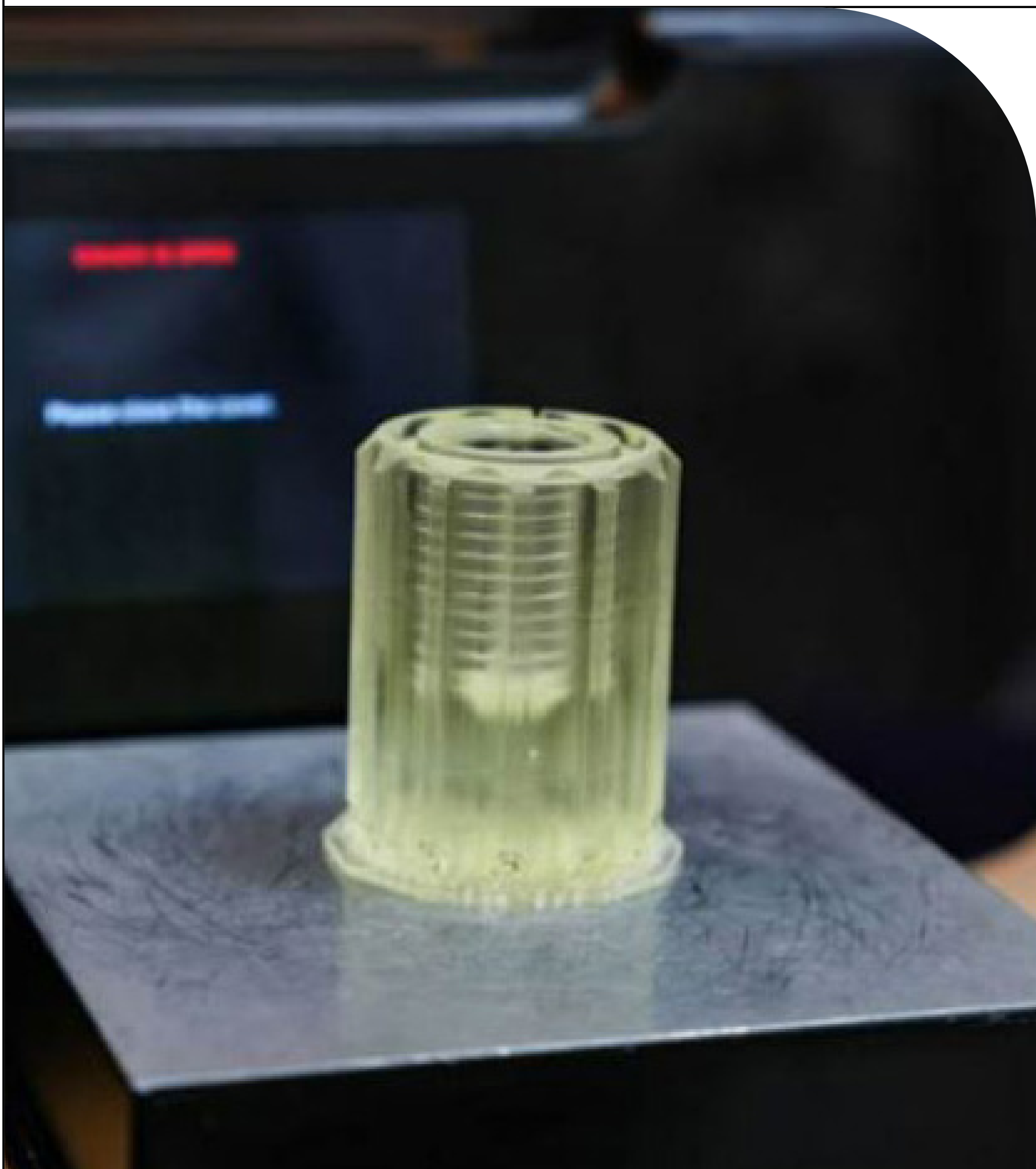
Case study

# Figure Engineering

## 3D-printed chemically resistant electroplating masks for aerospace applications



# SUMMARY

**PARTNER**
Figure Engineering
www.figureengineering.com

**INDUSTRY**
Aerospace & Defense

**APPLICATION**
Electroplating masks

**PRINTING TECHNOLOGY**
Stereolithography (SLA)

**MATERIAL**
Resist 3D™ SLA resin incorporating Arkema's Sartomer® photocurable materials

# CASE STUDY

## INTRODUCTION

In the field of Maintenance, Repair, and Overhaul (MRO), electroplating is a critical process to ensure that aircraft and other machinery are maintained in optimal working condition, repaired when necessary, and overhauled to extend their operational life. This process, utilized by the U.S. Air Force, requires precise masking to protect certain areas from being plated. Traditional masking methods, including tapes, waxes, or lacquers, are labor-intensive, expensive, hazardous, and wasteful..

To address these challenges and bring a tailored solution to market, Figure Engineering worked in collaboration with key players in the additive manufacturing industry, including specialty materials provider, Arkema, to develop a chemically resistant SLA resin specifically designed for 3D printing of masks used in electroplating.

# Resist 3D™ resin for electroplating masks

## CHALLENGE

Electroplated coatings are used for corrosion control, thermal resistance, impact protection, and dimension restoration.

Masking metal parts in preparation for industrial electroplating in Aircraft MRO involves labor-intensive, expensive, hazardous, and wasteful manual tasks, and is a process overdue for modernization. Traditional methods involve manual application of tapes and lacquers, that are not only time-consuming but also prone to errors.

Attempts have also been made to produce reusable masking from machined chlorinated polyvinyl chloride (CPVC). However, long lead times, high cost, and the dangers of machining CPVC have prevented this process from becoming widespread.

### Waxes/Lacquers/Tapes:

- Skilled-labor intensive
- One-time use
- Disposed as hazardous waste

### Machined CPVC:

- High cost
- Long lead time

Additive manufacturing is becoming more commonly used in **aerospace applications**, due to a variety of benefits such as:

1. Ability to create complex and lightweight structures
2. Reduction in material waste
3. Faster prototyping and production cycles
4. Greater customization and flexibility

