Customized Masking Solutions
Don't Require Customized Masks.
Are Your Masking Solutions Failing?

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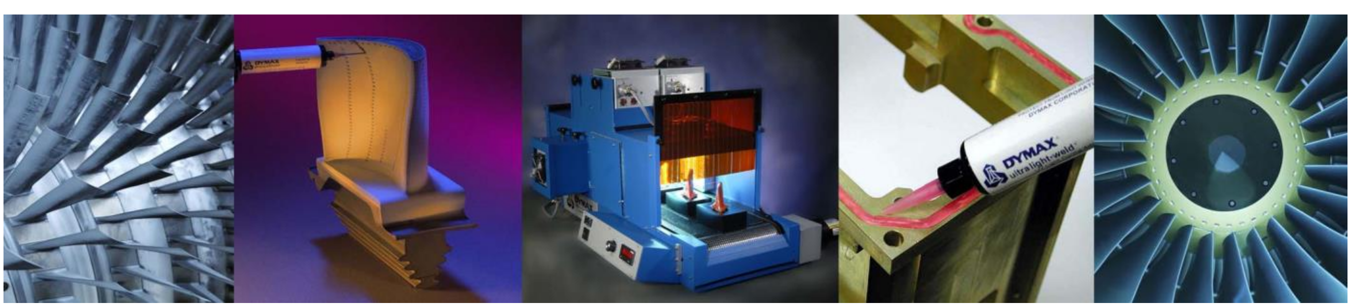


Introduction

If you're masking with conventional methods, you know the challenges associated with complex design configurations and the need for reliable protection from aggressive chemical processes, high temperature coatings, or other surface treatment processes. Even minute gaps or voids in coverage can result in edge-lift and leakage that can significantly compromise protection and adversely impact your bottom line.

Manufacturers, faced with the most challenging economic conditions in decades, have aggressively sought means to reduce costs without sacrificing product quality. Optimizing process efficiency and minimizing material consumption are viable pathways to significant reductions in manufacturing expense. Light-curable materials (LCMs) provide significant advantages over conventional masking methods such as lacquers, waxes, and tapes and costly customized boots, plugs, or caps, by offering several avenues to increase productivity, ensure reliable protection, and reduce waste.

Temporary UV-curable maskants provide reliable surface protection under harsh conditions and are an ideal choice for many surface treatment and machining operations. These resins cure in seconds upon exposure to UV light and provide superior protection during machining, grit blasting, shot peening, acid etching, and plating. They also offer surface protection during handling or transportation and from thermal spray coatings. UV-curable maskants are a better solution to the challenge of controlling scrap and rework caused by unreliable masking. These solvent-free masking resins simplify component-masking processes prior to surface preparation and finishing operations. Their ease of application, speed of cure, and consistent reliability surpass those of traditional masking products and provide substantial process savings. These UV masking resins are available in several viscosities and can be applied by spraying, dipping, or brushing. Methods of resin removal include incineration, peeling, or dissolving in water.

What is masking and why it is necessary?

A mask acts as a self-sacrificing barrier for surface protection and is an essential element of most surface finishing and enhancement processes. The mask protects parts during a partial surface treatment that is either abrasive or is simply not appropriate for surfaces that are not to be treated. The concept of protecting a surface with a mask may appear simple enough, but after thorough review and analysis, it becomes apparent that masking can add significant costs to any operation. UV-curable masking resins simplify component-masking processes prior to surface preparation and finishing operations.

How do UV-curable maskants work?

LCMs are typically comprised of five basic elements: the photoinitiator, additive, modifier, monomer, and oligomer (Figure 1, page 3). The ultraviolet (UV) light-curing process begins when the photoinitiator in the LCM is exposed to a light-energy source of the proper spectral output. As illustrated in Figure 2 on page 3, the molecules of the LCM split into free radicals (initiation), which then commence to form polymer chains with the monomers, oligomers, and other ingredients (propagation), until all of the ingredients have formed a solid polymer (termination). Upon sufficient exposure to light, the liquid LCM is polymerized, or cured.

