Increase Image Quality Through Optical Filters

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#TheVisionShow

Agenda

- Why should you use optical filters?
- How filters control light?
- Increase contrast and resolution with optical filters
- Filter quality
- Optimize your lighting with optical filters
- Application examples
- Q & A

Increase Image Quality Through Optical Filters

Filters are a Necessity Not an Accessory

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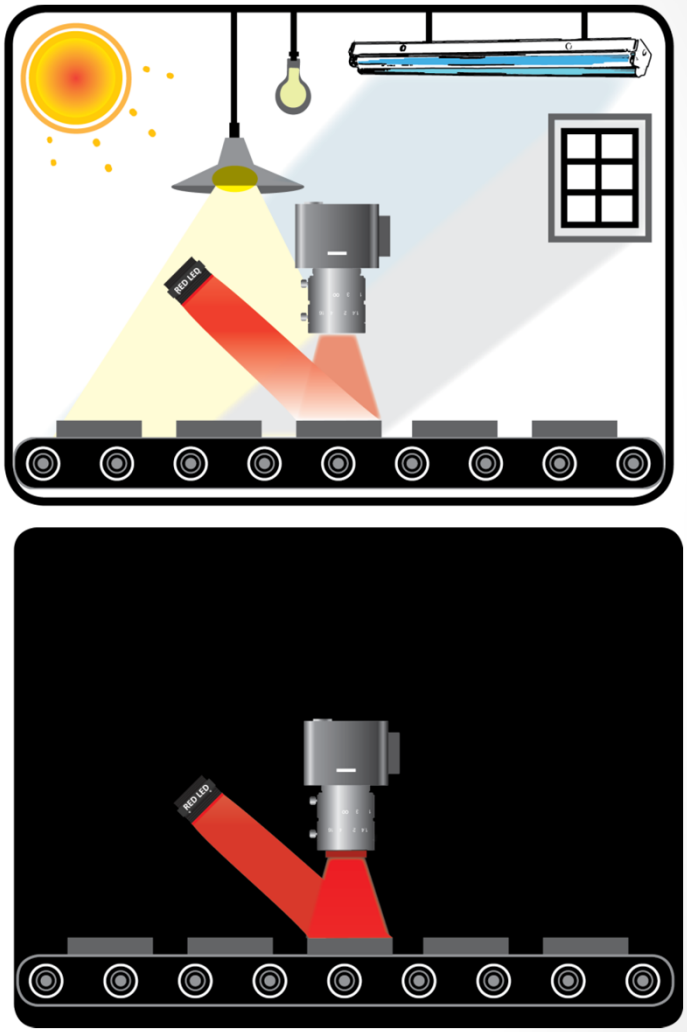
Why Optical Filters?

Control quality & quantity of light entering the vision system

Block all unwanted ambient lighting, such as sunlight & overhead lighting

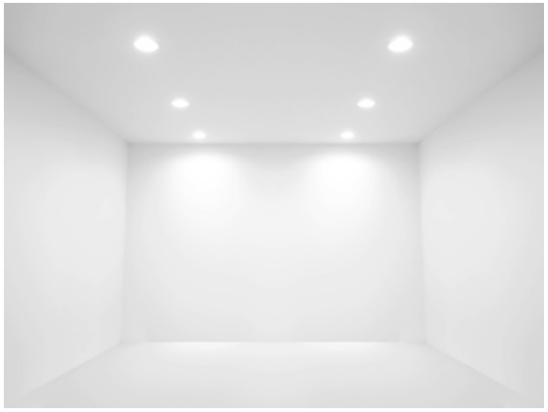
Pass only the output of lighting used for inspection

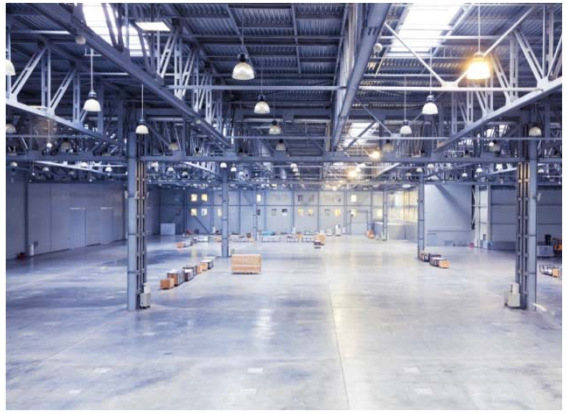
Increase contrast and resolution

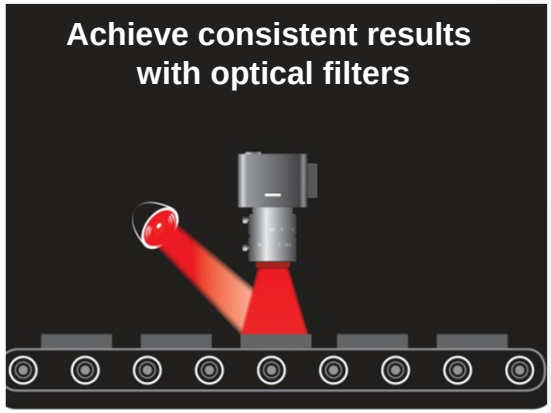


Inexpensive insurance policy for the system

The most cost effective way to improve repeatability and stability in any machine vision system!

