WHITE PAPER

Using far-UVC 222nm light to significantly reduce pathogens like SARS-CoV-2 (COVID-19) in indoor spaces

The disinfection technology we need right now

We need technology that effectively reduces harmful pathogens and helps people feel safe in indoor spaces--from cinemas, theme parks and attractions, museums, and giant screens to houses of worship, corporate and government applications. We need ongoing solutions to defend ourselves from pathogens to reduce their incredible impact on our families, businesses, schools, and communities.

An added layer of defense

We need commercial UV disinfection that automatically and continually add a layer of defense as part of a multi-disinfection strategy like regular cleaning.

Let's start with the science.

Not all UV light is created equal

Using UV light for disinfection is well-established. UVC light is a type of UV light that inactivates airborne and surface pathogens like viruses and bacteria by damaging their RNA and DNA, neutralizing them.

Conventional germicidal lamps emit UVC light with longer wavelengths (>230nm) that also effectively reduce airborne and surface pathogens but presents a human health hazard to unprotected eyes and skin.

What's new is the discovery and application of far-UVC 222nm light, a sweet spot on the UV spectrum, to effectively inactivate pathogens with people present. It's technology that's safer for use in occupied spaces that allows for automated, continual pathogen-reduction.

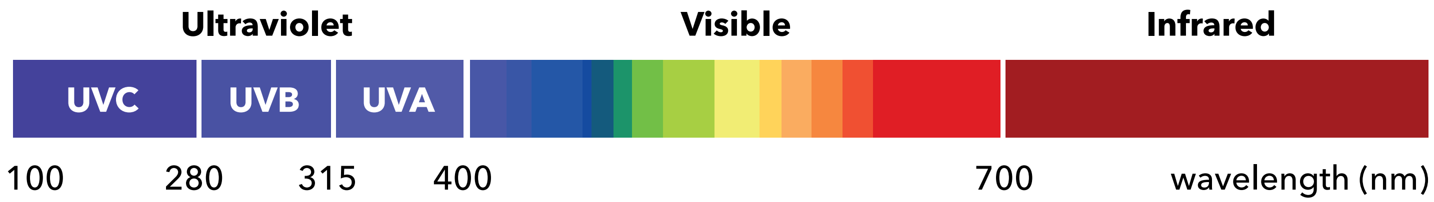
Let's start with a quick look at UV light.

UVA, UVB, and UVC: What's the difference?

UV light is made up of 3 bands: UVA, UVB and UVC. Around 95% of the sun's rays that reach the ground are UVA rays. They have the longest wavelengths (315nm-400nm) and can damage our skin, causing premature aging such as wrinkles and are thought to play a role in some skin cancers. UVB rays (280nm-315nm) make up around 5% of the sun's rays, and while they don't penetrate our skin as deeply as UVA, they can cause significant damage to our skin, including redness, sunburn, and skin cancer. We use sunscreen and wear sunglasses to protect our eyes and skin from both UVA and UVB rays.

Most UVC rays (100nm-280nm) don't reach the earth's surface because they're absorbed by the ozone layer. UVC has the shortest wavelengths that, at ranges below 230nm, aren't able to deeply penetrate the protective outer layers of our skin and eyes.

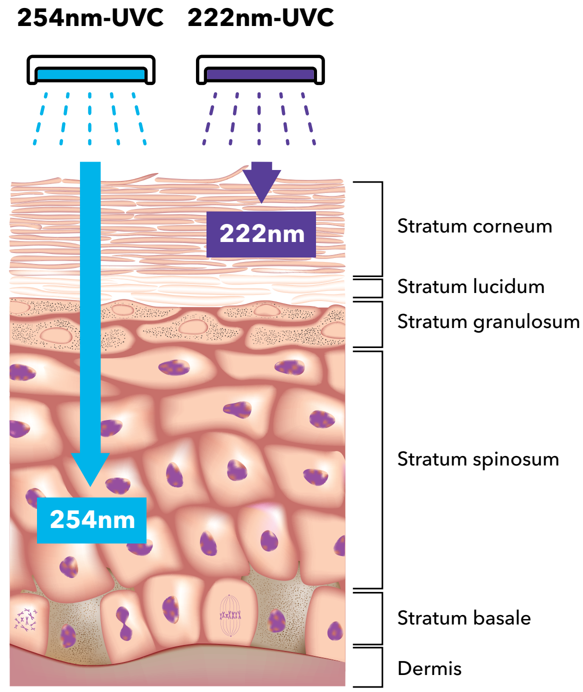
The spectrum of visible and invisible light



This graphic illustrates the 3 types of ultraviolet light the sun produces: UVA, UVB, and UVC.

