



CITIUS
COMPOSITES

**MOLDING
A BETTER
TOMORROW,
TODAY.**





**Vacuum Infused Composite Parts
with Reusable Silicone Membrane**

Elevating Manufacturing Excellence
Through Quality and Efficiency



OVERVIEW

This document explores the technical, industrial, and economic benefits of manufacturing composite parts with Reusable Silicone Membranes (RSMs). By integrating advanced silicone technology, RSMs enable manufacturers to produce critical components with enhanced quality, lower production costs, and reduced environmental impact.

Composite materials, combining fibers and resins, deliver unmatched tensile strength, weight reduction, and corrosion resistance. These attributes make composites indispensable for industries requiring durable, lightweight solutions that extend product life and optimize performance.

WHY CHOOSE CITIUS?

Leadership in Silicone Innovation

The Citius team has over 15 years of experience in silicone molding, offering bespoke solutions tailored to diverse industries. With unmatched expertise in material science and industrial engineering, the Citius team has led the evolution of silicone mold-making in India, setting new standards for quality and innovation.

Integrated Expertise

Our end-to-end capabilities encompass the design, development, and delivery of high-performance molds and critical components. Citius meets rigorous industrial and environmental certifications, combining technical excellence with an unwavering focus on quality and sustainability.

Customer-Centric Approach

Citius collaborates closely with clients, providing support from feasibility studies to full-scale production. By addressing technical and economic challenges, we deliver solutions that enhance performance, safety, and profitability. Our global network of specialists ensures success for even the most demanding applications.



THE RISE OF COMPOSITE MOLDING



A Global Perspective

Composite materials are reshaping industries by offering superior alternatives to traditional metals like steel and aluminum. By combining resins and fibers, these materials provide unparalleled benefits, including:



Tensile Strength:

Ideal for high-stress applications.



Weight Reduction:

Critical for energy efficiency in transportation and aeronautics.



Corrosion Resistance:

Ensures durability in harsh environments.



Extended Lifespan:

Reduces maintenance and replacement costs.

Industries such as wind energy, automotive, and aerospace rely heavily on composites for lightweight, durable, and high-performance solutions. However, the higher production cost of composite materials necessitates a strategic approach to balance expenses, customer pricing, and long-term value.

Addressing Manufacturing Challenges

Manufacturers can enhance efficiency and reduce costs through:



Optimizing Raw Material Usage:

Ensuring the best resin-fiber combinations for specific applications.



Streamlining Production Processes:

Reducing labor and material waste, especially for complex or high-volume parts.

ESTABLISHED METHODS IN COMPOSITE MOLDING

Manual Lamination

This labor-intensive, open-mold process involves layering fiberglass and manually applying catalyzed resin. While cost-effective for small-scale production, it is unsuitable for serial production due to:

- **High dependency on operator skill.**
- **Inconsistent quality of output.**
- **Health risks from prolonged exposure to uncured resin in open environments.**

Resin Transfer Molding (RTM)

RTM utilizes rigid molds and pressurized resin injection to create smooth, uniform parts. Benefits include fast filling times and precise thickness control. However, challenges include:

- **High complexity and cost of mold fabrication.**
- **Expensive machinery, limiting scalability for large-scale production.**

Light RTM (L-RTM)

A variation of RTM, L-RTM uses vacuum or low pressure for resin introduction. It is effective for smaller parts but requires high technical expertise.

Vacuum-assisted resin transfer molding (VA-RTM)

VA-RTM employs vacuum pressure to infuse resin into a mold, blending the principles of traditional RTM with open-mold hand layup processes. It is known for its cost efficiency, a high fiber-to-resin ratio and superior interior finishes, but challenges include:

- **High void content in the final laminates.**
- **Long cycle times.**
- **Air bubble risks, often necessitating time-intensive rework or scrapping.**



Vacuum Infusion (VI)

VI employs a rigid lower mold and a flexible top mold made of disposable plastic film to infuse resin under vacuum pressure. This method provides improved fiber-to-resin ratios and produces lightweight yet durable components. Limitations include:

- **Dependency on single-use plastic consumables, leading to increased costs and waste.**
- **Labor-intensive placement of plastic film, often requiring skilled operators.**
- **Challenges in achieving uniform surface finish, leading to post-processing health risks and delays.**
- **Environmental Concerns: Resin-contaminated plastic films generate significant waste that is neither cost-efficient nor eco-friendly.**

Vacuum Infusion with single-use bags works well for low-volume, high-precision parts like Formula 1 car components but struggles with scalability in serial production due to these constraints.

