Metal plating stereolithography parts: Applying the M&Ms Principle

By Scott Nordlund

History has shown that combining two good materials in the right order to form a more functional composite structure can be nothing short of revolutionary.

Take M&Ms ® Chocolate Candies. The U.S. military wanted to supply chocolate snacks to troops fighting in World War II, both for energy and to help overcome some of the loneliness of being overseas, far from home. The problem? Chocolate melts pretty easily, especially when it's shoved into the backpack of a solider on the move.

To solve this confectionary quandary, Forrest Mars developed a candy coating that encases the chocolate completely. That coating protects it from melting – even in the hot, steamy jungles of the South Pacific – while still being not just edible, but tasty as well.

The problem was solved – much to the benefit of GI morale all over the globe – and an entirely new product category was born.

That same principle of taking something that is already good on its own and making a composite that is even stronger and more durable is now being applied to stereolithography (SL). RePliForm inc. (www.repliform.com) together with Dinsmore & Associates is pioneering this process using accurate, high temperature resins from DSM Somos ® and encasing them with a metal cladding to produce metal-like parts that are extremely strong and durable.

In testing conducted by DSM Somos and RePliForm Inc., nickel-plated SL parts had more than six times the impact strength and double the heat deflection temperature of non-plated SL parts.

Seeing the value the metal cladding process provides to manufacturing and design engineers, DSM Somos is spearheading a new product design solution called MC^2 (Metal Clad Composite) and it combines two familiar technologies -– 1) electrically applying a copper-nickel composite coating (called a cladding) to plastic and 2) stereolithography – to create a new approach to rapid prototyping and short production runs of metallic parts.

This cladding gives the part performance and durability that is much closer to solid metal than can normally be achieved through SL, at a cost that's three to four times less than that of machined or die cast parts (depending on the part's size and complexity). As a result, engineers can design and test the performance of metallic parts under real-world conditions for longer cycles than possible with uncoated SL parts. They also save time since SL composite prototypes and short production runs can be created far faster than machined or die cast parts in many cases. Which means several variations of the same part can be quickly and cost-effectively tested.

Of course, there's more to MC² than there is to dipping chocolate in a candy coating. There are a myriad of permutations and decisions that will affect the overall outcome.

The DSM Somos MC² design solution is more than just a process. It is a comprehensive offering of technologies, design assistance, and specialized expertise, that combines to make it easy to take advantage of this innovative approach to composites.

Service bureaus that are part of the MC² system become the conduit for delivering metal-like parts that meet the application needs of the design engineer for both rapid prototyping and short production runs.

With MC², engineers can take advantage of the benefits right away, without the lengthy learning curve that normally accompanies a new technology. That's because all of DSM Somos' partners in the program have passed a rigorous certification process that assures they have the depth of knowledge to make recommendations and contribute ideas from day one.

The Sum is Greater

Remember the old commercials about how peanut butter cups were "invented?" Two good things that already existed were combined to create something even better.

That's much the case with the products that result from the MC² process. At the core of the operation is stereolithography, a process that uses resins such as Somos NanoTool™ to turn a CAD design into a corresponding physical model, layer by layer.

An SL machine washes over a grid with liquid UV -sensitive resin, then a laser is used to solidify each layer according to the original design. The object takes shape as each layer is "printed" onto the previous one. In addition to being relatively quick to produce, this additive process also allows the part to have more complex geometries and thinner walls than subtractive methods such as machining, where material is taken away from a solid piece in the building process. It has the same advantages over die casting because engineers are not limited by the need to remove a two-piece mold.

Of course, the part that results from SL is still plastic. And even though Somos NanoTool provides outstanding stiffness and high temperature resistance over other resins, it still doesn't match up to the durability or EMI shielding of a metal part, limiting its usefulness as a prototype for heavy-duty testing or as a production part.