Structure of the epidermis

This graphic illustrates a significant difference between 254nm and 222nm light: the shorter wavelengths of far-UVC 222nm light can't deeply penetrate the outer layer of our skin. This layer, the stratum corneum, consists of dead skin cells and serves as the primary barrier between our bodies and the environment. Conversely, longer wavelengths like 254nm are able to deeply penetrate the layers of our skin, and can damage the DNA in our skin cells, causing burns and skin cancers.



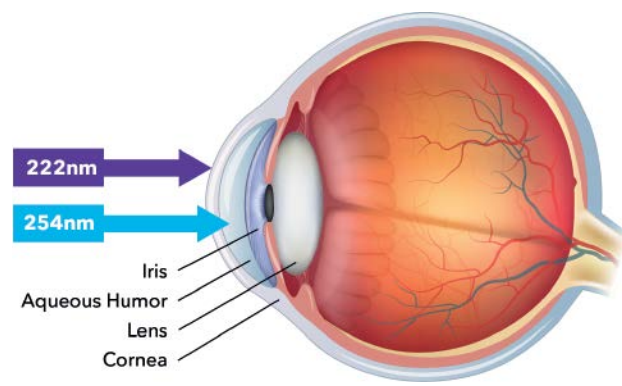
Penetration of epidermis of 254nm vs 222nm.

Shorter UVC wavelengths yield effective results

Instrumental in spearheading the use of far-UVC light to fight the spread of viruses and combat antibiotic-resistant bacteria: Dr. David J. Brenner, Ph.D., D.Sc., a theoretical physicist and Higgins Professor of Radiation Biophysics, College of Physicians & Surgeons, Columbia University. His mission is to find mathematical and physics-related solutions to biological problems. In his pivotal April 2017 TED Talk, Dr. Brenner shares his research on how far-UVC could potentially kill superbugs and be used around people.

Anatomy of the eye

This graphic clearly illustrates how 254nm (and longer) wavelengths are able to damage our eyes—including incurable diseases like macular degeneration—because wavelengths of 230nm and above can penetrate our eyes. Shorter wavelength 222nm light has a limited range that prevents it from penetrating past our corneas, the outermost layer of our eyes.



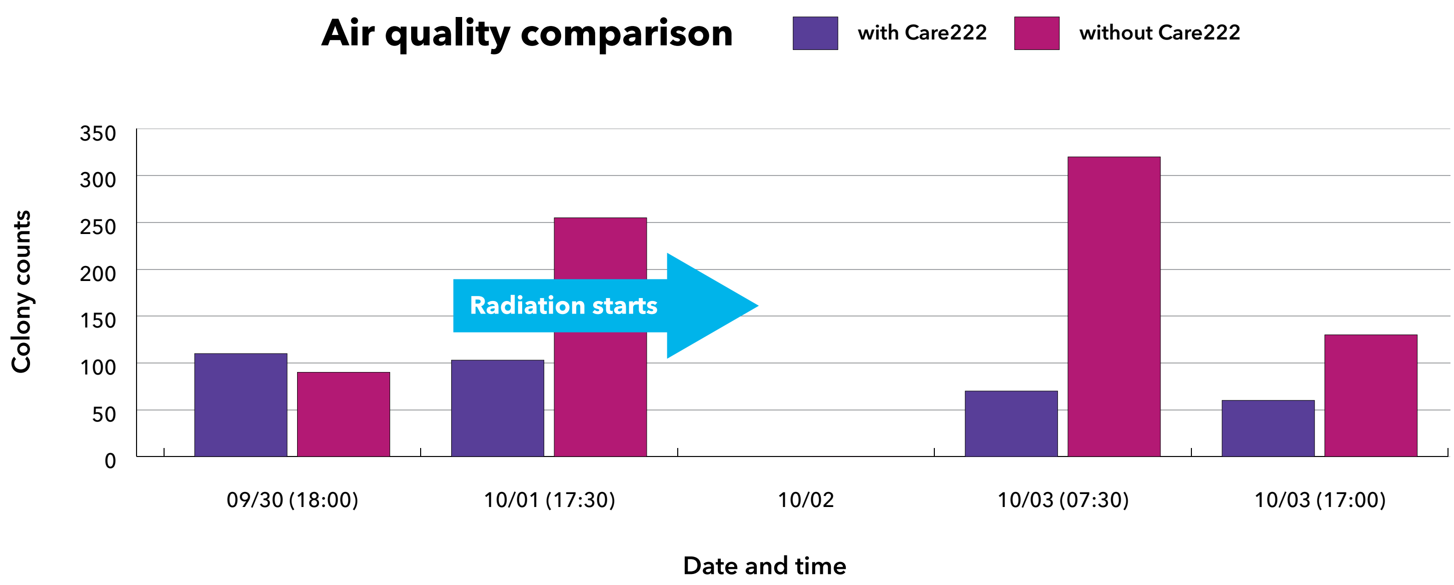
DNA absorbance relative to wavelength.

