OmniCure®

UV Curing • In Control

UV Curing of Fiber Optic Coating

The Challenge

Reduce operational costs and increase productivity of fiber optic drawing towers, while maintaining high product quality and rapid throughput.

The Solution

The OmniCure® AC9225-F UV LED curing system with custom lens and optimized LED light engine to deliver extremely focused high-irradiance UV light for fast curing of fiber optic coating materials.

The Benefit

Increased profitability through significant reduction of electrical consumption, increased productivity, elimination of costly safety and environmental issues and reduced consumable parts count.

Application Note | Rev: C, Part Number: 072020

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Application Overview

Modern fiber optics has undergone remarkable advances since their development in the 1960s. The increasing demand for fiber optic cable, especially in the telecommunications industry, has led to high volume production of optical fiber.

The fiber optics market is expected to grow at a CAGR of 10% between 2019 and 2024 to reach a value of $6.9 billion. The demand is increasing and driven by investments in new information technology and telecommunication sectors, upcoming developments and projects in the U.S., China, India, Brazil, and Western and Eastern European countries.

Glass optical fiber is pulled on a multi-story drawing tower where, at the top, a preform is heated and drawn to a thin strand (see figure 1). To protect the fiber, two layers of coating material such as acrylate polymer or polyimide are applied in concentric layers and rapidly cured with high-intensity UV light.

In some scenarios, both coating layers are applied sequentially and then UV cured in a 'wet-on-wet' process. Alternatively, a wet-on-dry' process applies the primary layer of coating which undergoes UV curing before applying the secondary layer, followed by additional UV curing steps.

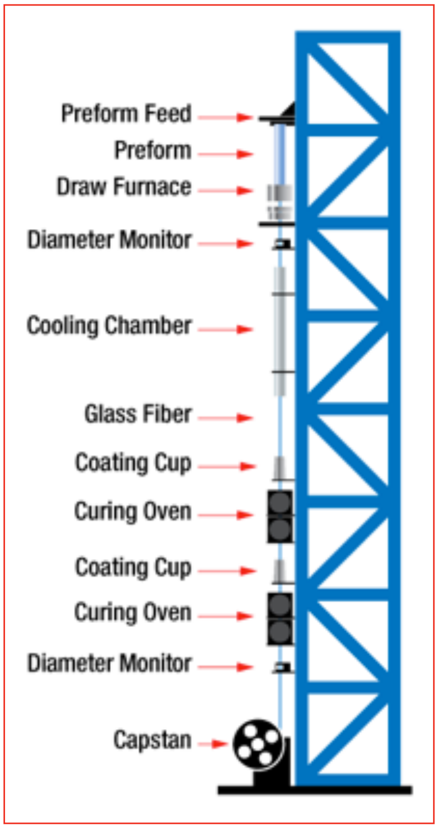


FIGURE 1: Schematic of a fiber optic drawing tower.

In current fiber-optic manufacturing processes, high-intensity UV arc lamp or microwave excited UV lamp systems are used to cure the fiber coatings. These systems produce UV light by passing electric arcs or microwaves through a glass tube containing high-pressure mercury vapor. A very wide spectral output from below 200 nm to above 800 nm is produced in these lamps. However, only the UV energy from 250 nm to 400 nm is effective for curing. As such, lamp systems produce a large amount of extraneous wavelengths, including IR light, which do not contribute to curing. These lamps suffer from a number of disadvantages, including:

- Low efficiency. UV lamps are inherently inefficient in producing UV light, which results in higher electrical operating costs.
- Ballast replacement. The ballast in the power supply of UV microwave systems must be frequently replaced. This results in manufacturing downtime and additional cost in terms of parts and technical support.
- Reflector cleaning and replacement. High maintenance and operating costs include periodic cleaning of a reflector used to achieve a uniform cure around the cylindrical fiber. The surface of these reflectors are exposed to intense UV light and fiber coating material, and must be replaced after several hundred operating hours. This reflector is not required with UV LED systems.
- Limited lifetime. The UV arc lamps require replacement every 2,000-5,000 operating hours, while UV microwave excited lamps require replacement every 6,000 to 8,000 operating hours, which again results in additional costs and process downtime.
- Ozone production. Radiation of wavelengths, less than 200 nm, generates ozone from oxygen in the air. UV arc lamp systems which generate light below 200 nm produce ozone, which must be filtered and vented to the outside with an exhaust system. Production facilities, which must conform to EN14001 requirements, include costly stacks and scrubbers.