Figure 1

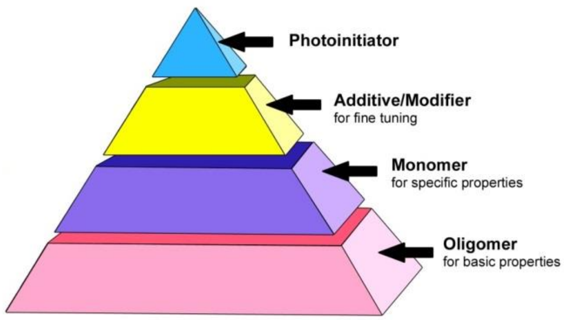
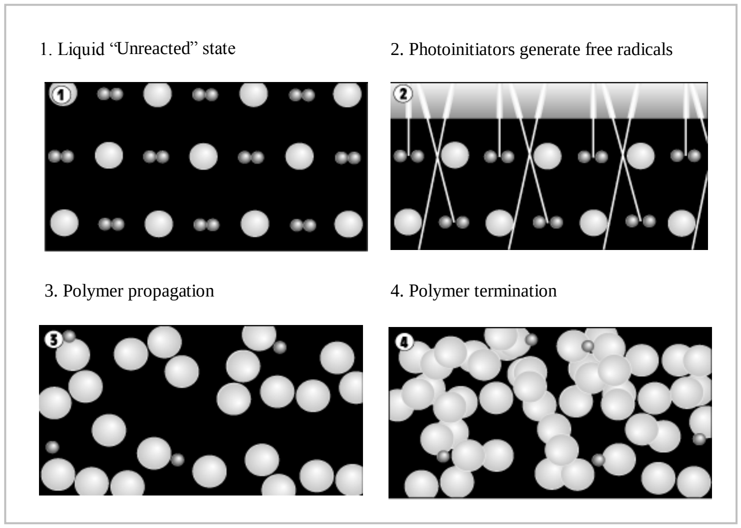


Figure 2



UV Curing Systems

The ultraviolet-light energy source is critical to the UV-mask curing process. UV-curing lamps and systems of various configurations and styles are commercially available. Spectral output of the lamp, intensity, component configuration, desired production throughput, and budget are all factors that help determine which type of light curing system is appropriate.

Once a curing process for a masked component is established, re-qualifying it is not possible. This ensures complete cure of the UV masking resin each and every time, which is essential for achieving reliable and repeatable protection of the masked surface. The best source for assistance in selecting a curing system and qualifying a curing process is the manufacturer of the UV masking resin. Their expertise with both UV masking resins and curing systems can help implement a complete optimized system that supports the masking process with minimal time and expense.

UV-Curable Masking Resins

There are three basic grades of UV masking resins which are grouped by their removal mechanism: burn-off, peelable, and water-soluble. For aerospace engine components, orthopaedic implant, or other metal, plastic, or glass surface protection masking needs, these UV masking resins are viable options for reliable and consistent surface protection.

Burn-Off Masking Resins

Burn-off masking resins typically offer superior surface adhesion while providing resistance to heat and aggressive chemical solutions such as acid/alkali baths. The burn-off-grade resins are typically used to mask hot-section aerospace components prior to surface treatment operations. For masking areas where UV light cannot penetrate, some burn-off grades also offer a secondary heat-curing capability. The removal process for a burn-off-grade mask requires baking the components in an air-enriched furnace between 540°C and 760°C (1000^{o}F and 1400^{o}F). The composition of the mask allows it to completely combust and be exhausted from the furnace without the metallurgy of the heat-treated component being affected.

Peelable Masking Resins

Peelable masking resins, the most versatile of the three, provide reliable protection through good adhesion to a variety of clean metal, glass, and plastic surfaces. The peelable-grade resins are resilient enough to withstand a variety of surface treatment processes used in the manufacturing of orthopaedic implants and other metal finishing operations. A simple peeling process removes the maskants. Curing after a few seconds of exposure to the light source, peelable maskants have been successfully qualified for surface protection in processes such as grit blasting, shot peening, acid cleaning, plating, anodized coating, and thermal coating.

The adhesion between the mask and substrate is strong and durable, possessing sufficient strength to survive through multiple surface cleaning and processing operations, while eliminating the need to strip and re-mask between processes. Peelable UV masking resins offer uniform adhesion from edge to edge, preventing processing media from creeping underneath. Remove these maskants by prying up an edge manually or with the help of a non-abrasive tool, then pull. The elasticity and flexibility of the material typically permits fast removal in one piece rather than in fractured segments. The peeling process is made even easier by warming the cured mask to 60-85°C (120-150^{o}F) in a warm water bath or oven, or using a localized heating element. The surface is residue free after the mask is removed. The peeled material, essentially a plastic resin, is non-hazardous and may be disposed of in accordance with local regulations for industrial scrap plastic.

Water-Soluble Masking Resins

Water-soluble masking resins provide excellent protection against the harsh media and aggressive blasts from "dry" finishing processes such as grit blasting, grinding, shot peening, and some plasma spraying. The water-soluble resins can be applied using the same methods as the peelable grades. However, the truly significant difference of the water-soluble grades is their removal mechanism. Unlike the burn-off and peelable grades, which are urethane-based, the water-soluble masks are formulated with water-soluble polymers. As their name suggests, the water-soluble grades dissolve in liquid. The ideal removal method utilizes heated water 60-85°C (140-180^{o}F) and a spray wash or agitated/ultrasonic bath. The agitation of the heated water speeds up the removal process. The mask completely dissolves in the water leaving no residue on the component surface.

Advantages of Light-Curable Masking Resins

Light-curable masking resins can enable numerous process improvements in the areas of throughput, quality, durability, labor costs, and improved work safety as shown in Table 1 below.