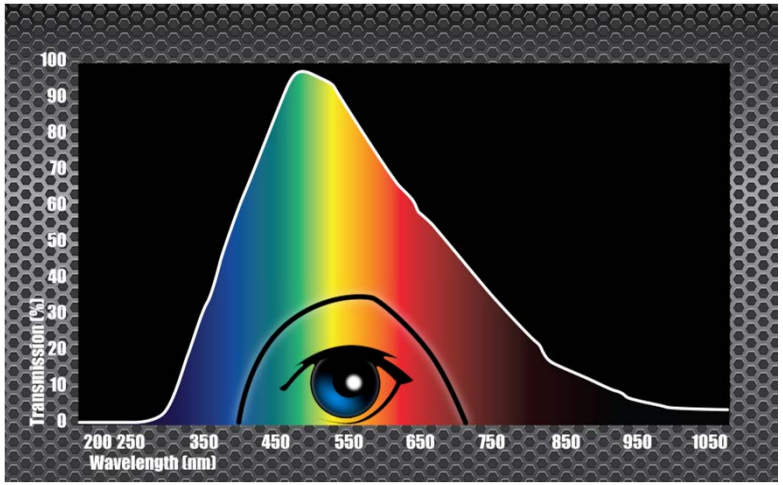




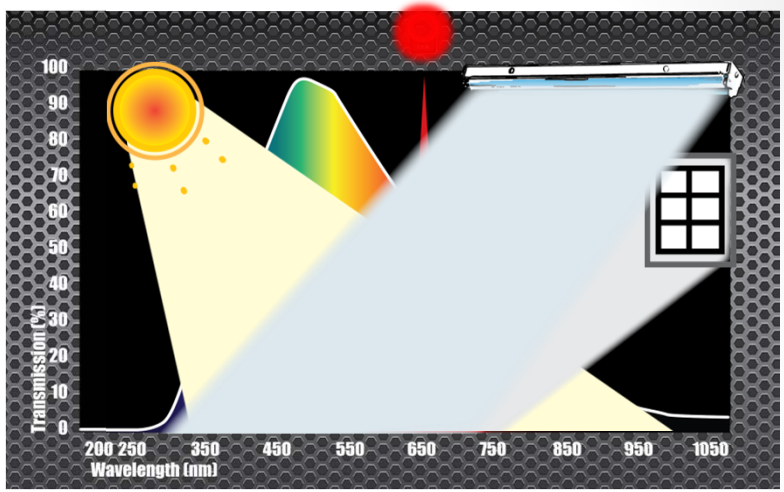


The simplest & quickest way to protect the system

How Filters Control Light

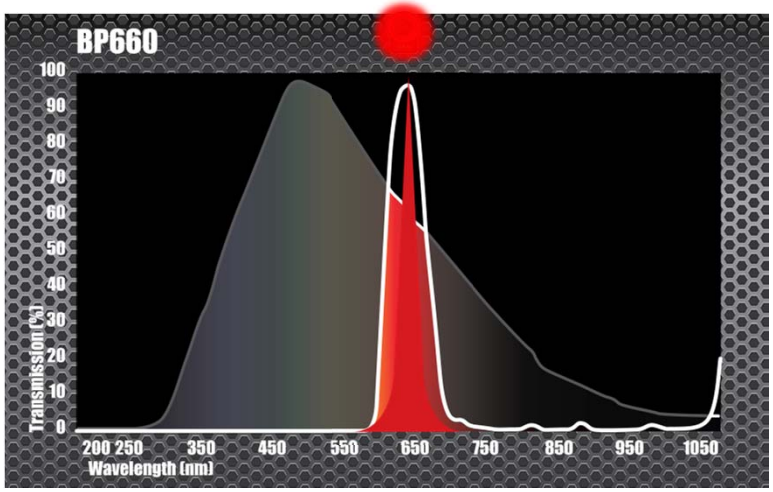


Digital Camera Spectral Response



Interfering Light Reaching the Application

Optical filters can eliminate light shields.

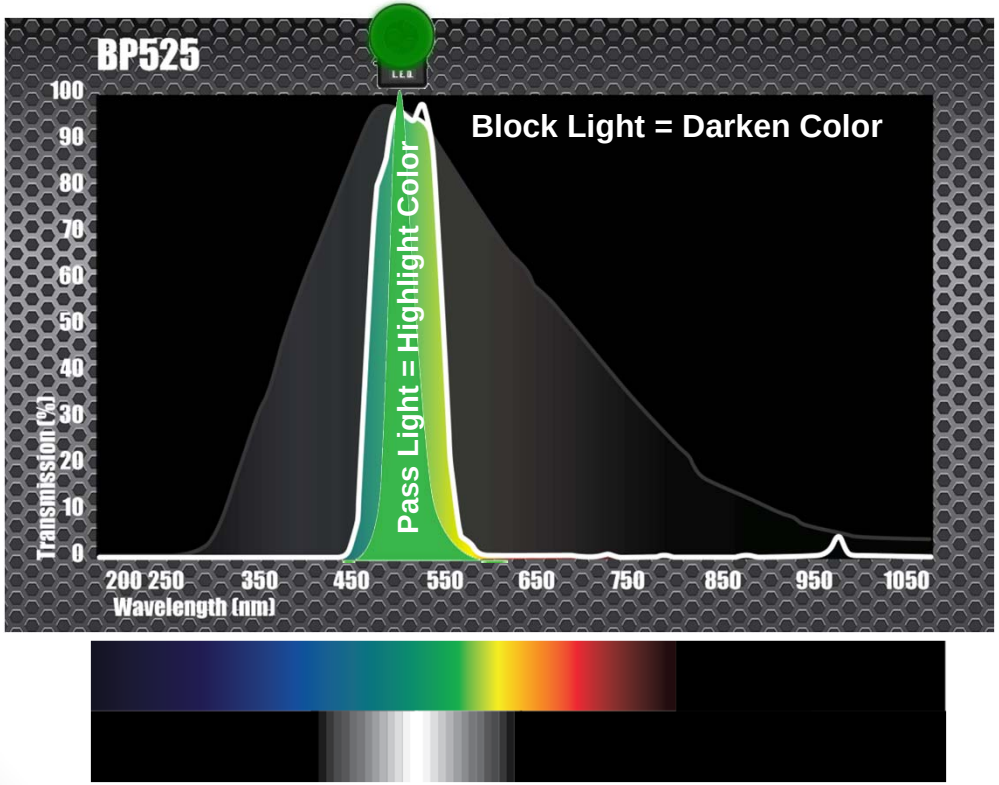


Bandpass Filters Block Interfering Light

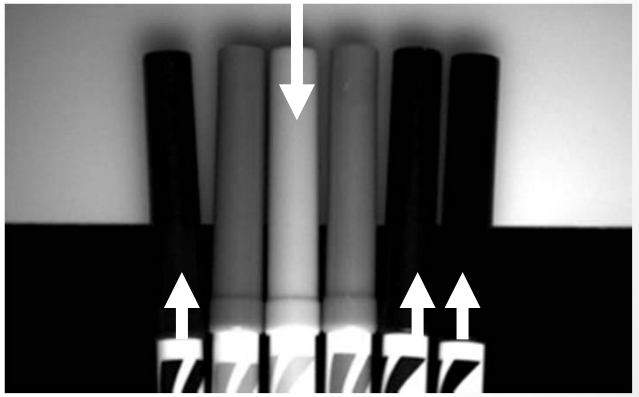
Filters Control Light

How Filters Can Increase Contrast

Selectively pass or block light wavelengths which can highlight or darken areas of an image



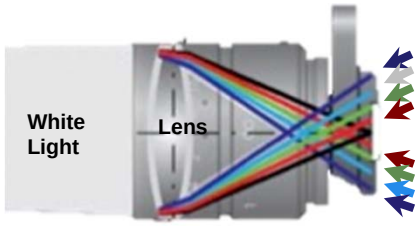
Pass Light With Green Bandpass Filter And **Highlight** Green Colored Marker



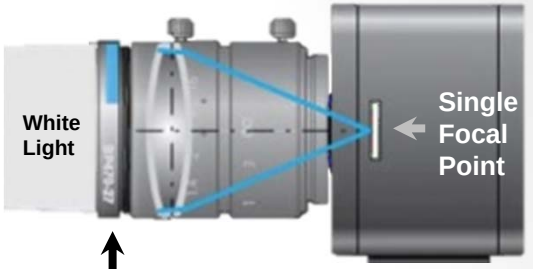
Blocked Wavelengths With Green Bandpass Filter **Darken Blocked Colors**

Increase Contrast and Resolution

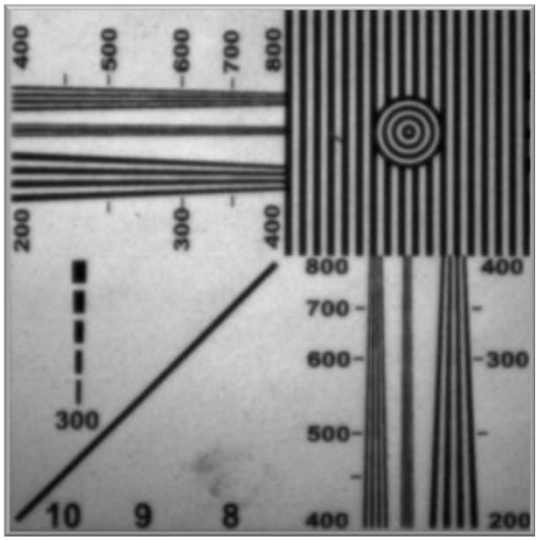
A lens with *Chromatic Aberration* doesn't focus all wavelengths of light to a single point resulting in less than optimal images.



