WHITE PAPER

Maximizing Manufacturing Efficiency:

The Benefits of DLP 3D Printing for Miniature ESD Components Fabrication

Introduction

The emergence of Additive Manufacturing (AM) has been fueled by its ability to transform digital designs into physical objects. Unlike conventional manufacturing techniques, which involve complex tooling and machining processes, AM builds objects layer by layer using materials such as plastic, metal, and ceramics, based on digital designs.

Over the years, significant advancements in AM technology have transformed the production of numerous components. The rise of the DLP (Digital Light Processing) AM method, in particular, has been driven by its ability to fabricate parts with unparalleled precision and accuracy. By harnessing the power of digital light projection, this technique offers enhanced control over the manufacturing process, enabling the creation of complex geometries and customizable designs that were previously unimaginable.

ESD components play a vital role in various industries, especially in electronics and telecommunications, where the protection of sensitive equipment from static charges is crucial. In today's rapidly evolving technological landscape, the demand for miniature electronic components is steadily increasing. To meet this demand, manufacturing processes with the capability to produce components with enhanced electrostatic discharge (ESD) protection and intricate features, while also offering cost and time savings, are crucial.

Traditionally, micromachining has been the go-to method for creating these components. With the advent of DLP AM, manufacturers now have a superior alternative that offers numerous advantages. In this article, we will explore the capabilities of DLP in the realm of manufacturing miniature ESD components, as well as the cost and time-saving benefit it brings to the table.

Discover the advantages of using DLP 3D printing over micromachining for the fabrication of ESD components. Save time, cost, and achieve superior part quality with ESD resins.

The Power of DLP for Intricate Features

The layer-by-layer nature of AM processes allows fabrication of complex geometries that traditional manufacturing methods struggle to replicate. This remarkable capability enables the production of various components that offer enhanced functionality and optimal performance.

DLP AM employs a reservoir of liquid photopolymer resin that is cured layer-by-layer using a digital light projector. One frequently used machine setup for DLP AM is referred to as the "bat" technique, also known as the "constrained surface" method. In this approach, parts are built upside-down by solidifying the resin against the bottom surface of the vat. Initially, the build platform descends into the vat for the first layer formation and gradually ascends with each subsequent layer (*see* **Figure 1**).

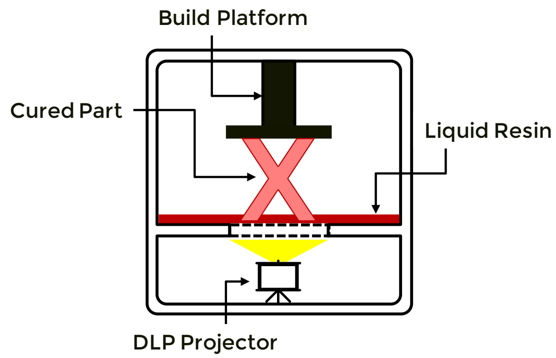


Figure 1: *Schematic of the "Bat" setup for DLP AM.*

One of the key advantages of DLP AM is its ability to deliver superior surface finish and resolution compared to other AM technologies (*see* **Figure 2**). DLP machines can achieve layer thicknesses as low as 10 µm, resulting in a smooth surface finish and exceptional dimensional accuracy. This level of precision is crucial for miniature ESD components, which require stringent tolerances to function reliably.