MODERNIZING VACUUM INFUSION

With Reusable Silicone Membranes (RSMs)

Revolutionizing Composite Manufacturing

The integration of Reusable Silicone Membranes (RSMs) into Vacuum Infusion processes offers transformative advantages:



Enhanced Quality:

Precision molding enables consistent replication across serial production.



Reduced Waste:

RSMs replace disposable polyethylene films, significantly reducing consumable usage.



Improved Safety:

Fully enclosed systems minimize operator exposure to hazardous materials.

RSMs streamline production workflows while achieving greater sustainability and cost efficiency. Transitioning to this technology, however, requires careful attention to material compatibility, process adjustments, and upfront investment.



Single-Use Plastic Films vs. Reusable Silicone Membranes in Vacuum Infusion

RSMs deliver superior performance compared to single-use plastic films:



Durability:

Designed for reuse across multiple cycles, significantly lowering consumable costs.



Flexibility:

Adapts to a wide range of part sizes and complex geometries.



Time Savings:

Eliminates the need for frequent film adjustments, ensuring quicker production cycles.

Although initial costs for RSMs are higher, their long-term benefits—cost amortization, improved efficiency, and reduced environmental impact—make them an attractive solution for manufacturers aiming for scalability and sustainability.

Addressing Transition Challenges

Successful implementation of RSM technology involves overcoming several challenges:



Material Testing:

Initial R&D trials optimize resin-fiber ratios.



Skill Development:

Operators must be trained to handle RSMs and maintain molds effectively.



Process Adjustment:

Workflows may need reconfiguration, particularly for manufacturers transitioning from manual methods or traditional vacuum bagging.

Tailored Support:

Citius offers comprehensive support during this transition, including feasibility studies, prototyping, and production scaling to ensure a seamless integration of RSM technology into your manufacturing processes.

ESSENTIAL TECHNICAL INSIGHTS

For Reusable Silicone Membranes

Mechanical Properties

Achieving the right balance of flexibility, tensile strength, and hardness is critical for parts manufactured with RSMs. These properties are enhanced due to higher compression in RSM-based processes, resulting in:



Thinner parts with better fiber-to-resin ratios.



Higher hardness levels, improving durability and performance.

Designing parts for specific applications requires careful evaluation of these mechanical properties to ensure optimal results.



Mold Size and Complexity

RSMs are ideal for small-to-medium molds, but challenges may arise with very large molds (e.g., wind turbine blades) due to silicone's weight and handling requirements.



Solution:

Citius RSMs can be customized with accessories for easy handling, maintaining durability and performance standards even for complex geometries.

Chemical Resistance

The chemical compatibility between silicone and resins significantly impacts the membrane's longevity. Key factors influencing wear rates include:



Resin Curing Time:

Faster curing minimizes membrane stress.



Heat Dissipation:

Proper temperature control ensures consistent performance.



Mold Design:

Optimized mold designs extend membrane life.



Curing Time and Temperature

Citius RSMs are engineered for high-efficiency resin curing, withstanding temperatures up to 200°C. This capability provides a distinct advantage over alternative materials that underperform in high-temperature conditions, enabling their use in demanding applications.

Ensuring Consistent Performance

By addressing these considerations, manufacturers can maximize the benefits of RSM technology, achieving superior quality, durability, and cost-efficiency in high-demand composite production.

EVALUATING LONG TERM VALUE

Total Cost of Ownership of Reusable Silicone Membrane Processes



Balancing Initial Investment with Long-Term Returns

While the upfront cost of Reusable Silicone Membranes (RSMs) may appear higher compared to traditional methods, their long-term economic advantages are significant. Evaluating the Total Cost of Ownership highlights their real value in terms of:



Reduced Consumable Expenses:

Durable RSMs eliminate the recurring costs of single-use plastics, offering substantial savings in high-volume production.



Enhanced Efficiency:

Faster mold setup and reduced labor requirements lead to shorter production cycles and improved productivity.



Improved Product Quality:

Consistent replication across production runs minimizes waste and rework, reducing quality assurance costs.