The physics of far-UVC 222nm light: Studies, safety, and efficacy

Dr. David J. Brenner, Ph.D., D.Sc.
Theoretical physicist
Higgins Professor of Radiation Biophysics
College of Physicians & Surgeons
Columbia University

COVID-19 Virtual Symposium: April 8, 2020
(Video length – 11:23)

Watch the video »



^ This graph compares the number of bacteria found in air sample collections in the treated and untreated bathroom stalls at regular intervals during the test, showing the efficacy of the far-UVC 222nm light that Care222 lamps emit in combating airborne pathogens.

Ushio's studies on far-UVC 222nm light using Care222 lamps

Inspired by Dr. Brenner's research, Ushio® Inc., a lighting manufacturer in Japan, performed 2 studies to test the effectiveness of far-UVC 222nm wavelengths using their Care222® filtered far-UVC excimer lamps. The first examines the efficacy of using 222nm light to kill bacteria in a public bathroom.

Over 3 days, researchers took surface samples from the floor, toilet seat, doorknob, and switch panel before, during, and after testing, and then analyzed the swabs for bacterial growth. Researchers also collected air samples in each stall throughout the study to test air quality and the presence of airborne contaminants.

Measuring the effectiveness of 222nm light on surfaces

The study found that after treatment, bacteria growth in the stall treated with 222nm light was noticeably lower than the untreated stall in almost all areas. Over time, bacteria levels were either further reduced or maintained at a relatively lower level in the treated room.

Testing the efficacy of 222nm light on airborne pathogens

The air quality results are also promising for pathogen reduction because airborne-transmitted diseases can be harder to control than surface-transmitted diseases.

In shared spaces, invisible contaminants, such as bacteria, viruses, pollution, and volatile organic compounds can quickly spread. Airborne particles can also lead to increased surface contamination.

Study results:

Researchers were able to use far-UVC 222nm light to reduce the number of bacteria in high-interaction spots.

What we can learn from this study:

- Far-UVC 222nm technology has the potential to reduce pathogens in the air and surfaces of indoor spaces
- Keeping the contamination levels of surrounding air and surfaces low and controlled is pivotal for maintaining the health and quality of our environment