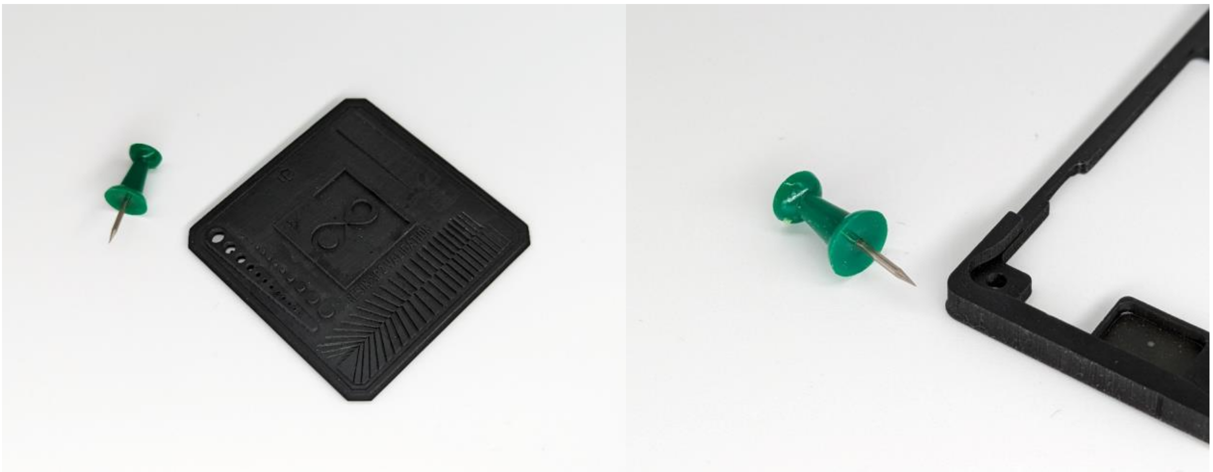


Figure 2: *Example of components fabricated using DLP AM technology showcasing ability to build intricate patterns & achieve smooth surface finish.*

With DLP, manufacturers can create complex geometries with ease, including fine surface textures, internal channels, and delicate patterns. The high-resolution nature of DLP 3D printing ensures that every detail is captured accurately, allowing for precise replication of miniature ESD components.

The Power of High-Quality ESD Resins

Static-Dissipative resins for DLP are engineered materials designed to restrict or dissipate electrostatic charges. A crucial component of these resins for ESD protection is the inclusion of conductive filler materials. Fillers, such as carbon black, carbon nanotubes, and metal particles, are commonly used for this purpose due to their high electrical conductivity. With the ability to control the resin's properties, such as surface resistivity and volume resistivity, designers and manufacturers can achieve precise ESD requirements.

The high-quality dispersion of conductive fillers in the polymer matrix holds paramount importance for the development of static-dissipative materials. However, it should be noted that not all resins are of the same quality. To illustrate this point, optical microscopy images of Formula1B ESD resin from Mechnano and one of the competitor resins are presented in **Figure 3**. The images indicate that competitor resin contained a higher concentration of CNTs compared to Formula1B. The crucial distinction between the two is the inferior dispersion quality observed in the competitor resin, where a significant number of CNT bundles coexisted alongside regions lacking CNTs. In contrast, microscopy of Formula1B demonstrates a well-distributed and uniform dispersion of CNTs without the formation of CNT bundles or areas devoid of CNTs due to integration of Mechnano’s proprietary discrete, dispersed, and functionalized CNTs (D’Func) into the resin.

Formula1B **Competitor**

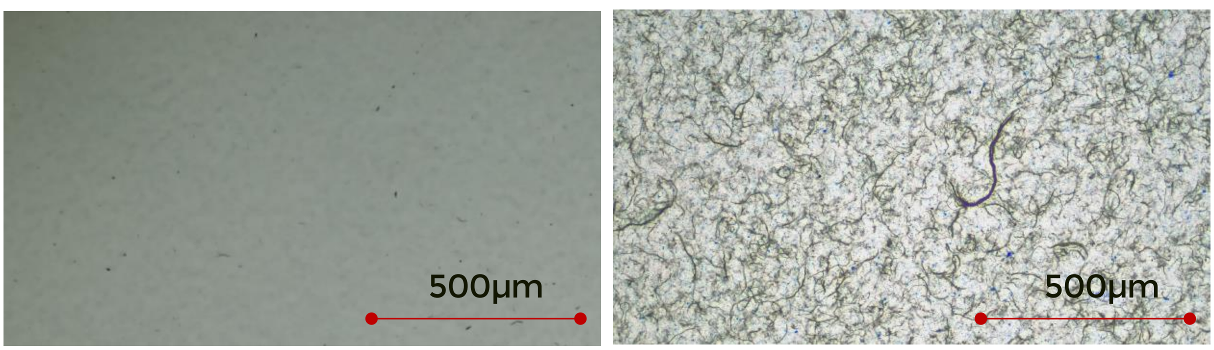


Figure 3: *Optical microscopy images of the Formula1B and competitor resins, as indicated. The dispersion quality of the competitor resin is inferior to the quality of Formula1B, which contributes to discrepancy in the ESD readings.*

The importance of high-quality dispersion of conductive filler in the polymer matrix for static-dissipative materials cannot be understated. A uniform dispersion of the conductive filler maximizes the chances of interconnectivity between the filler particles, facilitating an effective electrical pathway for static dissipation. This, in turn, minimizes the accumulation and discharge of static electricity, thereby reducing the risk of electrostatic discharge (ESD) damage to sensitive electronic components and ensuring the safety of both individuals and equipment. The presence of regions without CNTs and highly concentrated areas adversely affects the uniform distribution of the conductive filler in the manufactured component, resulting in sections with inconsistent conductivity.