Case Study: Cost Analysis for Silicone Membrane Infusion of a 10 sqm Part

Using polyester resin, foam core, bi-ax, and glass fiber.

Consumables Required for Silicone Membrane

Product Name	Unit	Estimated Quantity	Total Cost (₹)
Silicone RTV for Bagging	Kg	75	₹273,750.00
Vacuum and Resin Channels	Nos	31	₹41,500.00
Accessories			₹18,250.00
Total Cost :			₹333,500.00
		Labor (10%) :	₹33,350.00
		Grand Total :	₹366,850.00

Comparison: Consumables for Plastic Film Infusion on a 10 sqm Part

The consumables for plastic infusion involve significantly lower material costs, as shown below:

Product Name	Price per Unit	Estimated Quantity	Cost (₹)
Peel Ply	₹150.00	7	₹1,050.00
Infusion Film	₹100.00	15	₹1,500.00
Sealant Tape	₹30.00	14	₹420.00
Spiral Wrap	₹30.00	17	₹510.00
	Total Cost :		₹3,480.00

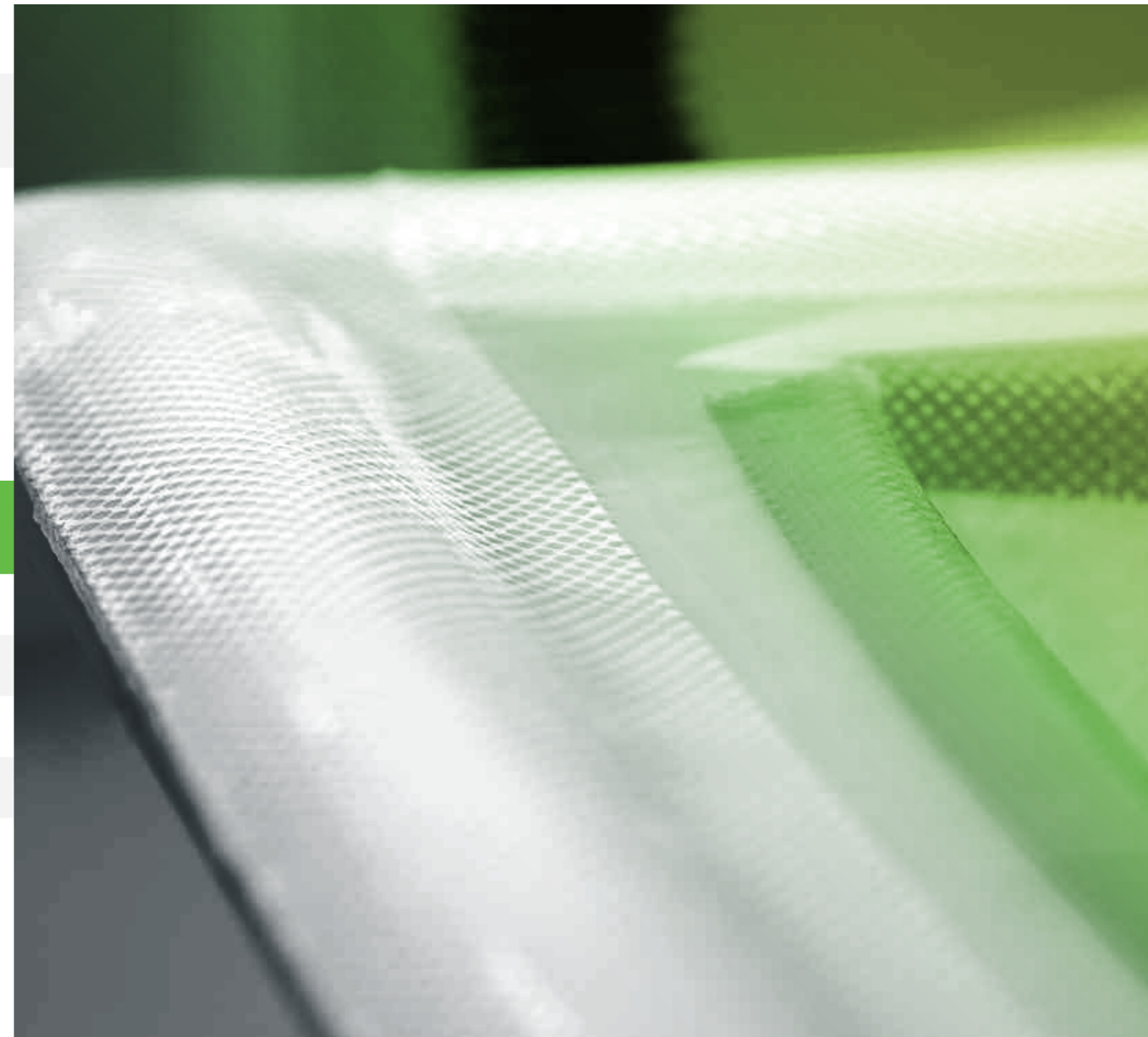
Break-Even Analysis

Based on the cost study, silicone membranes demonstrate a significant advantage in long-term use, achieving break-even after 105 parts.



Current Output Example:

This RSM is still in use after producing over 350 parts, further validating its cost-efficiency.





Return on Investment (ROI)

RSMs optimize production processes across multiple dimensions, ensuring measurable ROI:



Consumables:

Substantial savings through the elimination of disposable materials.



Raw Materials:

Enhanced fiber-to-resin ratios reduce material waste.



Labor:

Streamlined workflows lower operator time and training requirements.



Quality Assurance:

Consistent part quality reduces inspection, rework, and repair costs.

Best Use Cases

RSMs are highly suitable for mid-to-large serial production runs, where initial costs are offset by repeated use and improved operational efficiency.

GAUGING THE SUITABILITY

Of Reusable Silicone Membranes for High Volume Manufacturing

Maximizing Value in High-Volume Manufacturing

Reusable Silicone Membranes (RSMs) are particularly effective in Vacuum Infusion processes for serial production, offering unparalleled consistency, efficiency, and waste reduction. However, careful evaluation of the following factors is necessary to ensure the viability of RSM implementation:

Process and Design Considerations



Part Complexity:

RSMs excel in replicating intricate geometries, ensuring precise replication across multiple cycles, which is critical for high-precision applications.



Mold Geometry:

While RSMs are ideal for medium-to-large molds, they may be less practical for extremely large designs (e.g., molds exceeding 100 sqm) due to weight constraints and handling challenges.

Application-Specific Durability

The number of cycles a RSM can endure depends on several variables:



Material Compatibility:

Silicone properties must align with the resins and fibers used to maintain longevity.



Operational Conditions:

High temperatures, pressure variations, and chemical exposure directly affect wear rates and overall performance.

Environmental Impact

Switching to RSMs significantly supports sustainability goals by reducing plastic waste and lowering the carbon footprint of manufacturing processes. Key benefits include:



Minimization of single-use plastic disposal.



Reduction in emissions associated with the production and disposal of disposable consumables.



Citius Composites: Partnering for Success

Citius offers comprehensive support throughout the transition to RSM-based processes, ensuring manufacturers can achieve seamless integration and optimal results.



Feasibility Studies:

Detailed assessments to evaluate the technical and economic advantages of RSMs for specific applications.



Prototyping:

Support in developing and testing initial prototypes to refine processes and ensure compatibility with RSM technology.



Production Scaling:

Expert guidance on scaling up production, ensuring cost-efficiency, and maintaining quality standards in high-volume manufacturing.

EXPLORING SILICONE POLYMERS

Versatility & Core Advantages

The Versatility of Silicone Polymers

Silicones are among the most adaptable materials in modern manufacturing, delivering superior performance across a wide array of applications, including mold making, pad printing, potting, prosthetics, and special effects. From Reusable Silicone Membranes (RSMs) in composite molding to advanced industrial devices, silicones combine durability and flexibility to meet diverse industry demands.

Key Advantages of Silicones

Silicone products excel in challenging environments due to their unique physical and chemical properties:



Durability and Flexibility:

Silicones maintain their shape and elasticity under extreme conditions, ensuring long-lasting reliability.



Resistance to Aging:

Superior protection against UV radiation and oxidation makes silicones suitable for long-term use.