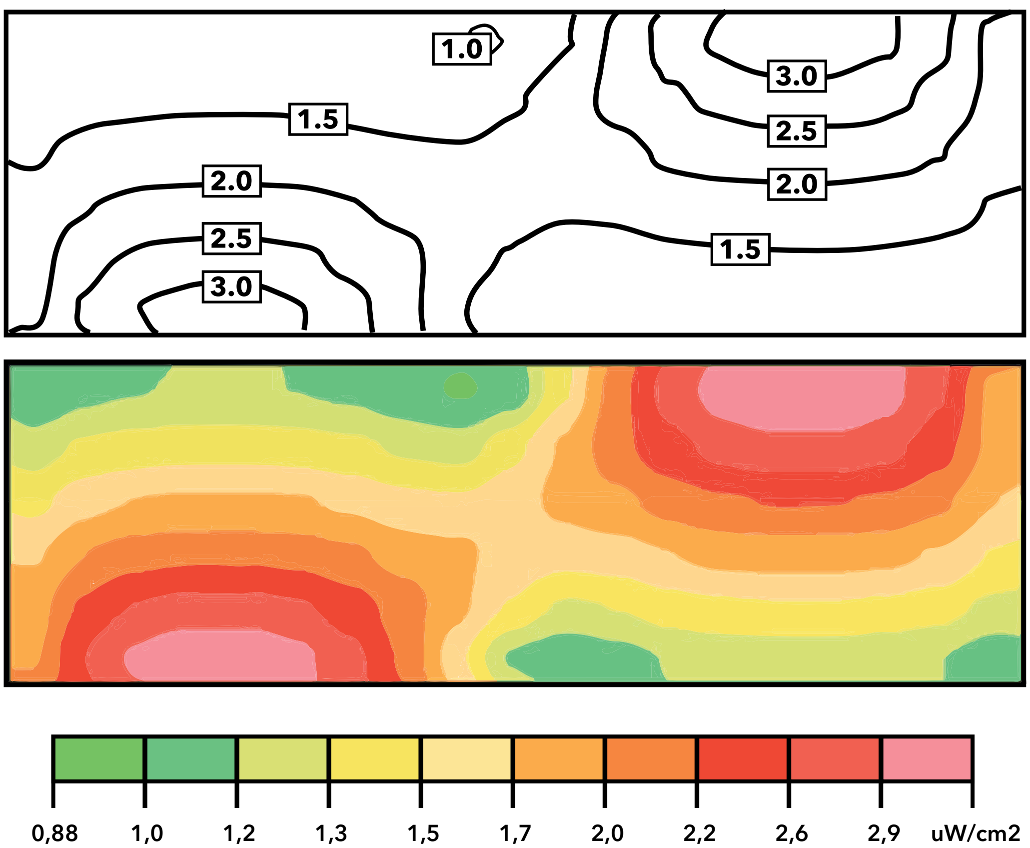
The second experiment: Workplace testing

Ushio researchers conducted a second experiment in 2 similarly sized meeting rooms, treating only the first (Room 1) with far-UVC 222nm light. They used a conference table at the center of each room as a target surface to test contamination. Researchers installed 2 x far-UVC 222nm modules positioned diagonally from one another on opposite walls of Room 1, with each module disinfecting a different side of the conference table.

Both rooms—treated and untreated—were occupied during the day by people attending meetings. Over the course of the 2-week experiment, researchers collected bacteria in the morning and evening from the conference tables at 2 different places, then cultivated them in petri dishes. The combined colony count from both samples was considered the total colony count for that room.

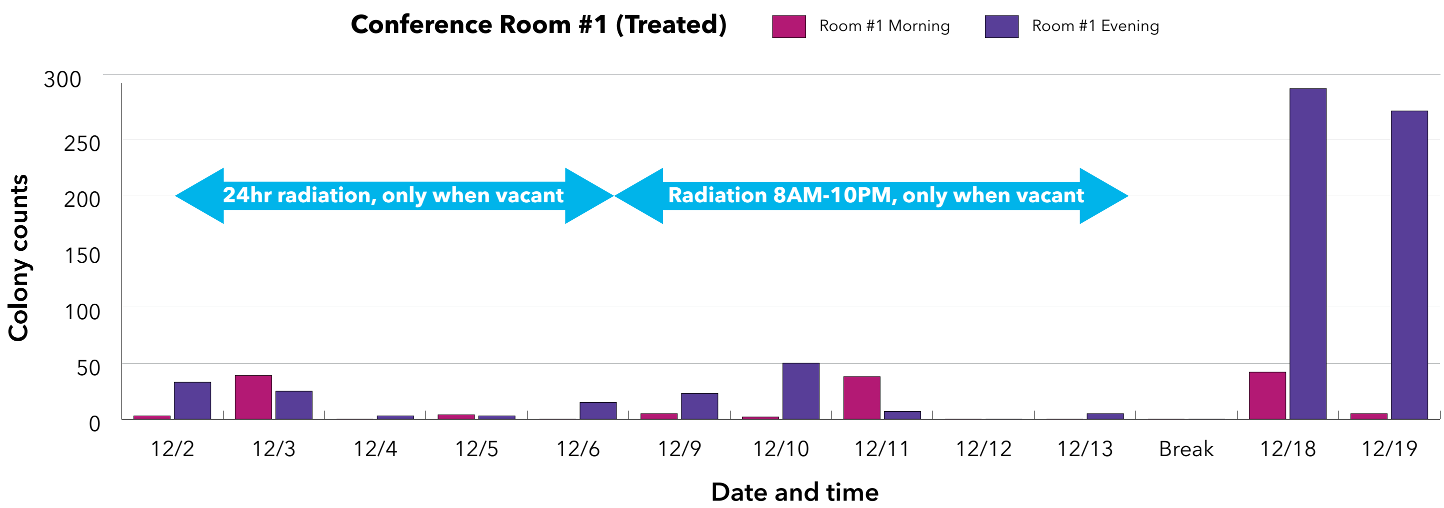
During the first week, using motion sensors they installed on the Care222 lamps, researchers continuously irradiated the room with 222nm light (including overnight) except when occupied. During the second week, they only irradiated the room during the day (not overnight) except when occupied. As a control, Room 2 received no irradiation but the room had similar levels of occupancy.

