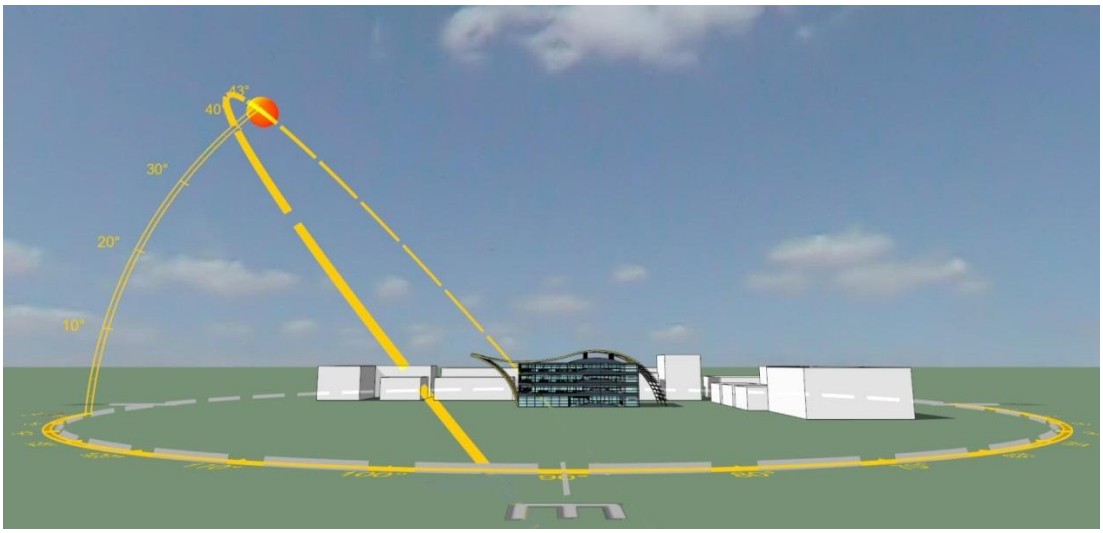


Figure 6

This solar path is unique; dependent on the day of the year and the latitude of the office location. How our products perform is dependent on these parameters, and in addition, to the orientation of the building, the size and placement of its windows and numerous interior variables. We are currently working on a complex model that will take the detailed particulars of a specific office, and predict lighting improvement as a function of time of day, day of year, latitude and orientation of office. This is a daunting task, but we believe it will be helpful to our customers. Meanwhile, we have a number of recent projects that will serve as test beds for how our product works in the real world over a period of time.

And finally:

- **What is SerraGlaze? It is a daylighting system that increases the health and well-being of building occupants and saves energy.**
- **Why do you want it? Because it works!**
- **How does it work? Very nicely, thank you.**