While additive manufacturing of masks for MRO is a great solution, existing polymer materials lacked the combination of chemical-, heat-, and impact-resistance needed to withstand the extreme and chemically aggressive environment of an aerospace plating bath.

### Identified requirements:

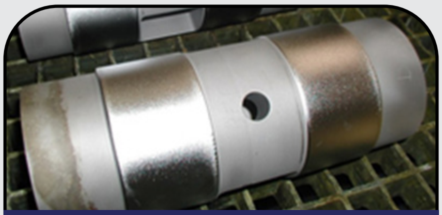
- No porosity
- Chemically resistant
- High impact strength
- Low thermal expansion
- Non-conductive
- High surface energy (bubble shedding)
- No component migration

All commercially available additive materials that were tested failed to meet the requirements Therefore, **the team at Figure Engineering set out to develop a solution** for the U.S. Air Force that fulfilled the specified criteria.

## Aerospace Plating Process


Application


Electroplating


Removal


Part in Service

# SOLUTION

The team at Figure Engineering knew that the right solution would require the right partners along the value chain, especially on the materials. They worked through a **rigorous component screening** process to ensure optimal mechanical properties of the new formulation.

## Arkema as a materials partner

**Arkema, through its Sartomer® product line, is a leader in designing advanced liquid resins for energy-curable additive manufacturing.** Due to its broad product offering of acrylate and methacrylate monomers and oligomers, Arkema was chosen as one of the suppliers to be included in the testing.

While looking for candidate materials that have high impact strength, good chemical resistance properties, and would be chemically compatible with other components of the formula, the Figure Engineering team utilized the digital finder tool on **americas.sartomer.arkema.com** to help find the best materials for their testing. Within the product finder, the team was able to compare mechanical properties and even order samples directly on the website, to help speed up the product development process.

The screening procedure included various testing to compare components, including chemical resistance, swelling and impact resistance testing. Arkema's experienced team of application engineers and chemists specializing in additive manufacturing tailored to mass manufacturing were on hand to offer support and bring solutions. The Figure Engineering team observed that switching suppliers, even for the same materials, significantly impacted the properties of the final formulation and print quality. Arkema's materials, including an acrylate from the **SARBIO® product line of bio-based materials**, were among the final components selected and qualified for this solution.