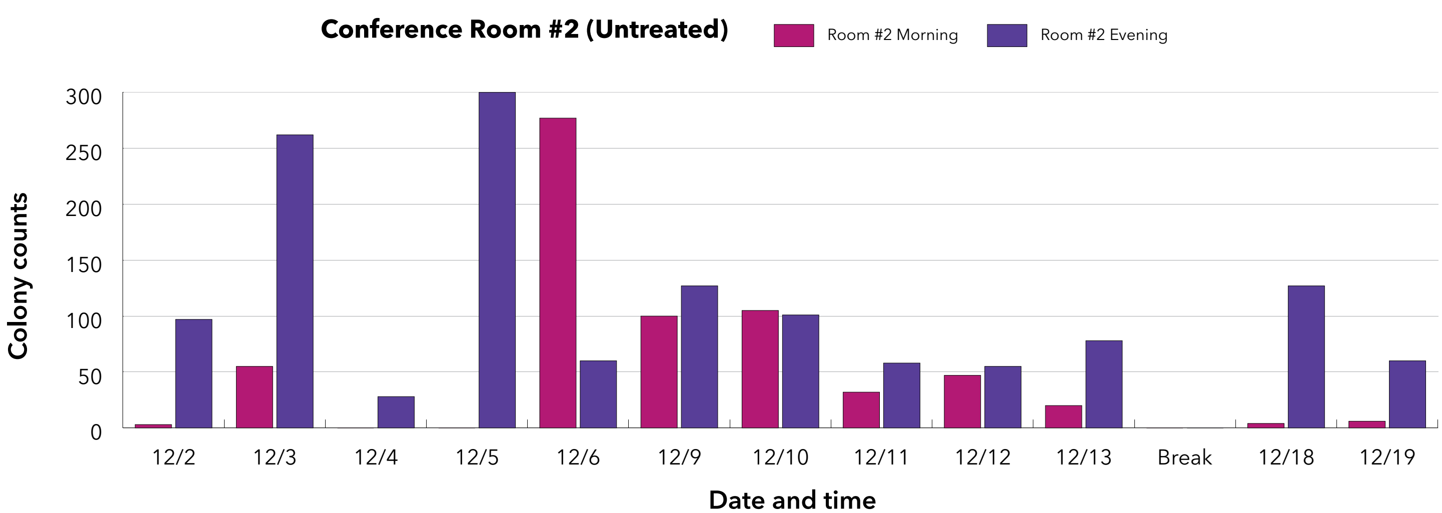
Contour and heat map from light simulation of Care222 onto conference table



In this simulation of the treated room (Room 1) you can see how light from 2 x far-UVC 222nm lamps projects onto the table. This heat map illustrates the varying intensity of light on different areas of the table, with green areas representing the least and pink experiencing the most intense irradiation.

Understanding when to irradiate to achieve the greatest impact





^ Bacteria colony counts of Room 1 and 2 throughout the experiment: The top graph shows dramatically low levels of contamination in Room 1 every day of the 2-week study while it was being irradiated with far-UVC 222nm light. Compare this to the high levels of bacteria in the untreated room (Room 2) in the bottom graph; contamination that was significantly higher than Room 1 throughout the study. Note that both Room 1 and 2 received typical manual cleaning throughout the study. Interestingly, the high bacteria counts shown on the far right of the top graph (Room 1) only happened after the study, when the room was no longer irradiated with far-UVC 222nm light.

What we can learn from this study:

1. Far-UVC 222nm light significantly reduced surface bacteria
2. Constantly or continously/intermittently irradiating indoor spaces was more effective than overnight treatments in this study
3. Regular irradiation helps keep contamination levels low and controlled
4. Using far-UVC 222nm light for disinfection is as effective as the traditional longer wavelength of 254nm light that can't be used while people are present

Is far-UVC 222nm light effective against airborne coronaviruses?