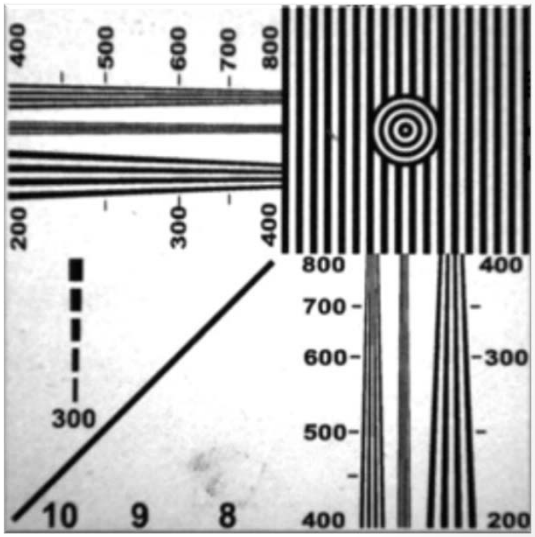
No Bandpass Filter



Bandpass Filter



Before Bandpass Filter



After Bandpass Filter

Extreme Durability

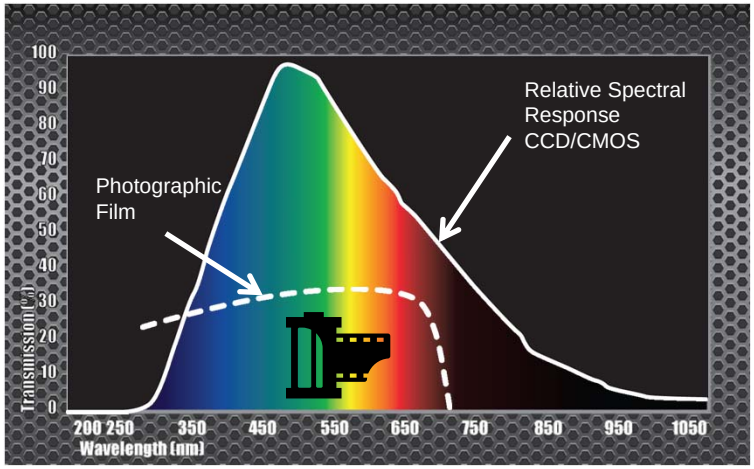
Mount to Any System

Does the Quality of the Filter Matter?

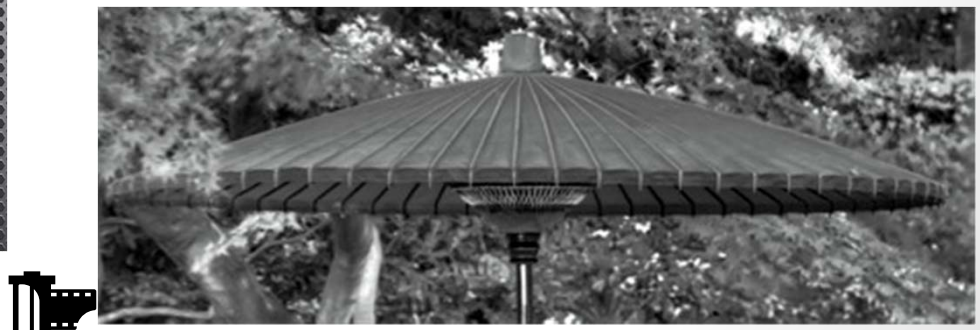
Filters designed for photographic film are not suitable for digital imaging systems!