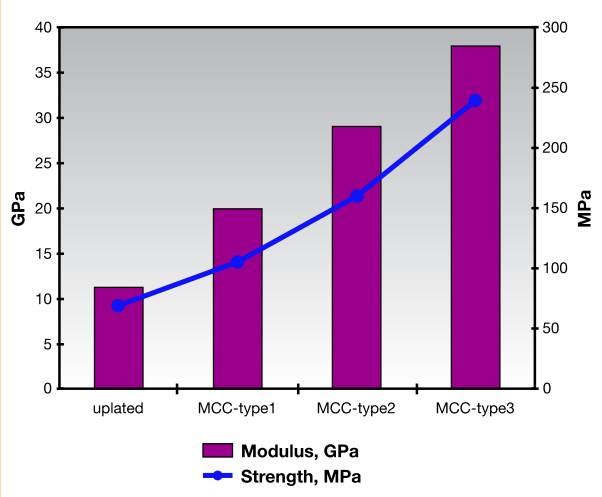
Adding the copper/nickel cladding solves this issue. Once the shape is created with SL, all surfaces are prepped for adhesion with a special wash that places ions onto the plastic. A thin layer of copper is applied by dipping the plastic model in a bath.

Once dry, the nickel layer is applied to the specified thickness. (The copper layer is used to give the nickel something to bond with electrically, since it does not adhere well to plastic.) Again, copper/nickel cladding is a common technology that has been proven in real-world applications for several years.

Neither of these processes is new per se. Both have been used individually in the industry for years. What's new is that RePliForm has created a way to make metal plating work better with SL, creating not just a coating but a true composite. This composite greatly increases the durability of these parts, making them far more useful for both testing and real-world applications.

Graph 1 shows the effect on tensile strength and tensile modulus for three basic thicknesses of metal cladding versus an unplated sample created with NanoTool. As one moves up through the various types (from Type 1 to Type 3), the SL walls get thinner, which means the amount of metal as a percentage of the overall resin material increases – as does the strength and the cost to produce, of course.

Graph 1. Shows tensile strength and tensile modulus values versus unplated NanoTool and three MC² construction types.



A certified MC² provider can work with the design engineer to determine the appropriate type – or even a variation between two types – that will work best for an application. They can also help determine the upper limit of cladding that can be applied to a particular part. In addition, an MC² provider will make sure that files for the SL part are modified in such a way that when the metal cladding is added, the final part will meet design tolerances. The MC² provider is the main conduit throughout the entire process.

MC² parts have improved physical properties such as fire retardance, solvent resistance and EMI shielding over unclad SL parts.

How MC² Opens Options

Nearly everyone involved in new product development has heard the saying "good, fast, and cost-effective – pick any two." With the introduction of MC², that need to choose has been eliminated. Here's an example of how:

Suppose you want to change the design of one part in a mechanism that includes several interr elated parts in close tolerances. You could use normal SL, which gives you good and cost-effective, but when you put the part in place for strenuous testing it may only last a few cycles before wearing out beyond tolerance. If the ability to survive hundreds of thousands of cycles is an issue, an SL part alone won't do the job.

You could use machining or die casting to create the part, but then you're actually only getting one of the above three – good. Y ou will be able to test over higher numbers of cycles, but it will take a long time and high cost to get to that point. Then if you're off just a little bit and need to make a revision, you start the whole hurry-up-and-wait process all over again.

Using MC² solves all of these issues. MC² parts are faster and less expensive to produce, allowing engineers to move into the test phase more quickly. They even allow you to create several permutations at once so they can be tested side-by-side instead of one at a time. And while the metal cladding may not pr ove as durable as a pure metal part over a huge number of cycles, it is more than sufficient for most test labs and even low volume production runs.

But durability isn't the only advantage the MC² process offers. Other benefits include:

- Ability to specify thinner walls than with processes such as investment casting – While investment casting offers some of the same benefits, including high durability and fast turnaround with less cost, the tradeoff is that walls cannot go below a certain thickness typically 0.06". MC² parts can have much thinner walls (0.01"), opening the design possibilities further.
- Ability to customize expensive parts for greater functionality or branding – Rather than being limited by what can be done with metal bending or even die casting, engineers can design to what they need, e.g. giving a distinctive shape to a housing that allows it to fit into a certain space. Engineers can also create specialty parts inside, such as holders to help route wires internally, that improve the design without adding to the cost.