A June 2020 study conducted by researchers at Columbia University Irving Medical Center entitled Far-UVC light (222nm) efficiently and safely inactivates airborne human coronaviruses reported that 99.9% of aerosolized seasonal coronaviruses (that cause the common cold) were inactivated when exposed to far-UVC 222nm light for 25 minutes.


OPEN Far-UVC light (222 nm
and safely inactivate
human coronaviruses

This study found:

1. Even with very low exposure (1.7 and 1.2 mJ/cm^2) to far-UVC light, more than 99.9% of coronaviruses present in airborne droplets were neutralized, meaning they could no longer reproduce or cause infection
2. Continuous exposure to far-UVC 222nm light at the current regulatory limit (~3 mJ/cm^2/hour) eradicated airborne viruses in minutes:
   - 8 minutes – 90%
   - 11 minutes – 95%
   - 16 minutes – 99%
   - 25 minutes – 99.9%

Is far-UVC 222nm light safe for humans?

A study published in August 2020 conducted by Kobe University researchers called Exploratory clinical trial on the safety and bactericidal effect of 222-nm ultraviolet C irradiation in healthy humans suggests that the filtered far-UVC light emitted by Care222 modules can be used to reduce pathogens while people are present. The study concludes that far-UVC (222nm) at 500 mJ/cm^2 was a safe irradiation dose (despite being far stronger than current ACGIH threshold of 23 mJ/cm^2 per 8-hour exposure) and possessed bactericidal effects, and that in the future, far-UVC (222nm) could be expected to contribute to the prevention of perioperative infection.

The study irradiated the backs of 20 healthy volunteers with far-UVC 222nm light at 50–500 mJ/cm^2 and evaluated the induced erythema (skin redness).


PLOS ONE

Exploratory clinical trial on the safety and bactericidal effect of 222-nm ultraviolet C irradiation in healthy humans

Abstract

Introduction

Methods

This study found:

1. Far-UVC 222nm light didn't cause any erythema on study participants at even high doses (up to 500 mJ/cm^2)
2. The bacterial colonies in the skin swab cultures were significantly lowered by far-UVC 222nm irradiation

Can far-UVC 222nm light inactivate SARS-CoV-2?

A study published in September 2020 in the American Journal of Infection Control by researchers at Hiroshima University entitled Effectiveness of 222-nm ultraviolet light on disinfecting SARS-CoV-2 surface contamination found that far-UVC 222nm light effectively reduced **more than 99.7%** of surface contamination of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), the virus that causes COVID-19.


ARTICLE IN PRESS

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

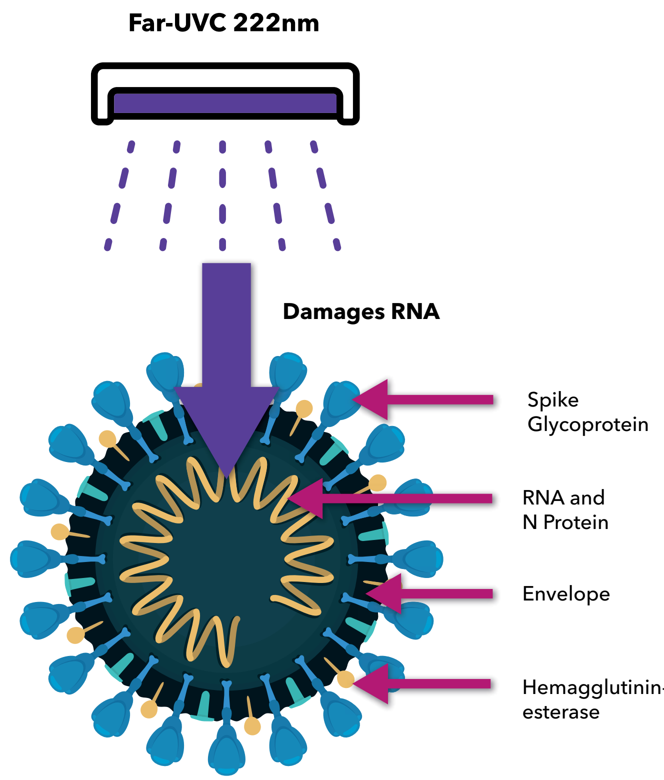
Major Article

Effectiveness of 222-nm ultraviolet light on disinfecting SARS-CoV-2 surface contamination

Hiroki Kitagawa MD, Toshihito Nomura MD, PhD, Tanuza Nazmul MBBS, Keitaro Omori MD, PhD, Norifumi Shigemoto MD, PhD, Takemasa Sakaguchi MD, PhD, Hiroki Ohge MD, PhD

How does far-UVC 222nm light inactivate viruses?