Color Image, No Filter

Red Photographic Filter – Lightens (passes) red wavelength

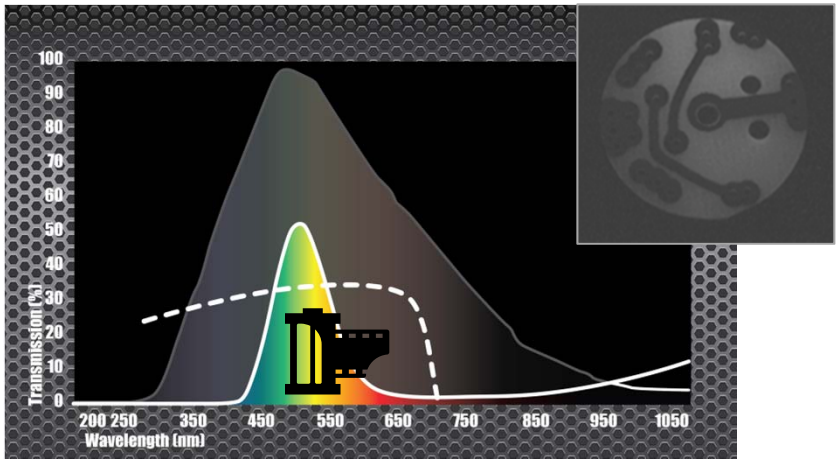


Relative Spectral Response: Film vs Digital Camera

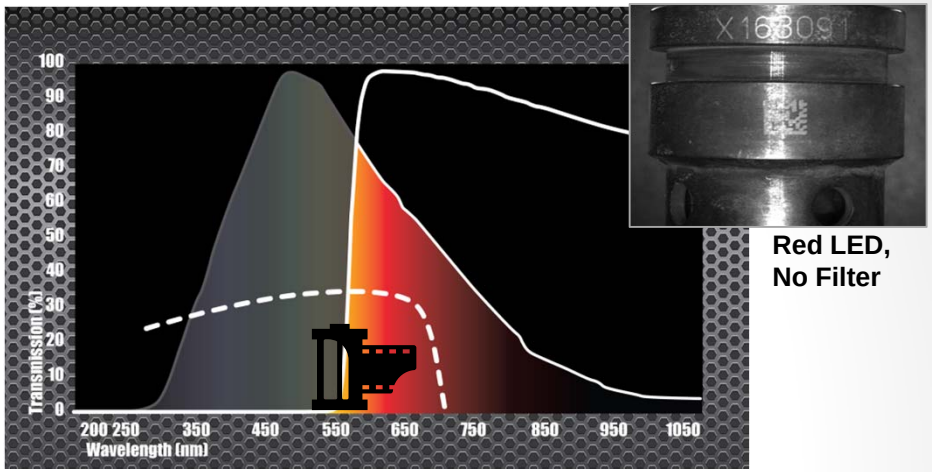


Green Photographic Filter – Darkens (blocks) red wavelength

And Here is Why…

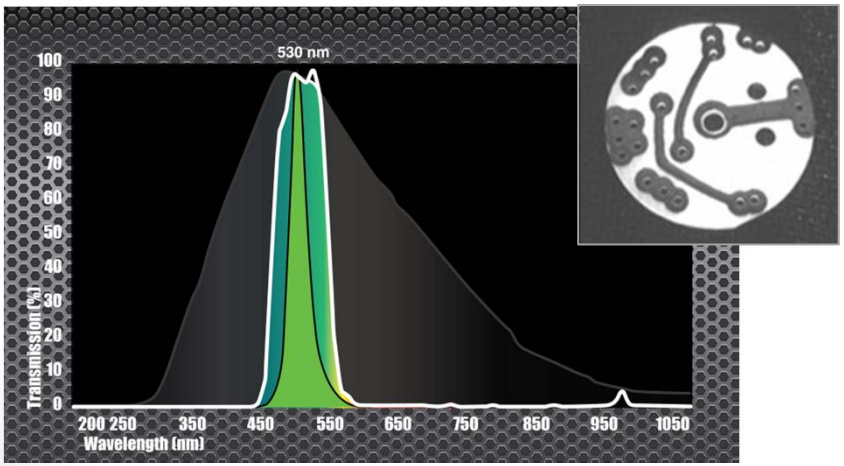


Photographic filters limit transmission when used with a digital camera

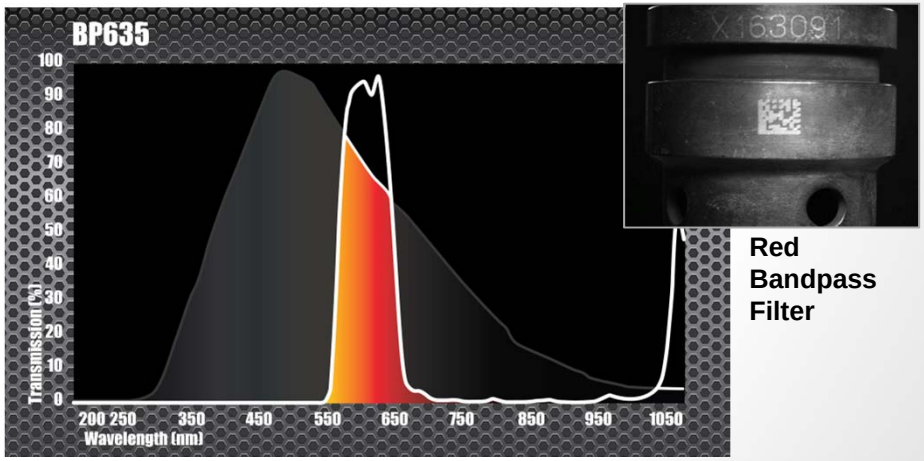


Red LED, No Filter

Sharpcut / Longpass filters are suitable for photography but not machine vision



Machine vision filters isolate the desired wavelengths



Red Bandpass Filter

Red Bandpass Filter

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Optimize Lighting with Optical Filters

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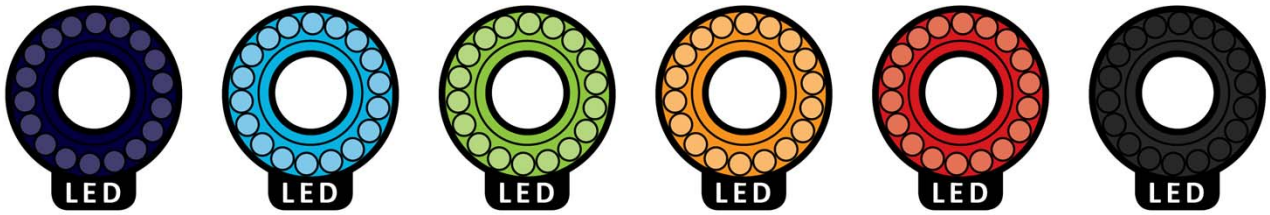
Monochromatic LED Lighting

Monochromatic (single color) LED lighting is most commonly used for illumination in applications to isolate the desired wavelength



Designed for Modern Day Illumination

Designed for High Transmission

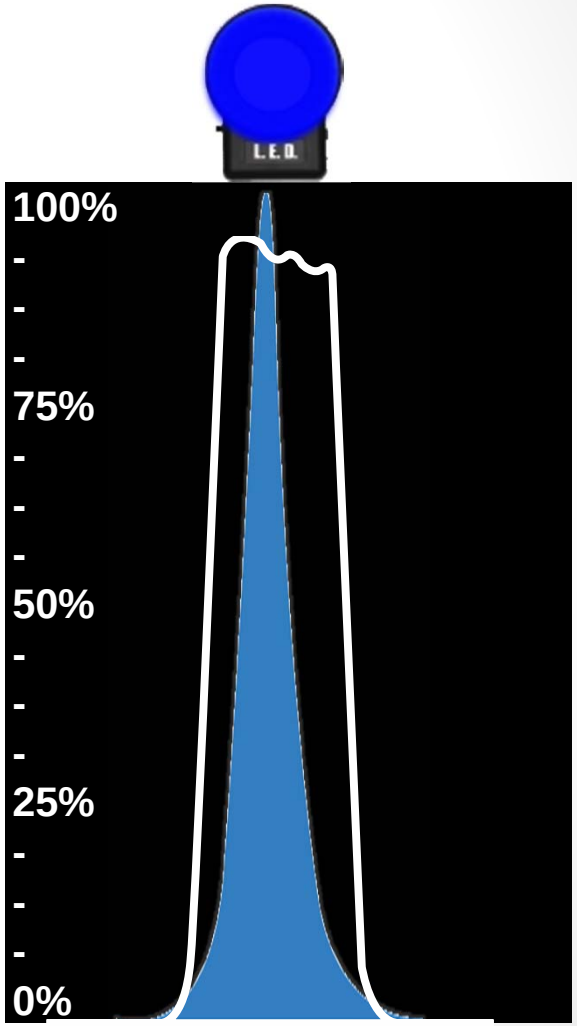
- All machine vision bandpass filters should have an anti-reflective coating to increase transmission