Nickel plated factory tooling component, courtesy of FineLine Prototyping.

- Ability to test for ergonomics of metallic hand held products – If you need to cost-effectively simulate exactly what a metallic end-use part will feel like in the user's hand, MC² will help you do it. By creating several models with different dimensions simultaneously, you can test a hand-held medical or other device for fit, feel, approximate weight, and ease of use.
- Ability to create prototypes with improved physical properties – Typical plastic parts have very limited physical properties, which can have an effect on both the tests you can run and the results you can achieve. The metal cladding process adds properties such as EMI shielding, fire retardance, solvent resistance, and thermal conductivity that allow engineers to test prototypes more thoroughly as well as specify low volume production run parts that can be used in harsher environments.

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Cost of the MC² process can be as much as 3-4 times less than machining or investment casting, depending on the part's size and complexity, and turn around can be as little as 1 week. Some of the applications currently featuring the MC² composite material are summarized in Table 1.

Table 1. Applications where MC² parts are used and typical coating amounts required.

Applications	Thickness in mils
Structural Replacement of die cast parts (wall thickness <0.060")	10-20% coating
Mimic sheet metal parts	10-20% coating
EMI Electronics and medical devices	1-2 mils
Decorative Plumbing fixtures	At least 5 mils
Barrier	At least 2 mils
Thermal	At least 3 mils

Understanding the MC² System

As stated earlier, the technology itself is only one part of the full MC² design solution. In that way it's much like having a Formula One race car on the track. In the hands of an inexperienced driver, it's a pile of rubble waiting to happen. But with an expert at the wheel, it's a potential champion.

DSM Somos has gone to great lengths to put together a championship team from top to bottom. It starts, of course, with our own scientists who have developed composite resins such as NanoTool to provide a solid base from which to work. NanoTool's greater stiffness, accuracy and low water absorption means MC² parts can be built with higher ultimate modulus, better durability and dimensional stability than can be achieved by cladding other plastic materials.

The next element is the certification and training of service bureaus in the nuances of optimizing the performance of the materials. This is an extensive process that requires months of both classroom training and hands-on experience. Once a service bureau is certified, it can help you with issues such as:

- What to do to allow for the thickness of the coating when tight-fitting tolerances are a concern
- How to design specifically for the MC² process, such as the need to avoid a sharp radius on inside corners
- Preparing your files to optimize them for MC²

Part courtesy of Alphaform AG.

- Which type of MC² cladding to use based on needs for flexural strength, tensile strength, wall thickness, and even budget requirements
- How to overcome problems when it appears the design and material properties are in conflict

The third leg in the stool is a partnership with RePliForm inc. As you know, normally with a three-step process like this (design, part creation, cladding) the engineer would be responsible for contracting for and managing each phase of the process. But with the MC² design solution, the service bureau is the conduit that manages the process end-to-end – including having RePliForm inc. add the cladding.

MC²-certified service bureaus have the relationship, taking care of everything from scheduling the part(s) in for coating to quality control to assuring on-time delivery. In the remote chance that something is not up to spec, the service bureau will take care of making it right. You have a single point of contact for all your needs, so you can focus on the design. In addition, DSM Somos is taking care of the marketing and application development in order to get more service bureaus interested in becoming MC²-certified. Just like M&M's, it's a sweet deal all the way through.

Avoid the Meltdown

In today's competitive market it's more important than ever to move from concept to production quickly and efficiently. And that need is driving more creative thinking.

Metal-clad composite parts are helping engineers in a variety of industries, including aerospace, automotive, medical, transportation and more achieve their vision and bring products to market faster, with greater performance and reliability, and at lower cost than ever before. Combining cladding with stereolithography, using high-performance resins from DSM Somos, and all within the MC² design solution, is the next logical step in that evolution.

Before you pull your next bag of M&Ms out of the vending machine, contact your DSM Somos representative for a list of MC²-certified service bureaus. It may be the best call you make all year.