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

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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 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, and their study was the foundation of modern plasma physics. Today, we use modern polymers and electron beam accelerators to create stunning 3D Lichtenberg figures – our modern "Captured Lightning™" sculptures.

We start out with polished pieces of optically-clear acrylic (Polymethyl Methacrylate, or PMMA), since this material has an ideal combination of optical, electrical, and mechanical properties. We also use a particle accelerator to generate a beam of high-speed electrons. Electrons within the beam are accelerated to over 99% of the speed of light. During acceleration, electrons in the beam acquire a large amount of energy, measured in millions of electron volts (MeV). We place our pieces of acrylic in the path of the electron beam, "irradiating" them. As they emerge from the accelerator, the electrons travel through 22 inches of air before reaching the top surface of the acrylic specimens. The energetic electrons don't stop immediately - instead, they rapidly slow down as they collide with acrylic molecules, finally coming to rest about ¼" to ½" below the surface.

As we continue irradiating the acrylic, trillions of electrons accumulate inside, forming a cloud-like layer of excess charge, called a "space charge". Since acrylic is an excellent electrical insulator, the injected electrons remain trapped in this space charge layer, causing an extremely high electrical stress that may approach 20 million volts per inch. Once the electrical 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, creating a brilliant blue-white flash of miniature lightning, accompanied by a loud BANG. The main discharge lasts for only 100 - 300 billionths of a second. The main discharge is then followed by hundreds of smaller secondary discharges that flash for up to 30 minutes as small 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 metal point. The sharp point concentrates the electrical field, triggering an electrical discharge at the tip. Specimens that do self-discharge form a chaotic tangle of discharges instead of a well-formed branched tree. The crystalline "flakes" that appear along the discharge paths are actually small curved fractures. These fractures are characteristic of the way that glassy materials break when mechanically overstressed.

Lichtenberg figures usually have tree-like or fern-like (dendritic) 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 a discharge-free zone along the edges of the specimen. Most of our Lichtenberg Figures were created with beam energies between 2 and 5 MeV. Beam dosage and energy are adjusted to produce well-formed figures within each sculpture. Although they look similar, every Captured Lightning™ sculpture is unique, fashioned in billionths of a second by a multi-million volt lightning bolt.

Newer sculptures often have an amber-colored layer, called solarization, between the irradiated surface and the discharge plane. Solarization is caused by defects (called "color centers"). These were created by X-rays or by electrons that are still stranded within the acrylic. 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 almost 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 and heat. 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. The solarized region in some specimens may also glow with a light yellow-green color when illuminated by the near-ultraviolet light emitted by blue LED's from one of our lighted bases. Solarization (and the associated fluorescence) usually fades in a couple of years. Some specimens may also show slight fogging in the solarized regions. 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 sculpture will remain beautiful for years. Dust it carefully using a dampened flannel cloth. Remove fingerprints using mild soap or 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 may scratch the surface. Never apply window cleaners, spray waxes, 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., or an automotive paste wax, but NOT a cleaner/wax combination! If your specimen has heavier scratches, use Novus #3 Heavy Scratch Remover first, then polish to a high luster using Novus #2.

Stoneridge Engineering - we create the most beautiful Lichtenberg Figures in the world

For more information, see ***http://www.capturedlightning.com***

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