Far-UVC 222nm light inactivates pathogens like coronaviruses by damaging their RNA, which effectively neutralizes them since they are unable to reproduce.



SARS-CoV-2 coronavirus. This graphic illustrates how far-UVC 222nm light penetrates and inactivates coronaviruses like SARS-CoV-2 (COVID-19) by damaging its RNA

Technology backed by research

- In February 2017, researchers at Columbia University Irving Medical Center published a research paper called Germicidal Efficacy and Mammalian Skin Safety of 222-nm UV Light that suggests far-UVC 222nm light is as effective at killing (antibiotic-resistant) bacteria as conventional germicidal UV lamps that use 254nm light, but without associated skin damage risks.
- In May 2020, researchers at Kobe University published a research paper entitled Long-term Effects of 222-nm ultraviolet radiation C Sterilizing Lamps on Mice Susceptible to Ultraviolet Radiation that investigated the long-term effects of far-UVC 222nm light on skin using highly photocarcinogenic phenotype mice. The results suggest that far-UVC 222nm lamps can be used as an alternative to 254nm, since 222nm exerts a comparable disinfection ability and can be safely used for disinfecting human skin.

Patented Care222 far-UVC technology

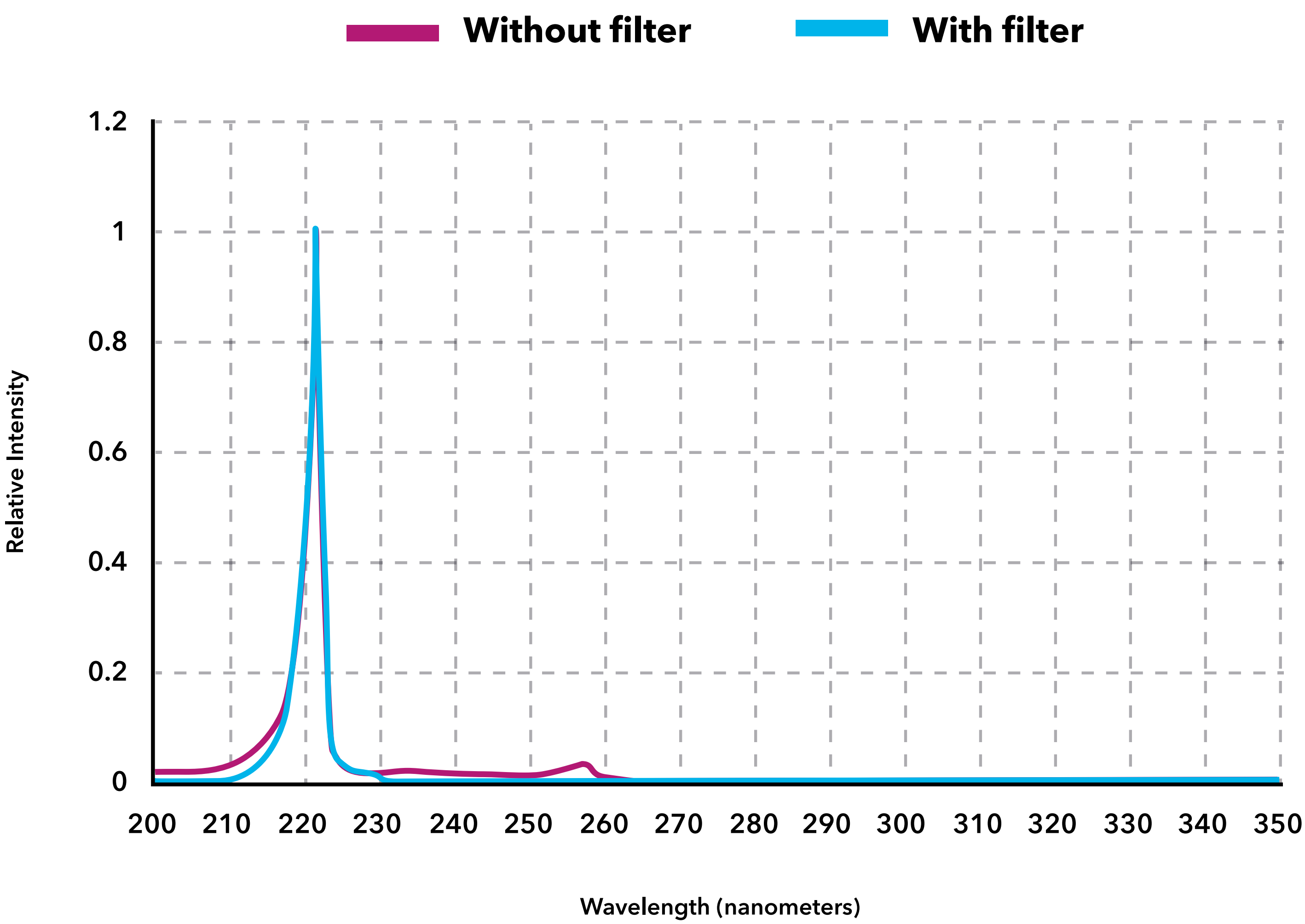
Care222 excimer lamps produce far-UVC 222nm light.