More light = faster speeds and added efficiency

Allows LED to operate with less intensity

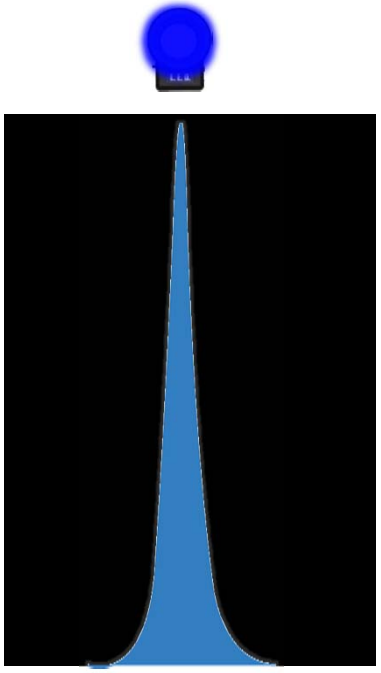
- Maximize output and increase lifespan of the LED which results in less light intensity on the factory floor

Mimic the output of the LED

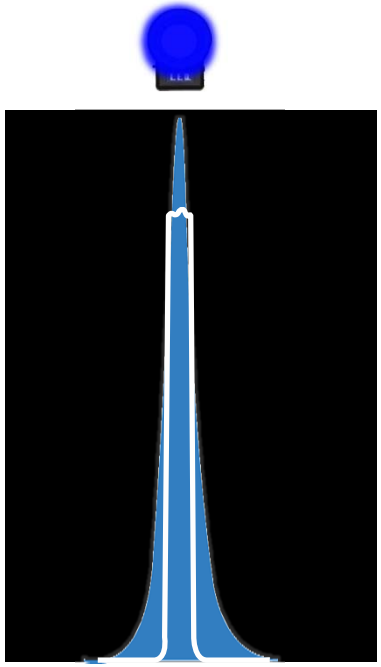


Designed for Modern Day Illumination

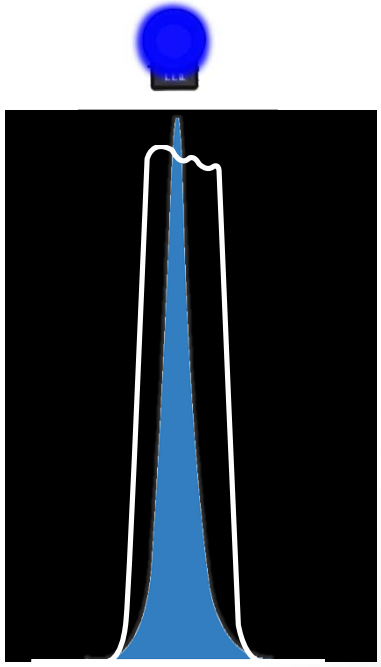
Typical monochromatic LEDs have a total light output of 60-70+/-10nm –bandpass filters are designed purposefully broad to accommodate the entire output of the LED



