Electroplating Non-Conductive 3D Printed Rapid Prototype Parts

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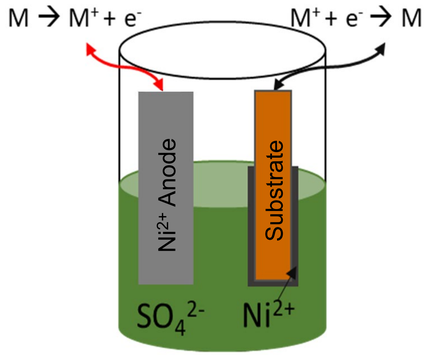
An Internally-Funded Joint Effort between Physical Sciences and Engineering Resource Centers

Introduction

Through a joint effort between Physical Sciences and Engineering, MRIGlobal has expanded its rapid prototyping capabilities by adding a fast and economical means to metal-plate 3D-printed polymer parts. Metal-skinned parts offer an interesting combination of material properties: plastic parts, for example, are lighter than solid metal parts but are generally less resistant to chemicals. Metal-plated plastic parts, however, exhibit low densities ***and*** chemical resistance – while also being cheaper and faster to produce than metal parts manufactured using subtractive or additive fabrication techniques.

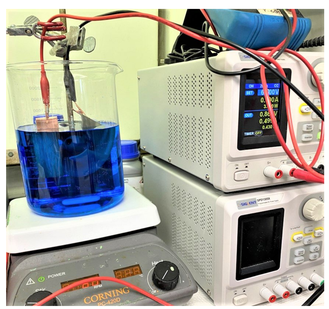
Background

Electroplating is a process used to deposit small amounts of metal onto a substrate to enhance the appearance and properties of the part.

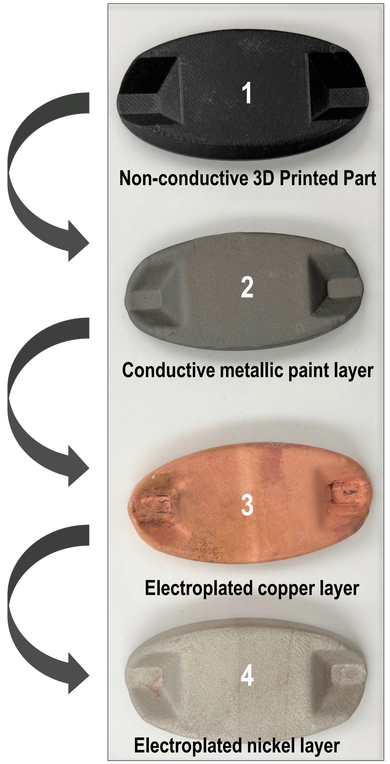


It is an established electrochemical process for natively metallic [electrically conductive] substrates and is used in a variety of industrial, academic, and commercial fields such as jewelry manufacture and aircraft parts. It is an economical method for applying a thin coating of expensive noble metal onto a less expensive base. The process is generally ***not*** adept for coating electrically insulative materials such as common plastics.

The process works by placing the conductive part in a salt bath of positively charged metal ions and applying a negative voltage across the part to be plated. The positively-charged metal ions in the solution will be attracted to the negatively charged part and a layer of the new metal will quickly form on the surface.



Process Overview



(1) The 3D printed part requires no additional design steps for the part to be successfully plated. The plating process starts by cleaning the part with an isopropanol rinse to remove surface contaminants.

(2) A metallic paint is then applied to provide the initial conductive base.

(3) First electroplated layer is a copper layer. Copper deposits well on less-conductive base materials and provides an excellent surface for secondary plating.

(4) Subsequent electroplated layer is nickel. Nickel serves as the next layer as it generally offers better chemical resistance and mechanical hardness.

The process can be repeated to apply multiple coats through multiple cycles if additional layers, metal types or build-up are desired.

Current Part Capability

MRIGlobal has thus-far demonstrated success with copper and nickel plating onto multiple thermoplastic polymers including PLA, ABS, and Nylon, with part sizes on the order of ~ 4-inches. Larger parts can be accommodated with a larger electrolyte bath, and additional metals such as gold and platinum are also feasible.

Copper Plated Polymer Part

Testing

Testing on the electroplated parts included adhesion testing (ASTM B571) and abrasion testing (ASTM D6037). The coupons' surfaces were also observed under the Keyence digital microscope and SEM to assess surface characteristics such as porosity. Adhesion testing included scribe-grid testing, heat quenching, and impact tests. Decontamination efficacy was evaluated by means of exposing the sample to bleach. Bleach exposure testing appeared successful, suggesting nickel coatings could survive agent decontamination processes. Additional vapor challenges would be required to ensure agent doesn't penetrate and absorb into the plastic.

Nickel-Coated Part Subjected to Scribe-Grid Test

Future Development

To expand upon this new capability, future efforts could focus on:

- Larger Parts
- More Complex Geometries
- More Noble Metals (e.g. Gold, Platinum)
- Other Insulative Substrates (e.g. Flexibles)
- Agent/Harsh Chemical Vapor Challenges

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References

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