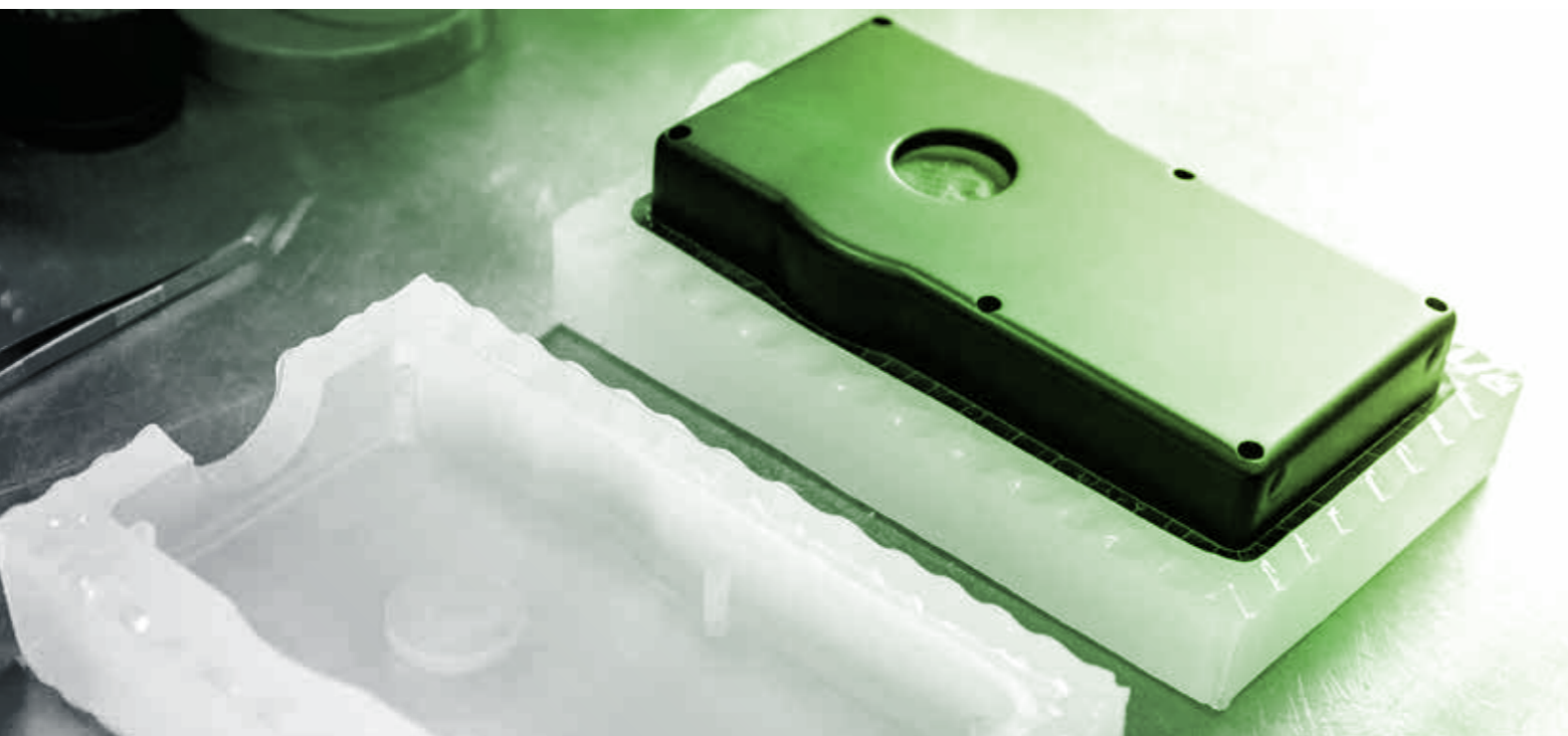
Thermal Stability:

With effective performance across a temperature range of -80°C to 250°C , silicones are ideal for high-stress applications.



Eco-Friendly Curing:

Room-temperature curing reduces energy consumption, offering a sustainable alternative to materials like natural rubber or thermoplastics.



Intrinsic Features of Silicone Products

Silicones have become indispensable for their ability to deliver precise, reliable results in demanding applications:



Thermal and Chemical Stability:

Performs consistently in environments with fluctuating temperatures or exposure to harsh chemicals.



Release Properties:

Facilitates precision molding with reduced defects and waste, saving costs and time.



Fire Resistance:

Emits low levels of smoke and toxic fumes in high-temperature scenarios, enhancing workplace safety.



Stress Compensation:

Protects components from damage caused by cycling stress or high-pressure environments, ensuring operational efficiency.

Silicone Applications Across Industries

Silicone's versatility positions it as a cornerstone material in sectors like:



Aerospace and Automotive:

For high-performance parts requiring heat resistance and durability.