Here's how: Care222 excimer lamps contain a chamber filled with noble gas that doesn't use inner electrodes and is completely mercury-free. High voltage applied across the outside of the glass excites the gas inside, causing far-UVC 222nm light to be emitted. And the construction of Care222 lamps allow them to instantly turn on or off without warm-up time or decreased lifetime, unlike other similar lamps.

A world first

Care222 is also the world's first UVC technology with a proprietary optical filter that blocks potentially harmful, longer (>230nm) UVC wavelengths from being emitted.

Care 222 far-UVC excimer lamp with and without proprietary optical filter



^ This graph illustrates the effectiveness of Care222's patented optical filter in blocking longer (>230nm) UVC wavelengths that are a human health hazard

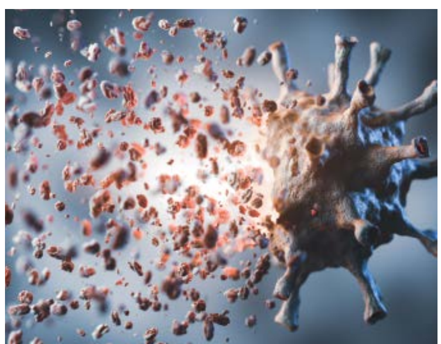
The disinfection technology we need right now

Christie CounterAct™ commercial UV disinfection fixtures contain patented Care222® technology that emits filtered far-UVC 222nm light, designed to neutralize pathogens with people present while meeting established safety guidelines.

Top 3 reasons to choose Christie CounterAct

It's designed for safer, continual disinfection.

Care222 lamps emit filtered far-UVC 222nm light, designed to automatically and continually inactivate pathogens with people present



It's effective.

The patented far-UVC light that Care222 technology emits can reduce 99.9% of pathogens–including coronaviruses like SARS-CoV-2

It's a world-first.

Care222 is the world's first UVC technology with a proprietary optical filter that blocks potentially harmful longer (>230nm) UVC wavelengths from being emitted

We thought of everything

- Configurable, automated operation within the current limits of current ACGIH and IEC guidelines, which may be reconfigured if these guidelines evolve over time
- Programmable to operate on a specific schedule according to your use case
- As easy to install as traditional commercial lighting fixtures, with automated control via an app
- Easy-to-service for straightforward lamp changes
- Instant on/off at full output power, and frequent on/off cycles don't affect lamp life
- Able to operate over a wide range of ambient temperatures
- Wireless Bluetooth® technology
- Available in black or white to fit existing color schemes
- Flexible leasing options are available

Now, and for the future

Urbanization, worldwide population growth, and global travel contribute to diverse contact among people, livestock, and wildlife, increasing the frequency and transmission of new pathogens that may harm us. We need safe and effective disinfection technology that reduces pathogens now, and for the future.

Put Christie CounterAct to work in your venue

Let's talk! Connect with a Christie sales representative today.

Visit the Christie CounterAct microsite »

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CD2250_Christie CounterAct with Care222_Whitepaper_Sept-21_EN_US Letter

Care 222®

CERTIFIED ISO 9001 QUALITY SYSTEM