Solid Blue 470 LED Spans 60-70 nm



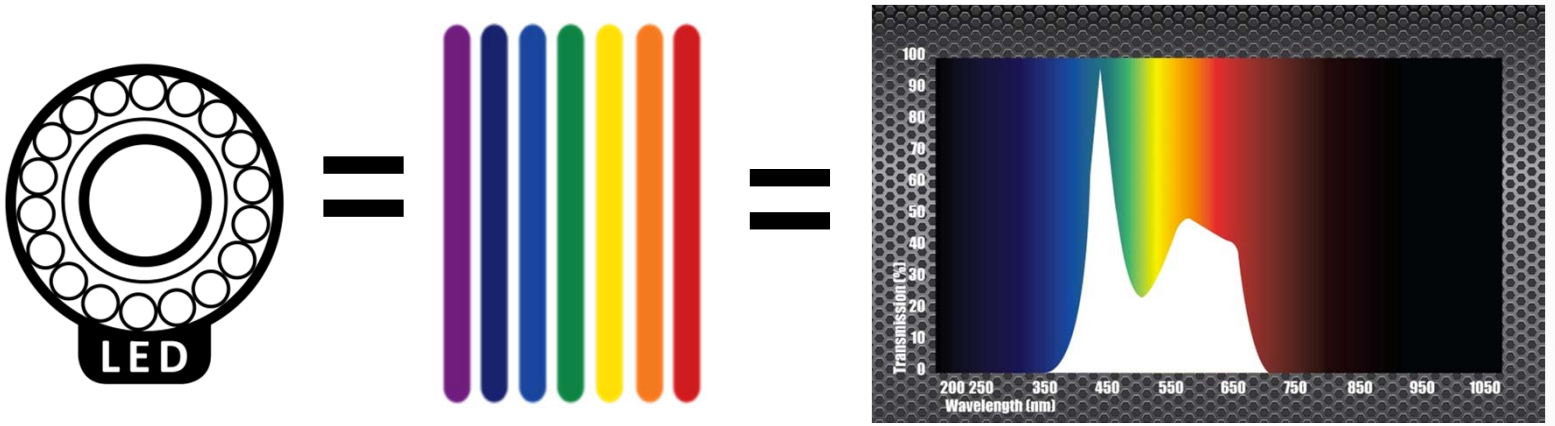
Acutely Narrow Filters Spans 20 nm



Bandpass Filter Spans 80-90 nm

White Light

Made up of the entire visible spectrum

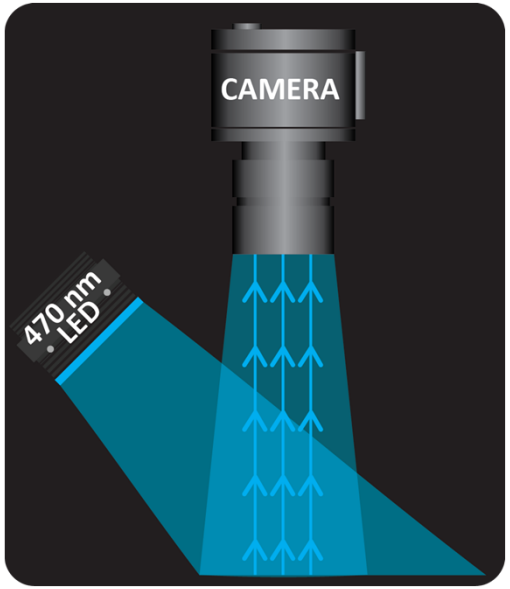


White LED

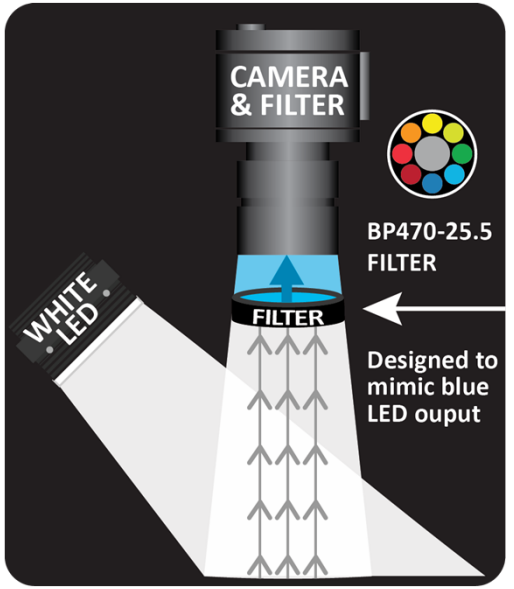
Visible Light

Spectral curve of a white LED shown spanning the entire spectrum

Test White Light and Bandpass Filters



Blue LED highlights push pin

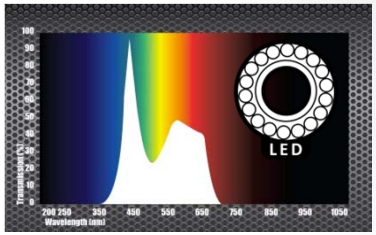


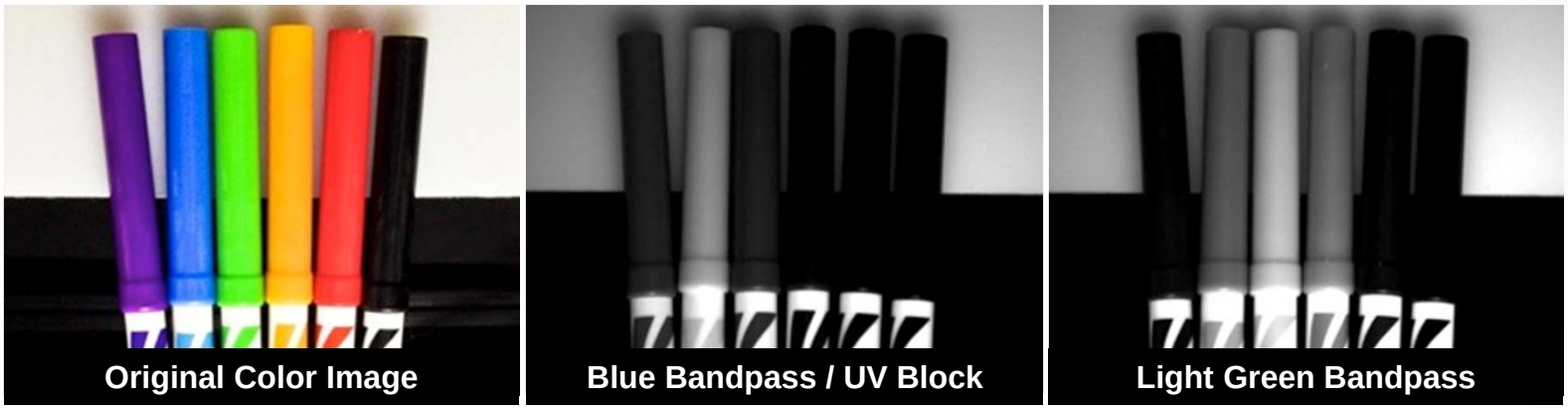
White LED no filter, no contrast

Blue Bandpass Filter highlights blue push pin

What's the Optimal LED Wavelength?

Utilize white light with bandpass filters to test & determine the optimal LED wavelength for your application





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Applications Solved with Bandpass Filters

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Date/lot Code Reading

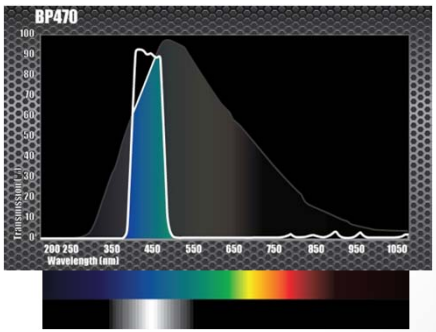
Challenge: Low contrast between yellow background and white letters

Solution:
Blue bandpass filter

Why does it work?: Blue bandpass filter blocks yellow reflection, darkening background

White Text Yellow Background

White LED, Blue Bandpass



2-D Code Reading

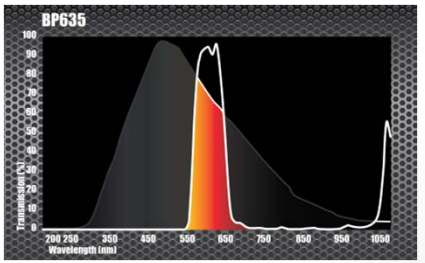
Challenge: Reading 2-D codes with ambient light changes on a curved metal surface

Solution: Red bandpass filter

Why does it work?: Only pass illumination from system, block overhead lighting

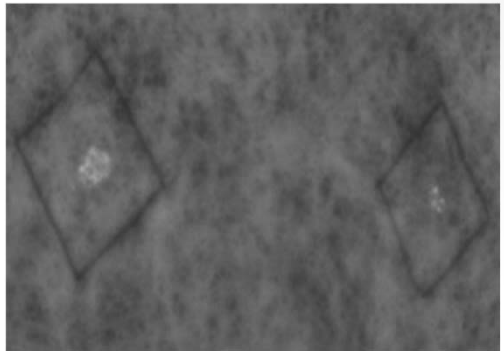
Red LED, No Filter

Red LED, Red Bandpass Filter



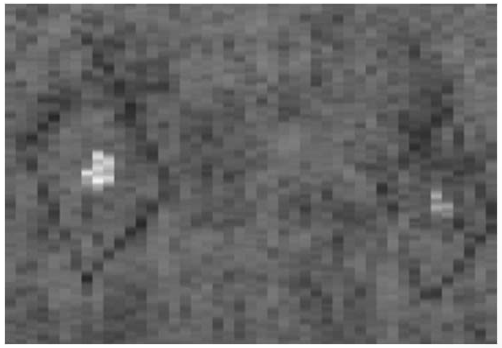
Camera Resolution Flexibility

A filter improves contrast significantly making it possible to get acceptable detection results using a lower resolution camera



High Resolution Camera

Orange Fluorescent Spot Detected In The Application



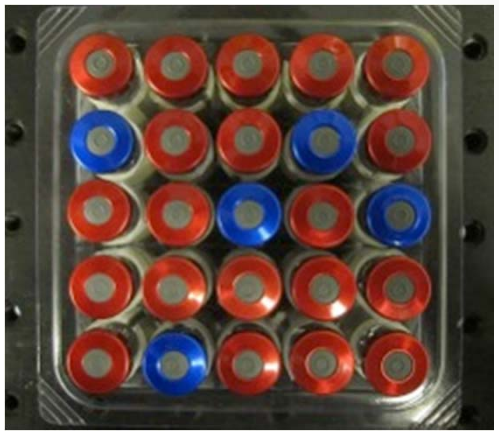
Low Resolution Camera With Orange Bandpass Filter

Color Sorting/Counting

Challenge: Low contrast between two colors

Solution: Blue or red bandpass filter

Why does it work?: Red bandpass filter highlights red, blue bandpass filter highlights blue