To support this argument, the measurement map for parts fabricated using the Formula1B and its competitor is presented in **Figure 4**.

The competitor part had resistance ranging from 10^7 to 10^{11} Ω, with multiple instances where an "Open Loop" reading was observed. An "Open Loop" or OL reading indicates that the tested component lacks continuity and possesses infinite resistance. Infinite resistance implies the absence of an electric current flowing through the component. In contrast, parts fabricated with Formula1B displayed highly precise surface resistance measurements, ranging from 10^6 to 10^8 Ω. The resistivity at any specific location on the component either varied by one order of magnitude or remained constant at 10^7 Ω. Ensuring consistent static dissipative readings across all sections of a component is crucial when safeguarding miniature electronic elements. The existence of both insulating areas and highly conductive areas can result in harm to the components, leading to malfunction or complete failure.

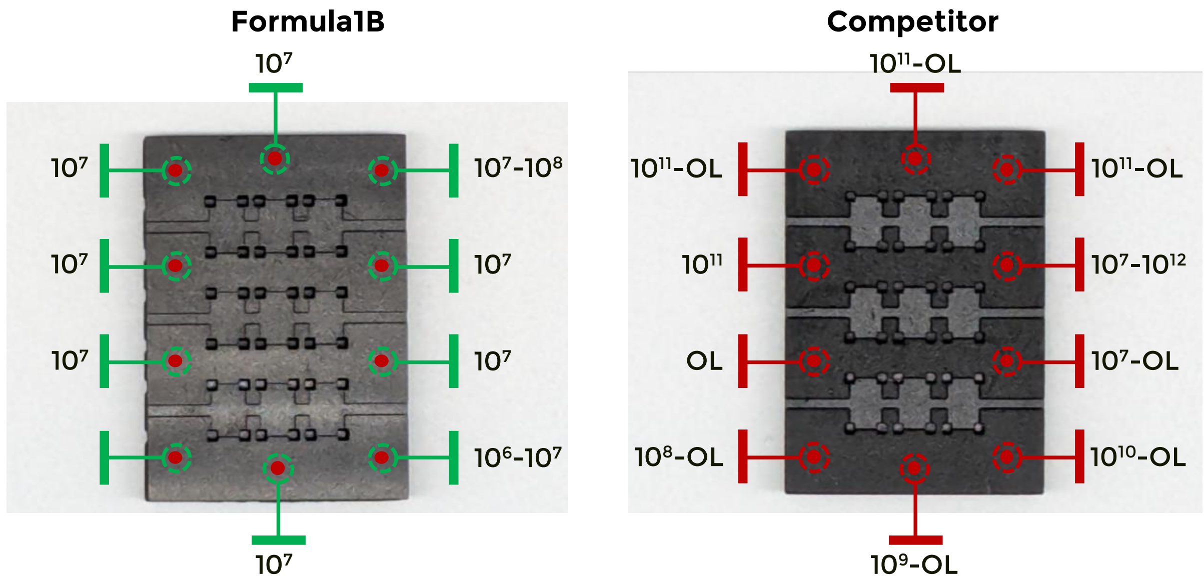


Figure 4: *ESD measurements map showing the range of resistance values collected from each location. The competitor part failed to deliver acceptable levels of ESD protection. The Formula1B part displayed nano-uniform ESD performance throughout the component.*

High-quality dispersion goes beyond offering uniform surface resistance; it guarantees mechanical strength and stability by minimizing undesirable factors like agglomeration or particle clustering.

Dispersion quality of the conductive filler is essential to optimize the performance and overall effectiveness of static-dissipative materials, making it a critical factor in various industries, including electronics, automotive, aerospace, and manufacturing. Achieving the desired level of dispersion uniformity and reliability necessitates correct implementation of dispersion techniques and utilization of cutting-edge processing technologies. The significance of these considerations drives research and development efforts to provide static-dissipative materials that not only meet but exceed industry standards.