UV LED Curing Systems for Increased Curing Efficiency

UV LED curing systems are widely deployed in the electronics, optics, and medical device industries, where they are valued for high efficiency, long lifetime, and low cost of operation compared to UV arc lamp systems. UV LED systems generate light at specific wavelengths, for example, 365 nm or 395 nm, which can be matched to the requirements of the coatings. OmniCure AC Series UV LED systems provide the further advantage of customized front-end optics which are able to maximize the irradiance at the cure site for a specified working distance. The customized lenses produce a highly focused beam (line) of light from the LED to optimize the efficiency of the curing by maximizing the UV energy onto the very thin strand of fiber. The OmniCure AC8225-F+ and AC9225-F further enhance the output beam over previous OmniCure systems by utilizing a technologically advanced custom LED light engine design.

UV LED systems, such as the OmniCure AC9225-F, (see figure 2) can provide an alternative or a complement to current UV arc lamp-based curing systems in fiber optic manufacturing processes. These systems can be used in a number of configurations depending on the manufacturing process and coating material. One cost-effective configuration involves replacing each UV lamp-based system and reflector mirror with one or more sets of OmniCure AC9225-F systems, with focusing lenses facing each other to achieve a uniform UV intensity at the fiber (see Figure 3).

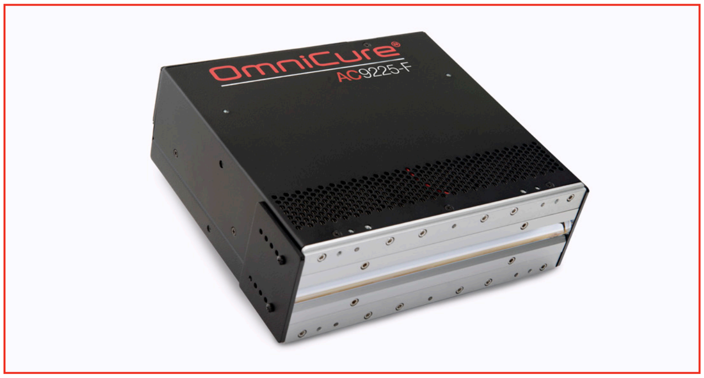


FIGURE 2: OmniCure AC9225-F with custom focusing lens for fiber curing applications.

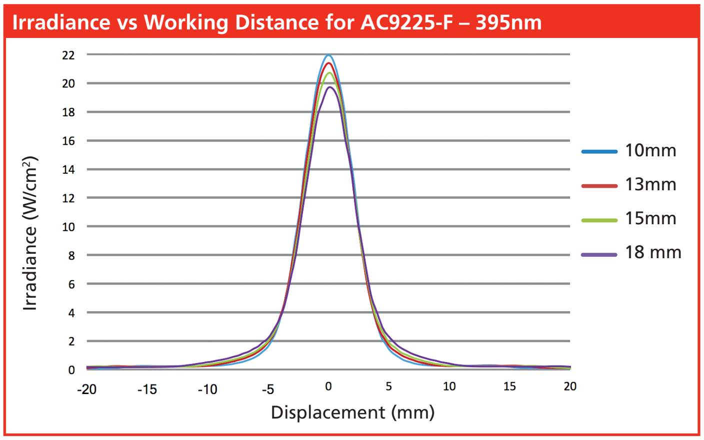
Lamp-based UV systems often use a mirror to reflect UV light back onto the cure site to achieve a more uniform cure. Because of their lower power draw and ease of installation, two UV LED systems can replace a single lamp-based system, and light from each system can be directed from opposite sides to cover the entire fiber diameter. Many other curing configurations are possible by matching coating materials to the wavelengths of UV LED.