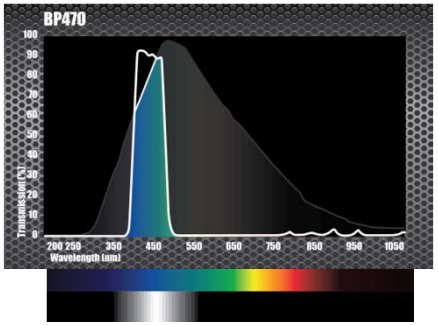


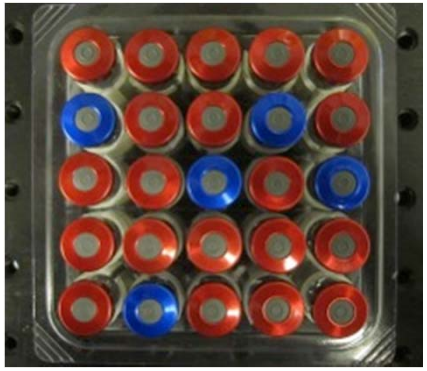
Original Color Image

Monochrome, No Filter

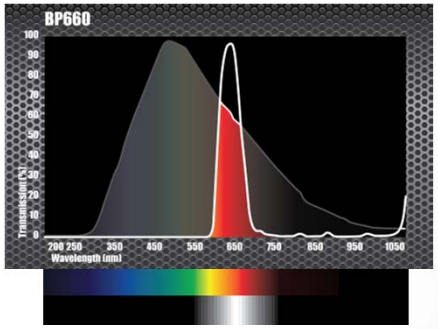
Color Sorting Results

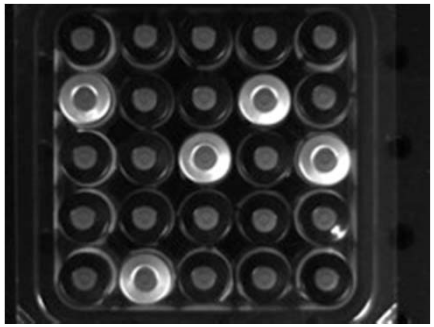
No Filter



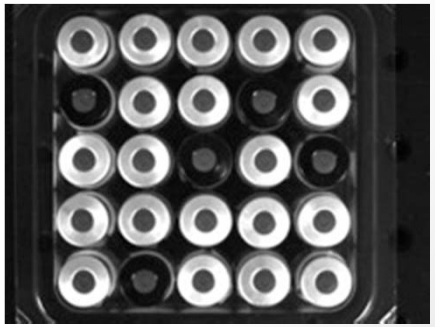


No Filter





Blue Bandpass Filter



Red Bandpass Filter

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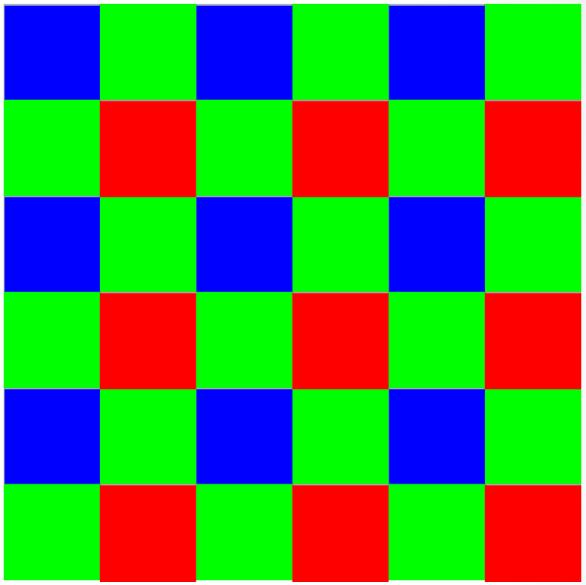
Monochrome or Color?

- A Bayer filter array runs over a monochrome sensor
- Analyzes each pixel's color information and, combined with that of adjacent pixels, recreates the full color image
- Resolution loss is most pronounced when detection of a single or a few colors is all that is required



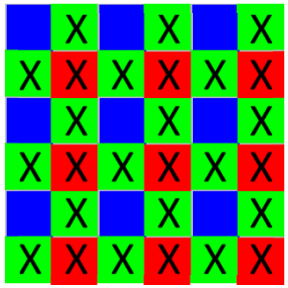
RGB sensor

25%	50%	25%
Red Pixel	Green Pixel	Blue Pixel

Monochromatic Imaging

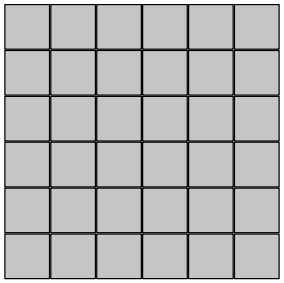
Significantly increase camera efficiency

Color

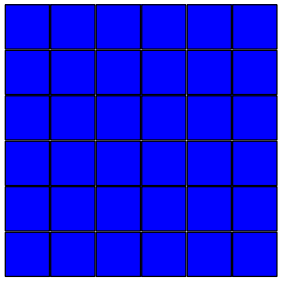


25% Efficient

Monochrome

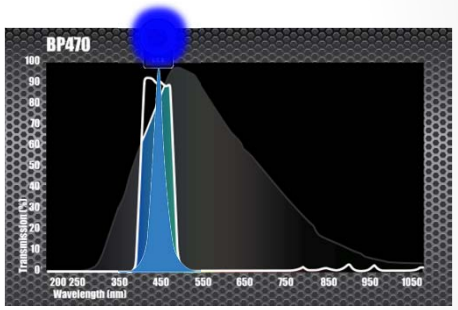


Monochrome with Filter



90% Efficient

Blue Bandpass Filter



Original Color Image, UV 395nm LED

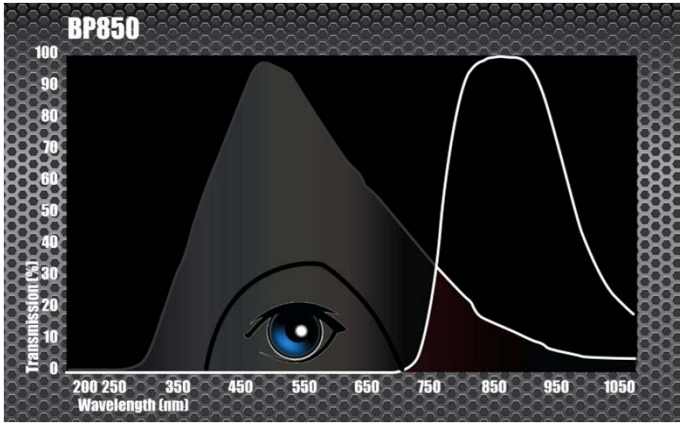
No Filter

Blue Bandpass Filter

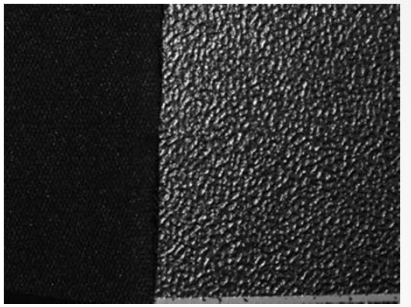
Entire sensor is used to detect intensity.

