What are Captured Lightning™ Sculptures (Lichtenberg figures) and how are they made?

Lichtenberg figures are branching patterns that are created on the surface or the interior of insulating materials by high voltage electrical discharges. The first Lichtenberg figures were two-dimensional patterns formed in dust that settled on electrically-charged resin plates in the laboratory of a German physicist, and their discoverer, Georg Christoph Lichtenberg (1742-1799). The principles involved in creating Lichtenberg figures are fundamental to the operation of modern copying machines and laser printers. Their study was the beginning of the science of Plasma Physics. Today, we use modern materials and electron beam accelerators to create stunning 3D Lichtenberg figures – our famous "Captured Lightning™" sculptures.

We make our sculptures out of polished acrylic (Polymethyl Methacrylate, or PMMA), since this material has an ideal combination of optical, electrical, and mechanical properties. We also use a linear accelerator, or "Linac", to generate a beam of high-speed electrons. Electrons within the beam are accelerated to "relativistic" velocities – over 99% of the speed of light. During acceleration, the electrons in the beam acquire a large amount of kinetic energy, measured in millions of electron volts (MeV). We place pieces of optically-clear acrylic in the path of the electron beam, "irradiating" them. The electrons first travel through 22 inches of air. When they slam into the surface of the acrylic, they don't stop immediately. Instead, they burrow inside, colliding with acrylic molecules and rapidly slowing down, finally coming to rest about ¼" to ½" below the surface.

As we continue to irradiate the acrylic, excess electrons accumulate inside, forming a cloud-like layer, called a "space charge", which may contain over a trillion extra electrons. Since acrylic is an excellent electrical insulator, injected electrons become trapped within the space charge layer, causing an extremely high electrical stress that can approach 20 million volts per inch. If the stress overcomes the insulation strength of the acrylic, chemical bonds between acrylic molecules begin to rupture, and a network of thousands of electrically-conductive ("ionized") branching pathway suddenly forms within the acrylic. These pathways allow the trapped charges to blast their way through the acrylic in a brilliant blue-white flash of miniature lightning, accompanied by a loud BANG. In a 4" x 4" sculpture, the main discharge may last for only 100 billionths of a second, but smaller secondary discharges often continue to flash for many minutes afterwards, as pockets of residual charge redistribute themselves.

Electrical breakdown occurs on a much grander scale when natural lightning drains highly-charged regions within storm clouds. However, unlike sparks in air, discharges within acrylic leave a permanent "fossil" record of their passage. The white-hot discharges create chains of small tubes and fractures inside the acrylic, and a tiny crater is also created on the surface at the exit point. If the specimen doesn't self-discharge as it is being irradiated, we manually trigger a discharge by poking the surface of the charged specimen with a well-insulated metal point. The sharp point concentrates the electrical field, triggering a discharge at the tip. Specimens that self-discharge usually form a chaotic tangle of discharges instead of a nicely branched tree. The crystalline "flakes" that appear along the discharge paths are actually small fractures. These curved fractures are characteristic of the way that glassy materials fracture when mechanically overstressed.

Lichtenberg figures usually have tree-like or fern-like structures that appear similar when viewed at various scales of magnification. As with numerous other self-similar phenomena in nature, Lichtenberg figures can be modeled by a branch of mathematics called Fractal Geometry. The outer surfaces of the acrylic sample and the surrounding air form a dissimilar dielectric interface where some of the trapped space charge can leak away. The regions of reduced charge density cause the discharge-free zone along the edges of the specimen. Most of our Lichtenberg Figures were created with electron beams having energies of 2 to 5 MeV. The beam dosage and energy are adjusted to produce well-formed figures within each sculpture. Although they look similar, your Captured Lightning™ sculpture is truly unique, fashioned in a flash by a multi-million volt lightning bolt.

Newer sculptures often have an amber tint, called solarization. This appears as a tinted zone between the irradiated surface and the discharge layer. Solarization is caused by defects in the molecular structure of the acrylic. Called color centers, these are created by structural changes in the acrylic from X-radiation or small numbers of stranded electrons. Powerful X-rays are generated when high-velocity electrons are rapidly slowed as they collide with acrylic molecules. Electrons in the beam are initially traveling at close to the speed of light prior to hitting the acrylic. As they collide with acrylic molecules, they rapidly slow down, releasing their kinetic energy in the form of high-energy X-rays. The color centers tend to absorb light at the blue end of the visible spectrum, so white light passing through a solarized region acquires an amber tint. Solarization usually fades with time. Gentle heating in air (more specifically, oxygen) often accelerates the bleaching process. Many specimens also show slight changes in the refractive index from residual stresses near the discharge fractures. Considerably more information about Captured Lightning™ sculptures, including short video clips of our team actually making various sculptures, can be found on our web site: **http://lichdesc.teslamania.com**

Caring for your Lichtenberg Figure

With care, your Captured Lightning™ sculpture will remain beautiful for years. Dust carefully using a dampened flannel cloth. Remove fingerprints using mild detergent and water, then rinse well and blot using a damp flannel cloth. Never wipe your sculpture with dry paper towels or Kleenex tissues, since these can scratch the surface. Never apply window cleaners containing ammonia, solvents, or scouring compounds, since these may permanently damage the surface of your sculpture. To restore your sculpture's original luster, use a soft cloth and a polish specifically made for acrylic, such as Novus #2 from Novus Plastic Polish, Ltd. If your specimen should develop heavier scratches, use Novus #3 Heavy Scratch Remover first, then polish to a high luster using Novus #2.

Stoneridge Engineering is proud to provide the most beautiful 2D and 3D Lichtenberg Figures in the world

For more information, see ***http://www.capturedlightning.com*** *Download a copy of this explanation at* ***http://lichpdf.teslamania.com***