Testing with new LED optimized coatings has demonstrated speeds of greater than 3500m/min in a wet-on-dry application using only four AC9225-F 395nm systems configured in a stacked pair of lenses facing systems.

For a "wet-on-wet process", optical shadowing of the primary coating by the secondary coating may lead to slower draw speed or the requirement for an increased number of UV LED systems. Further testing with different and improved formulations of primary coatings may be able to eliminate the problem of shadowing and allow faster throughput.

FIGURE 3: A set of OmniCure AC9225-F UV LED curing systems in a face-to-face configuration.

OmniCure AC9225-F 395nm systems feature a class-leading optical output of >20W/cm² at working distances from 10 mm to 18 mm, as seen by the optical distribution graph below.



Typically, an LED curing system is very sensitive to the working distance, where the irradiance level will change significantly with small changes to the working distance. The custom optics of the OmniCure AC9225-F system maintain the irradiance almost unchanged from 10 to 18 mm, the typical working distances for the fiber coating application.

High output, air-cooled UV LED systems such as the OmniCure AC9225-F are straight forward to incorporate into a curing station in a fiber drawing tower (see Figure 3). When used in a lens-to-lens configuration, no external mirror is required, which saves additional costs and downtime compared to lamp-based systems. UV LED systems use efficient and reliable constant-current drivers which require no ballast replacement, thus, reducing downtime compared to lamp-based systems. LED systems require no external venting to remove ozone, so operating costs are reduced and compliance with environmental standards such as EN 14001 is simplified.

The OmniCure AC9225-F UV LED system has overall efficiencies that allow a reduction in electricity operating costs of up to 60% depending on the application. The LED heads are also intrinsically long-lived and with innovative thermal designs have typical operational lifetimes of greater than 40,000 hours compared to 6,000 to 8,000 hours for UV microwave lamps and 2,000 to 5,000 hours for UV arc lamps. Cost savings from the reduced electrical consumption alone can be enough to very quickly pay back the investment on the installation of the LED systems. Visit https://www.excelitas.com/product/omnicure-ac8225-f-and-ac9225-f-led-fiber-uv-curing-system#cost-savings-calculator to calculate your costs savings when using an OmniCure UV LED system.

Benefits of UV LED Curing Systems

The OmniCure UV LED curing system offers many benefits for fiber optic manufacturing including:

- Reduced costs. The efficiency of the OmniCure AC9225-F UV LED system results in reduced electricity costs of up to 60% depending on the application.
- Increased productivity. UV LED systems do not require ballast replacement and have operational lifetimes of more than 5X that of lamp-based systems, resulting in increased manufacturing uptime.
- Reduced equipment replacement costs. Long LED lifetime, no ballast, and elimination of external reflectors reduce equipment replacement costs.
- Simplified environmental qualification. The OmniCure AC9225-F UV LED curing system does not generate any light below 200 nm, therefore produces no ozone, so filtering and venting is not required. This simplifies qualification for the stringent environmental standards and reduces the cost of installation.
- Ease of installation. The OmniCure AC9225-F UV LED system can easily be installed in existing curing stations and operated with existing manufacturing processes.
- No compromise inline speed. The OmniCure AC9225-F is specifically designed with a custom lens and LED light engine to provide the maximum irradiance for fiber curing, as well as allow you to realize all of the benefits of LED technology while maintaining the production speeds of a lamp system.

References

1. Article: Fiber Optics Market by Cable Type (Single-mode, Multi-mode), Optical Fiber Type (Glass, Plastics), Application (Telecom, Premises, Utility, CATV, Military, Industrial, Sensors, Fiber Optic Lighting, Security, Metropolitan), Region - Global Forecast to 2024 from www.marketsandmarkets.com/Market-Reports/fiber-optics-market-238443438.html

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