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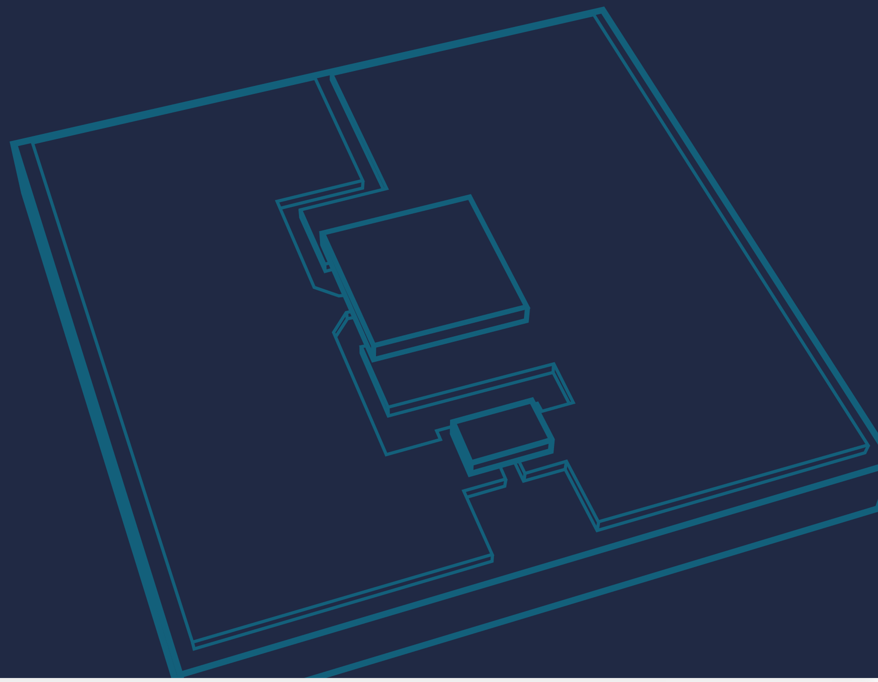
AN011



Using UV Reflective Materials to Maximize Disinfection

The increased performance of UVC LEDs allows for more design flexibility in disinfection applications. Design engineers can leverage highly UV reflective materials to maximize the efficiency of these reactors to meet design challenges or decrease the amount of UV intensity required throughout the system. This application note outlines how using reactor materials that offer higher reflectance of the UVC wavelengths can optimize the UV intensity and uniformity in the system.

Introduction

Ultraviolet (UV) disinfection relies on radiation emitted in the wavelength range of 250 nm – 280 nm (UVC) to inactivate pathogens. The amount of UVC radiation applied to a given volume over a specific time period needed for disinfection in a particular system is commonly referred to as the required UV Dose. UV Dose is comprised of two factors—the irradiance of the UVC light and the length of exposure to radiation. For more information about calculating UV Dose, see Crystal IS application note AN002.

Optimal UV reactor design ensures UVC light is delivered in the most efficient manner by maximizing overall UV dosage for all parts of the fluid entering the reactor (e.g., all of the fluid needs to be uniformly exposed) for disinfection. To achieve this, system designers consider reactor size and shape, flow rate and the UV power of the system.

In systems where there is less flexibility around flow rate, residence time becomes a crucial factor for system designers who must optimize the effectiveness of the UV light. Doing so ensures target microbes are exposed to enough UV light for complete DNA inactivation. This can be accomplished in one of two ways: by increasing the light output of the system or by improving the UV reflectance of the construction materials used inside the flow cell. This application note focuses on the latter method.

Improving UV Reflectance in the Reactor

System designers can optimize the field of uniformity by using materials with highly reflective properties for UVC light in reactors where the light source footprint is at a premium or there is a need to increase efficiency. This maximizes internal reflection to take full advantage of the UV energy or photons emitted from the light source. Table 1 shows the UV reflectivity of standard materials used in disinfection reactors.

Table 1

Material	Reflectivity
e-PTFE	95%
Aluminum-sputtered on glass	80%
Aluminum foil	73%
Stainless steel (various formulas)	20 – 28%

A common material used in commercial UV disinfection systems is stainless steel. While this surface is highly resistive to microbial growth, it only has 20 - 28% reflectance of UV light. Flow cells that contain e-PTFE (expanded Polytetrafluorethylene) provide more than 95% reflectance (as shown in the table above) of the UVC light—making systems constructed of these materials more than three times effective than traditional reactors. The following examples show how using highly reflective materials benefit applications in water and air disinfection.

Example 1: Water Disinfection Reactor

UV reactors are a mainstay for water treatment facilities and residential appliances designed to disinfect water flowing through a system for safe public consumption.

To illustrate the impact of material reflectivity, Crystal IS examined a reactor design shown in Figure 1 with a total power of 200 mW. Simulations were done with two different materials lining the reactor—the first composed of stainless steel (Reactor Model 1) while used e-PTFE (Reactor Model 2).

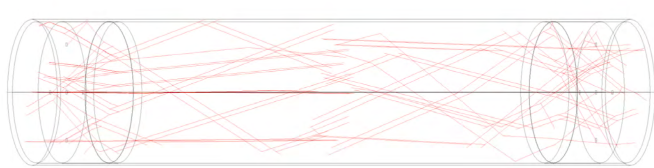


FIGURE 1: Optical model for light flow in UV reactor measuring 15 cm in length and 3.1 cm in diameter.