## Tough, chemically resistant SLA resin

Once the final composition was identified, printability was tested and tuned for Formlabs printers. With scalable, open access and material development opportunities, the team decided that Formlabs MSLA printers were the right choice to produce the chemically resistant masks.

**Figure Engineering's Resist 3D, developed in collaboration with the U.S. Air Force and incorporating Arkema's leading-edge raw materials, is chemically strong and impact resistant.** It enables improved tank/resin compatibility, greater print success rate, and 60-80% reduction in total print time.

Scan here to access
**Sartomer resin product finder** for Americas region
**americas.sartomer.arkema.com**

## Material Property Data

Obtained using parts printed on a Form 3 printer, washed, and cured on a Form Cure L.

| Test | Results | Method |
|---|---|---|
| **Tensile Properties** | | |
| Ultimate Tensile Strength | 14.9 MPa | ASTM D638 |
| Young's Modulus | 560 MPa | ASTM D638 |
| Elongation at Break | 38% | ASTM D638 |
| **Flexural Properties** | | |
| Flexural Strength | 17.4 MPa | ASTM D790-15 |
| Flexural Modulus | 490 MPa | ASTM D790-15 |
| **Impact Properties** | | |
| Notched Izod | 44.1 J/m | ASTM D256-10 |
| **Physical Properties** | | |
| Shore Hardness | 68D | ASTM D2240 |
| Density (Solid) | 1.07 g/ml | ASTM D792-20 |
| **Liquid Properties** | | |
| Viscosity (25°C) | 840 cP | ASTM D4287 |
| Viscosity (35°C) | 424 cP | ASTM D4287 |

## Chemical Resistance Data

Percent weight gain over 24 hours for a printed and post-cured 1 $cm^3$ in representative solution.

| Solution | Specification | 24-hour Weight Gain |
|---|---|---|
| Acetic Acid | 5% | 0.08% |
| Anodize | Boeing BAC5022 | 0.05% |
| Hard Anodize | Boeing BAC5821 | 0.05% |
| Alkaline Derust | 20% NaOH, 65°C | -0.12% |
| Chrome Etch | Pratt PS116, C-305 | 0.13% |
| Chrome Plating | MIL-STD-1501, 54°C | 0.13% |
| Copper Plating | MIL-C-14550 | 0.03% |
| Isopropyl Alcohol | 90% | 2.48% |
| Nickel Plating | Pratt PS321, PS324 | 0.07% |
| Nitric Acid Strip | Boeing BAC5771 | 0.49% |
| Passivate | AMS 2700 | 0.11% |
| Rochelle Salts | Boeing BAC5771 | 0.03% |
| Salt Water | 3.5% NaCl | 0.12% |
| Sulfuric Acid Etch | 30% Ambient | 0.01% |
| Water | — | 0.16% |

## Labor reduction

How does Resist 3D reduce labor?

**Significant time savings**

Hand masking takes 0.5 to 1 hour of skilled labor per part, while 3D printing with Resist reduces touch time to **less than 5 minutes per batch**.

**Cost efficiency**

Masks are **reusable for up to 20 plating cycles**, reducing the need for new masks and hazardous waste disposal.

**Skilled labor reduction**

There is an 85-90% **reduction in skilled labor** required per 20 cycles.

## Material cost reduction

What kind of material cost reduction is seen?

| | Small part with threads | Large part | Multi-part mask set |
|---|---|---|---|
| LEGACY price each | $250 | $2,000-4,000 | $4,000 |
| Resist 3D price each | $5 | $550 | $550 |
| | **98% reduction** | **Up to 86% reduction** | **86% reduction** |

## Next steps

Resist 3D was commercially released in October 2024. For more information on ordering this material, visit **www.resist3D.com**.

# OUTCOME

**The usage of partnerships across the additive manufacturing value chain** resulted in a solution to improve the quality of the electroplating process and address a need for better additive manufacturing materials designed for the challenges of the application. By collaborating with Arkema for the material composition, Figure Engineering was able to develop Resist 3D™.

3D printed masks using Resist 3D are reusable and chemically resistant. They offer significant labor and material cost reduction and precise and consistent masking. This reduces the risk of errors and improves the overall efficiency of the electroplating process.

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