Table 1

LCM Process Improvement	Achieved by:
Enhancing Productivity	▪ Fast curing and the ability to automate
Enhancing Quality	▪ Toughness, durability, and reliability of the UV-curable maskant ▪ Immediate in-line inspection ▪ Formulations matched to specific performance needs
Customized Maskant	▪ Masking resins conform to the most intricate designs ▪ Accommodate design changes immediately
Customized Curing	▪ "Instant cure" property, but only "on-demand" when exposed to light
Profitability	▪ Lower per-unit labor content ▪ Smaller footprint of light-cured process ▪ Compatible with J.I.T. and production flexibility requirements ▪ Improved quality that reduces opportunity for returns for defects ▪ One-part formulations that reduce waste and disposal costs
Worker Safety & Regulatory Compliance	▪ 100% reactive formulations ▪ Absence of solvents, volatiles, Materials of Concern

Savings

The costs associated with masking may not be clearly visible at first, as the masking material is traditionally low in cost and not the major contributing element to the overall cost of the task. Rather, it is the actual masking process itself, more specifically, the labor to apply and remove the maskant from the component, which can be the most significant cost factor. The more complex and intricate a component is, the longer it takes to apply and remove traditional masks such as tapes, waxes, and solvent-based lacquers. In addition to the application of the mask, there are other hidden costs associated with using these masks. These costs can include scrap, component rework, production bottlenecks, specialized ventilation, hazardous waste disposal costs, and higher insurance premiums. Factoring in the cost of labor with the other hidden costs, it becomes evident that simply using a lower-priced masking material will not provide the sought-after cost savings which are essential to maintain a competitive position in the market.

A detailed cost analysis comparing an existing masking process for surface protection on an aerospace engine component with a proposed UV masking process, can bring actual cost savings into clear focus. Table 2 on page 6 compares two masking methods: tape versus UV-curable masking resin for a grit blast application followed by a plasma spray application.

Table 2

TAPE			UV PEELABLE MASK		
	Cost Per Unit	Cycle Time Per 20 Pc.		Cost Per Unit	Cycle Time Per 20 Pc.
One half roll tape @ $30/roll	$15.00	---	UV Mask (.33 lb @ $100/lb)	$33.00	---
Apply tape - ½ hour per piece	$30.00	600 min.	Apply Mask	$2.00	40 min.
Remove tape	$10.00	10 min.	Peel Mask	$10.00	10 min.
Wash and Dry (Tape Residue)	$1.00	35 min.	---	--	---
Rework: 0.5%	$12.50	60 min.	Rework: 0.0%	$0.00	---
SUBTOTAL	**$68.50**	**705 min.**	**SUBTOTAL**	**$45.00**	**50 min.**
Scrap: 0.1%	$2.50	---	Scrap: 0.0%	$0.00	---
TOTAL	**$71.00**	**705 min.**	**TOTAL**	**$45.00**	**50 min.**
Equipment	**---**		Equipment: UV Lamp Hand Sprayer	 **$9,500.00** **$3,500.00**	
Component value after processing: $1,500.00 US *Production output: 2,000 pc per month* *Labor rate: $60.00 US per hour*					

The UV method utilizes a high-viscosity UV masking resin, permitting the operator to spray the liquid UV-curable resin on the external surfaces. After all surfaces are masked, the components are placed on a UV-curing conveyor. Throughput for the grit blast and plasma spray operations averages 500 units per week. Processed components are valued at $1,200 each. The use of the UV-curable masking resins reduces or eliminates many cost elements from the tape masking process. Because of the controlled viscosity, less material is used. Scrap is reduced from 0.1% to zero.

Whether a component is a turbine component or an orthopaedic implant its value ranges from several hundred to many thousands of dollars, making the reduction in scrap alone a significant factor. These reductions transform into a process cost savings of $26.00 per unit - over a 30% reduction. The time saved resulting from this switch is over 30 minutes per piece. This change in masking method permits faster turnaround for overhaul programs and higher throughput for new component manufacturing. From the magnitude of these cost savings, the added capital investment for the UV-curing system and dispensing is easily recoverable in a very short period. Typically, the capital investment recovery is in less than one year.

Conclusions

In today's environment, process cost reduction has taken on greater meaning. Competitive pressures in the market are forcing manufacturers to evaluate every aspect of their processes for cost reduction opportunities. Now, there is a better solution to an old issue of scrap and rework caused by unreliable masking.

Alternative masking methods such as UV-curable temporary masking resins simplify component-masking processes prior to surface preparation and finishing operations. This new alternative opens the door to savings never before possible. Masking labor costs can be reduced, if not cut in half, scrap can be eliminated, and overall component processing time reduced by 30% or more. In addition to cost-cutting opportunities, UV-curable masking resins improve the quality of the environment in the workplace by removing health hazards and reducing the risk of operator injury. Benefits of this nature can lead to improved employee morale, which contributes to higher productivity.

A very positive case has been made for today's UV-curable masking resin technology. Undoubtedly, manufacturers will identify more and more masking applications suitable for these masks. The one constant that will continue to drive these applications will be cost reduction and improved productivity in the workplace. UV-curable maskants are a customized solution without the price tag of a customized mask.

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