Time & Cost Savings with DLP

Time is of the essence in any manufacturing environment. When compared to micromachining, DLP offers significant cost and time savings in the production of miniature

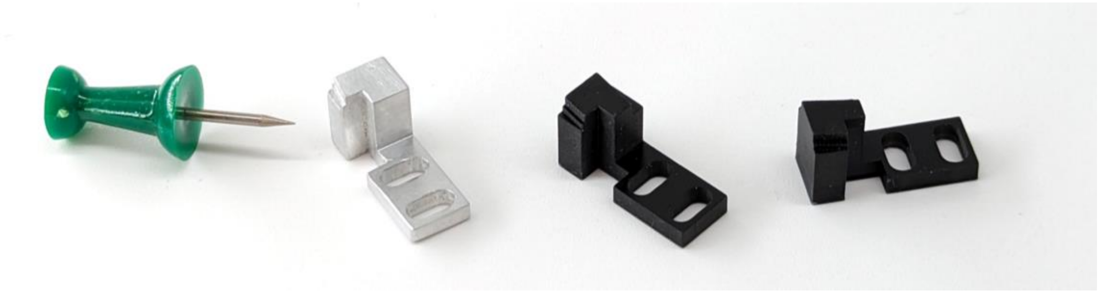
ESD components. Micromachining process follows a series of steps such as selecting the appropriate machining method (turning, milling, or drilling), setting up and calibrating the machining equipment to guarantee optimal performance, and the actual machining operation. As a result, the fabrication of ESD components using micromachining can be time-consuming and labor-intensive. Moreover, micromachining processes often require the use of expensive tooling, specialized machinery, and skilled labor. These factors contribute to high production costs and limited scalability.

On the other hand, DLP eliminates the need for costly tooling and complex machining processes, resulting in reduced upfront costs. With the flexibility of additive manufacturing, small-scale production runs can be achieved without incurring excessive manufacturing costs. Furthermore, DLP eliminates the time-consuming setup and retooling required for each component, as it can produce multiple components simultaneously in a single build. This not only reduces production time but also increases overall efficiency in the manufacturing process. Additionally, DLP offers rapid prototyping capabilities, enabling quick iteration and refinement of designs, further reducing the time to market for miniature ESD components.

Customer Success Stories

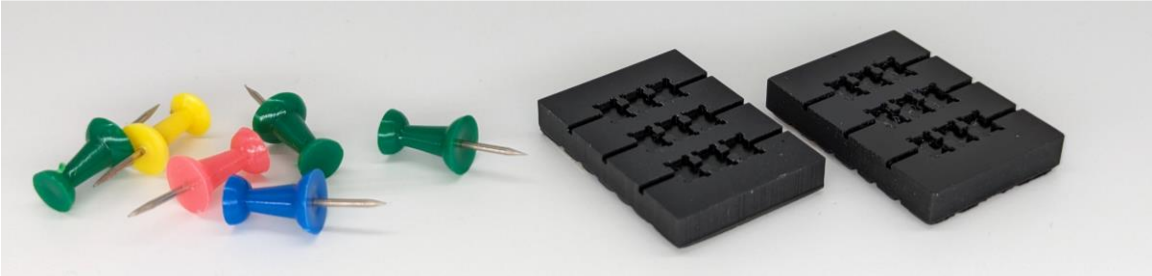
Here are a few instances where the shift from outsourcing machining services to in-house fabrication using DLP technology brings remarkable benefits to customers. This transition facilitates an impressive decrease in part lead time from 8 weeks to just 2 hours, along with a significant cost reduction of 84%.

Custom-made high mix low volume grippers



Aluminum vs. Formula1B	Time Savings	Cost Reduction
DLP	1.5 hours	$1.5 (resin only)
Machining	2 weeks	$500

Miniature electronic components carriers



Aluminum vs. Formula1B	Time Savings	Cost Reduction
DLP	2 hours	$80
Machining	8 weeks	$500 + $250 setup fee

Conclusions

DLP offers a viable approach to fabricating miniature ESD components, surpassing the limitations of traditional micromachining techniques. The capability of engineered resins to provide static discharge protection, coupled with the time and cost savings achieved through additive manufacturing, makes DLP a compelling choice for manufacturers in various industries. With its precise control over material properties, ability to create intricate features combined with reduced lead times, and cost-effectiveness, DLP is poised to reshape the future of ESD component manufacturing.

With DLP, manufacturers can produce intricate designs that were previously unattainable, achieving unparalleled levels of precision and performance. The freedom to create complex geometries and detailed features allows for design optimization and the production of miniature ESD components that provide superior protection against electrostatic discharge. The cost and time savings offered by DLP cannot be understated. By eliminating expensive process steps and reducing production time, manufacturers can maintain competitive pricing and faster turnaround times, ensuring their products reach the market ahead of the competition.

Are you ready to take your business to the next level? Look no further than Mechnano's ESD resins. Designed with the latest technology and extensive research, our resins are perfect for customers who want superior electrostatic discharge protection. With Mechnano's ESD resins, you can trust that your products will be shielded from static electricity, ensuring optimal performance and longevity. Join the ranks of satisfied customers who have found success with our resins. Contact Mechnano today and unlock the power of ESD resins. Your success story begins here.

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