



What are Lichtenberg Figures and how are they produced?

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Lichtenberg Figures are patterns that are formed on the surface or the interior of insulating materials by high voltage electrical discharges. The first Lichtenberg Figures were actually two-dimensional patterns formed in dust on charged insulating plates in the laboratory of their discoverer, Georg Christoph Lichtenberg (1742-1799). The basic principles involved in the formation of these early figures are also fundamental to the operation of modern copy machines and laser printers. Using modern materials and powerful particle accelerators, 3-D Lichtenberg Figures can now be created inside crystal clear acrylic, forming beautiful "Captured Lightning™" sculptures.

We use acrylic (Polymethyl Methacrylate - PMMA) as the medium for our Lichtenberg Figures since it has an excellent combination of optical, electrical, and mechanical properties. We also use a linear accelerator (LINAC) to create a beam of high-speed electrons. Electrons within the beam are accelerated to up to 99.5% of the speed of light. The high speed ("relativistic") electrons have acquired a very large amount of kinetic energy, measured in Millions of electron Volts or MeV. Specially selected and prepared specimens of acrylic are placed in the path of the electron beam. As the energetic electrons hit the surface of the acrylic, they don't come to an immediate stop. Instead, they lose energy as they collide with acrylic molecules, rapidly slowing down and coming to rest deep inside the acrylic specimen.

Under continued irradiation, electrons rapidly accumulate, forming a cloud-like layer of excess negative charge called a space charge. Since acrylic is an excellent electrical insulator, these electrons become trapped within the space charge layer. A huge electrical field (up to 2 million volts/cm) is developed inside the plastic, similar to the way that huge regions of excess charge develop within a thunderstorm. The tremendous electrical stress finally overcomes the insulating strength of the plastic. Molecular bonds begin to break, and branching ionized (electrically conductive) pathways rapidly form within the acrylic. The trapped charge violently surges out, accompanied by a brilliant blue-white flash and a loud bang. The branching discharge paths look similar to a miniature lightning bolt. The high current main discharge may last for only 20 – 50 billionths of a second, but smaller discharges may occur for 30 seconds or more after the main discharge.

Electrical breakdown occurs on a much grander scale during a lightning flash as the powerful discharge drains highly charged regions within storm clouds. However, unlike discharges in air, the discharge paths taken within the acrylic leave a permanent record of their passage as they melt and fracture the plastic along the way. The exit point appears as a small hole or at the surface of the acrylic. If the block doesn't self-discharge, a discharge is triggered by poking the surface of the plastic with a sharp conductive tool. This concentrates the electrical field around the tool's tip, creating a weakened area that initiates the discharge. The rounded, crystalline flakes appearing within the figure are actually small conchoidal fractures that were created by the hot electrical discharges as they forced their way through the acrylic. These fractures are characteristic of the way that amorphous (non-crystalline) materials fracture when mechanically overstressed.

Like snowflakes, every Lichtenberg Figure is unique. Lichtenberg Figures exhibit tree-like or fern-like structures that possess a high degree of self-similarity at various scales of magnification. As with many other phenomena in nature, the self-similar structure can be modeled by a branch of mathematics called Fractal Geometry. The outer surfaces of the acrylic specimen and the surrounding air form an interface where some of the excess space charge can leak away. This region of reduced charge causes the blank region seen along the perimeter of the block. Most of our Lichtenberg Figures were created with electron beams having energies of 3 - 5 MeV. Beam parameters are adjusted to produce well-developed figures.

Newer Lichtenberg Figures often have an amber or greenish tint, called solarization. Solarization appears on the side of the block that was bombarded by the electron beam. It's caused by the formation of defects, called color centers, within the structure of the acrylic as the acrylic molecules absorb ionizing radiation or are modified via electron collisions. The ionizing radiation is not from the electron beam, but is actually caused by powerful X-rays that are generated as the electrons are rapidly slowed down by the acrylic. Electrons within the beam are initially traveling at close to the speed of light as they first hit the surface of the acrylic. As they collide with the molecules of the plastic, they rapidly slow down, releasing their kinetic energy in the form of high energy X-rays, which are absorbed by the acrylic. This secondary X-radiation, called Bremsstrahlung (or "braking") radiation, is what actually causes much of the solarization. Solarization usually fades with time. Applying gentle heat will accelerate the fading process. "Fogging" sometimes occurs with older plastic formulations, forming a diffuse, slightly milky layer within some specimens, and many specimens also show slight changes in the refractive index due to residual stresses near the discharge fractures. More information about how our Captured Lightning™ sculptures are made can be found here: <http://lichdesc.teslamania.com>

Caring for your Lichtenberg Figure

With care, your Captured Lightning™ sculpture will remain beautiful for many 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 may scratch the surface. Never apply window cleaners containing ammonia, alcohol, 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 offer the most beautiful 2D and 3D Lichtenberg Figures in the world

For more information, see <http://www.teslamania.com>
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