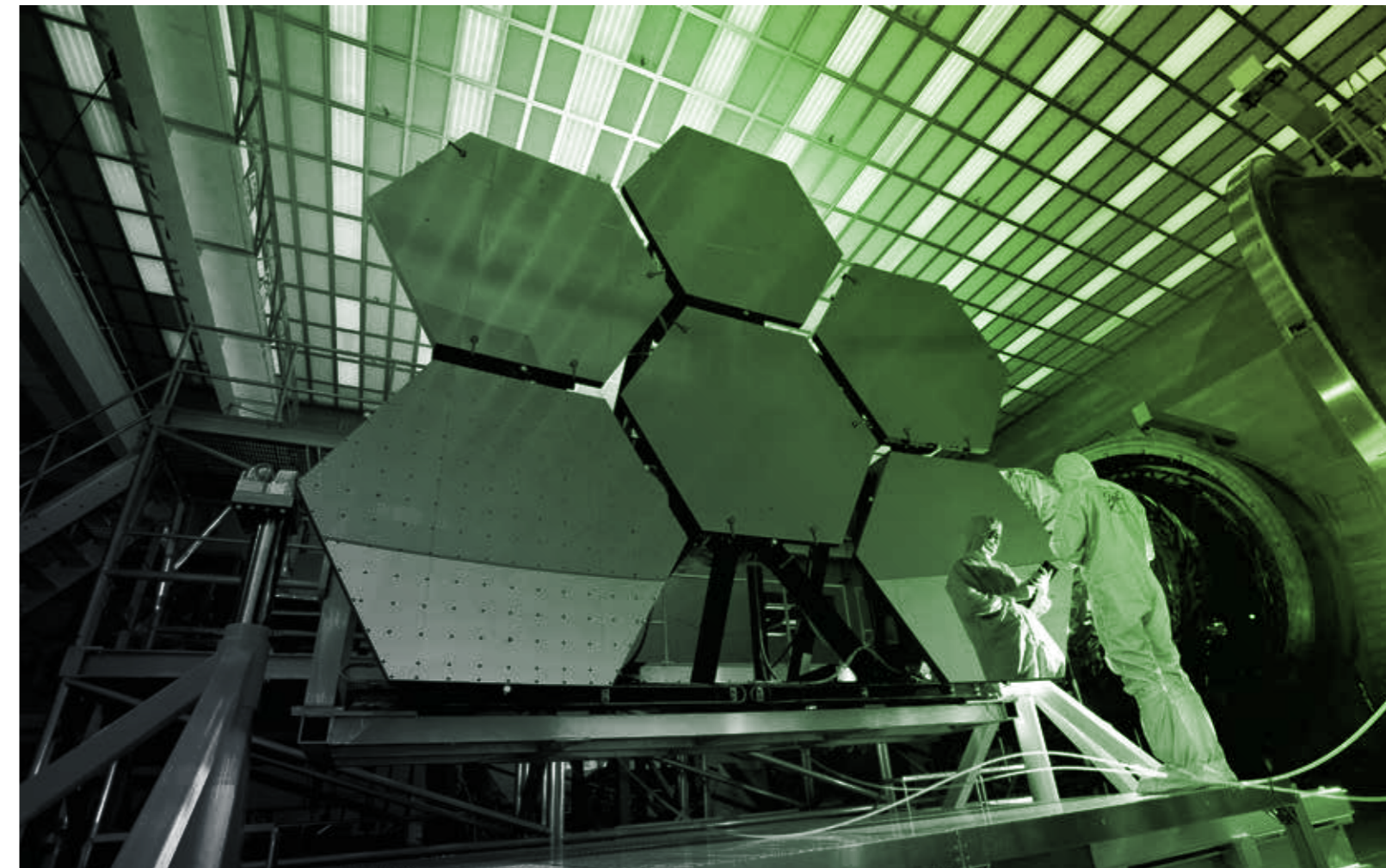
Healthcare:

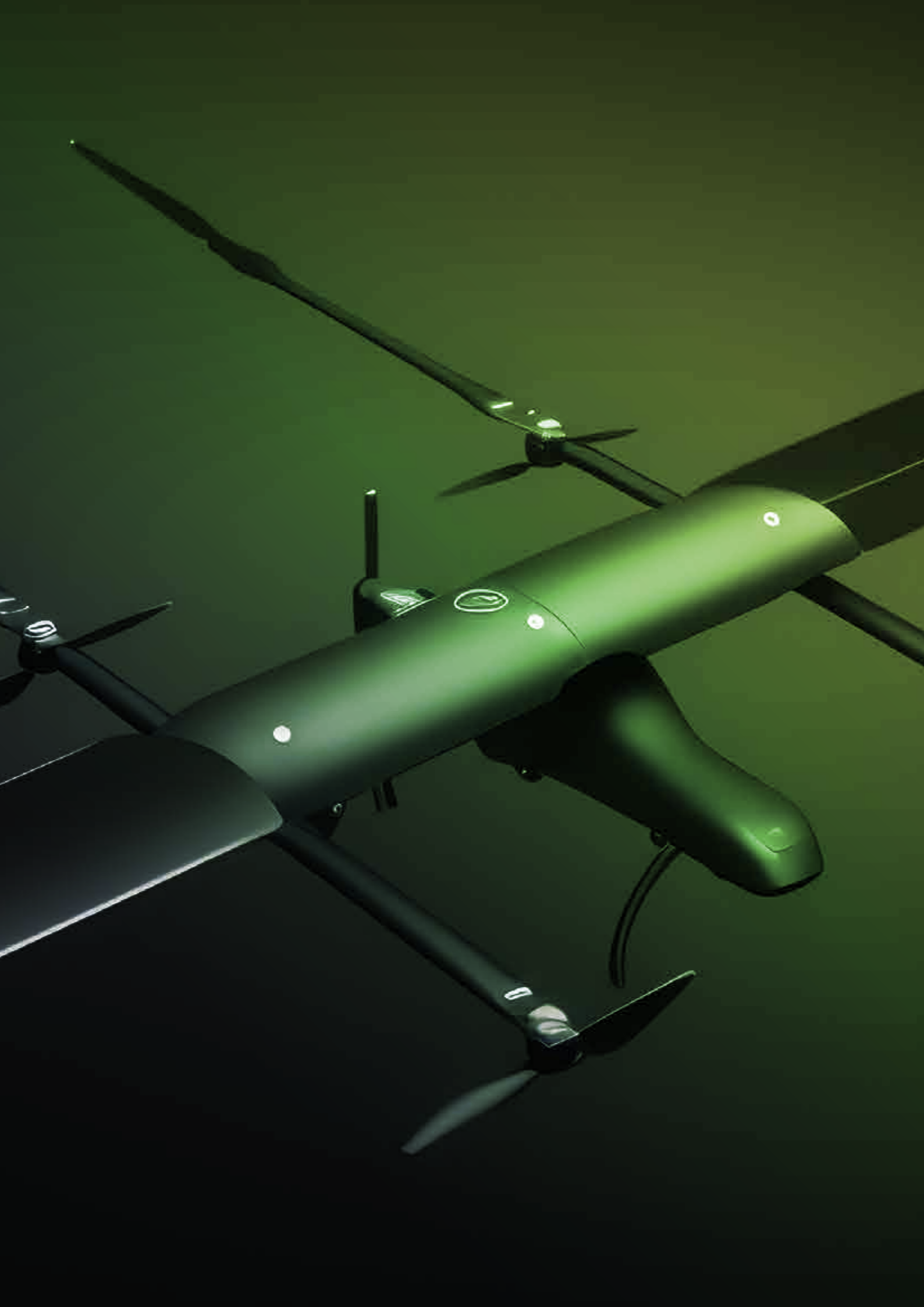
Used in prosthetics and medical devices for its biocompatibility and flexibility.



Consumer Products:

Leveraged in electronics, cookware, and sealants for its longevity and safety.





Citius: Driving Innovation in Silicone Composites

Citius leads the industry in silicone technology by combining decades of expertise with a commitment to customer-centric innovation.



State-of-the-Art Expertise:

Citius delivers advanced silicone solutions tailored to meet the unique needs of the composite industry.



Global Reach:

Serving clients across South America, Europe, and Asia, Citius continues to expand its influence and deliver value worldwide.





THE CITIUS ADVANTAGE

With its unwavering dedication to innovation, Citiu helps its clients push the boundaries of what is possible in composite applications. By partnering with Citiu, manufacturers can harness the unmatched potential of silicones to revolutionize their processes.





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