The light distribution was modeled for different distances from the end caps throughout the reactor to study the impact of internal reflection. At the center of the reactor 7.5 cm from the end caps, the average irradiance in Reactor Model 1 was 4.5 mW/cm2 whereas in Reactor Model 2 the average was 17 mW/cm2.
The radiation patterns at the mid-point of each model can be seen in Figure 2.

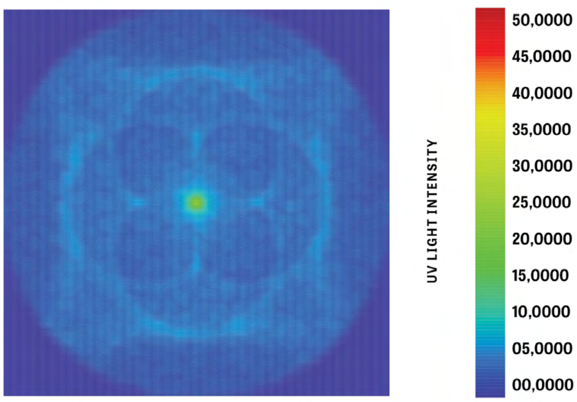


FIGURE 2A: Stainless steel radiation pattern 7.5 cm from end cap.

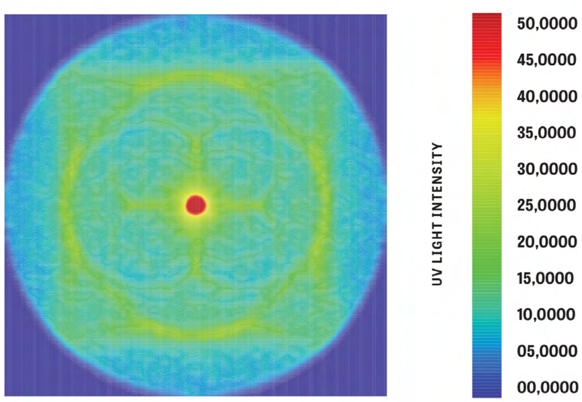


FIGURE 2B: e-PTFE radiation pattern at 7.5 cm from end cap

Table 1 indicates that the reflectivity of e-PTFE is higher than that of stainless steel. The radiation patterns show a higher level of irradiance in the second Reactor Model (Figure 2b), thus the higher the UVC reflectance of the materials used in the reactor, the more efficient the use of UVC light in the system. This allows design engineers to achieve their target dosage requirements with less optical power.

Example 2: Air Disinfection Reactor

HVAC systems rely on UV disinfection to inhibit mold growth and reduce energy consumption. Filtration coupled with UV light is commonly integrated into ducts for complete disinfection.
These ducts come in various sizes—the models in this example are based on a duct that is 380 cm wide by 250 cm long. The 35 LEDs in the system were arranged in a grid pattern to ensure the entire duct was covered with UVC light.

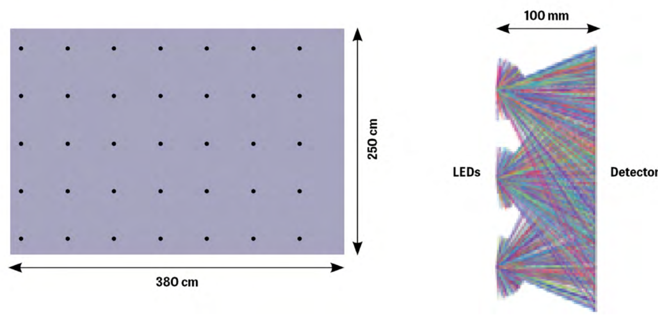


FIGURE 3: Arrangement of UVC LEDs in the duct.

The irradiance was modeled within the duct based on two different materials: Duct Model 1 comprised of a surface having no reflective properties and Duct Model 2 is lined with Alzak Sheet aluminum which has more than 80% reflectance. The increase in reflectance between Duct Model 1 and Duct Model 2 increased the peak irradiance from 0.2 mW/cm2 to ~0.3 mW/cm2. In addition, the UV dispersion was more uniform within Duct Model 2, as can be seen in Figure 4a and 4b.

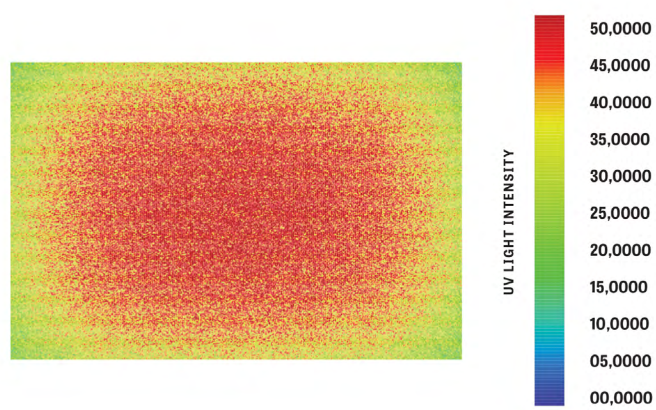


FIGURE 4A: Irradiance model of Duct 1 without UV reflective surfaces.

FIGURE 4B: Irradiance model of Duct 2 lined with 80% UV reflective materials on all four sides.

As the performance of UVC LEDs increases, design engineers can leverage the benefits of smaller footprints and instant-on capability into disinfection applications that, until now, were heavily dominated by mercury lamp configurations. Designers can maximize the disinfection capability of UVC light by using highly reflective materials on the interior surfaces of reactors for various applications in water, air and surface disinfection.

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