Combined with a blue bandpass filter that transmits 90+%, a monochrome sensor vs a color sensor is at least 3 times more efficient

Imaging with Infrared Filters

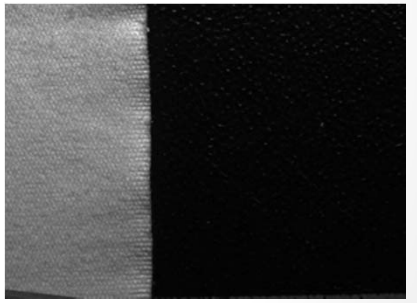


No Filter



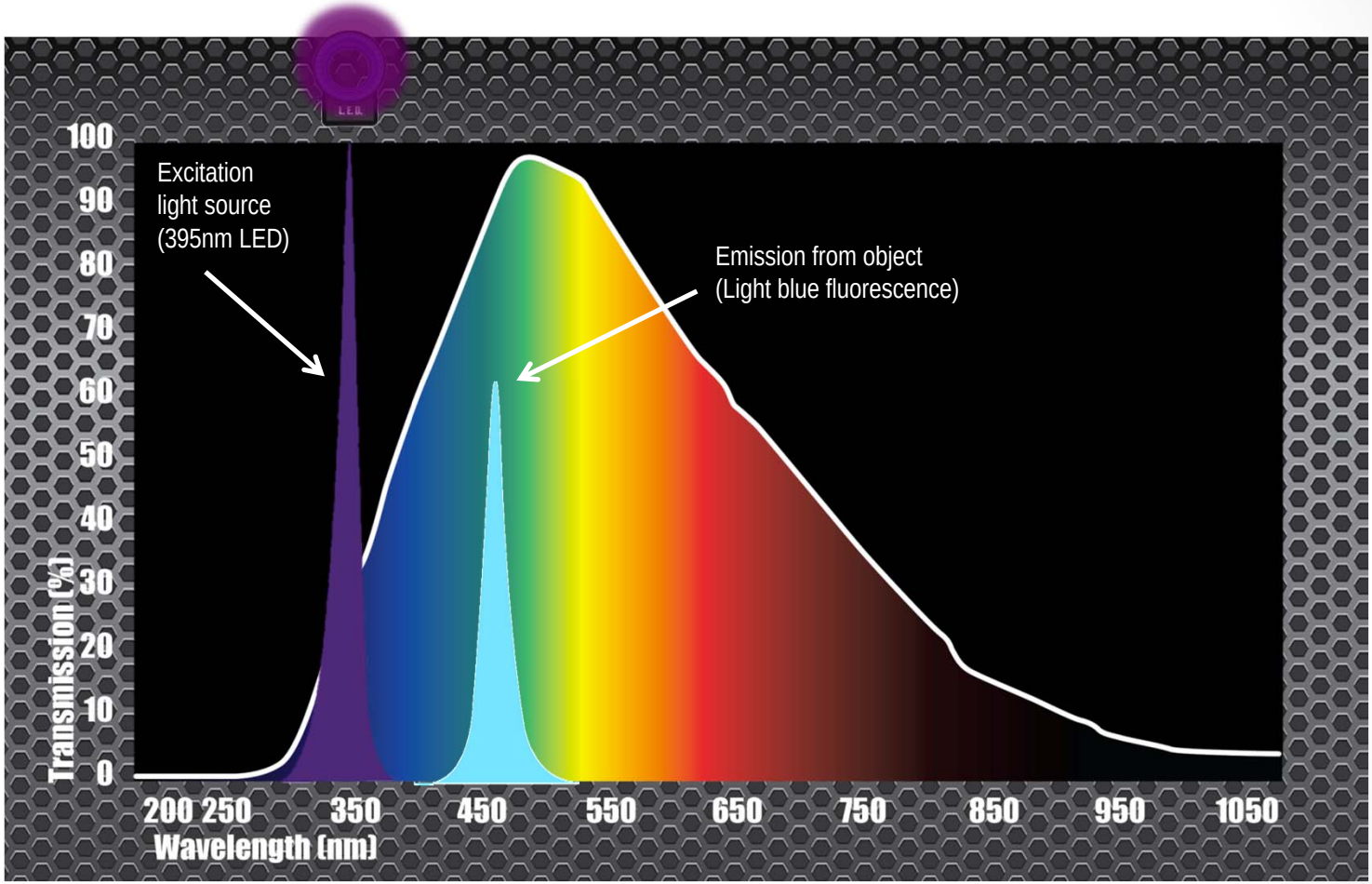
No Filter

IR Bandpass Filter

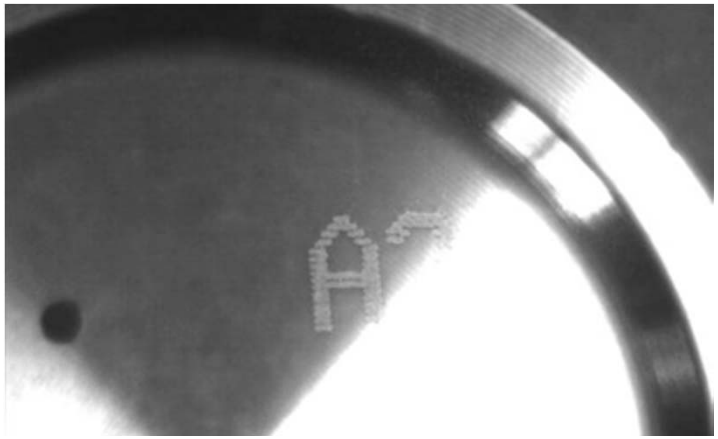


IR Bandpass Filter

Fluorescence and Optical Filters

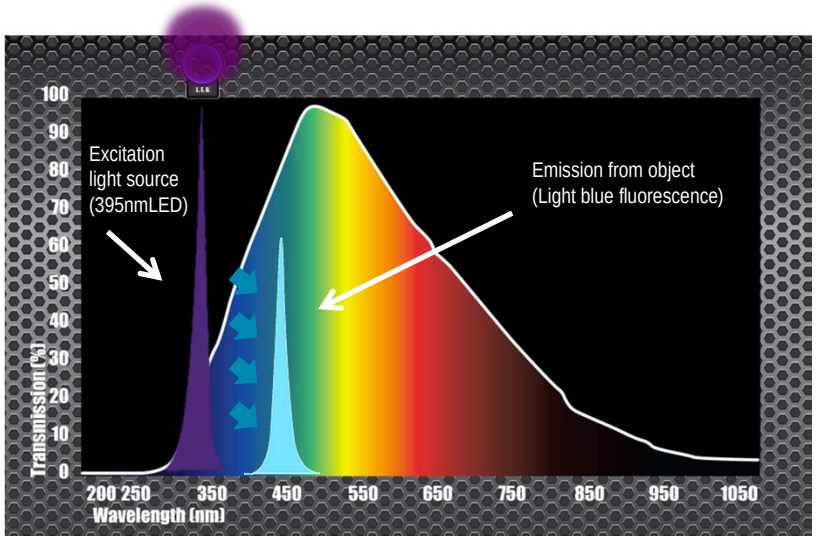


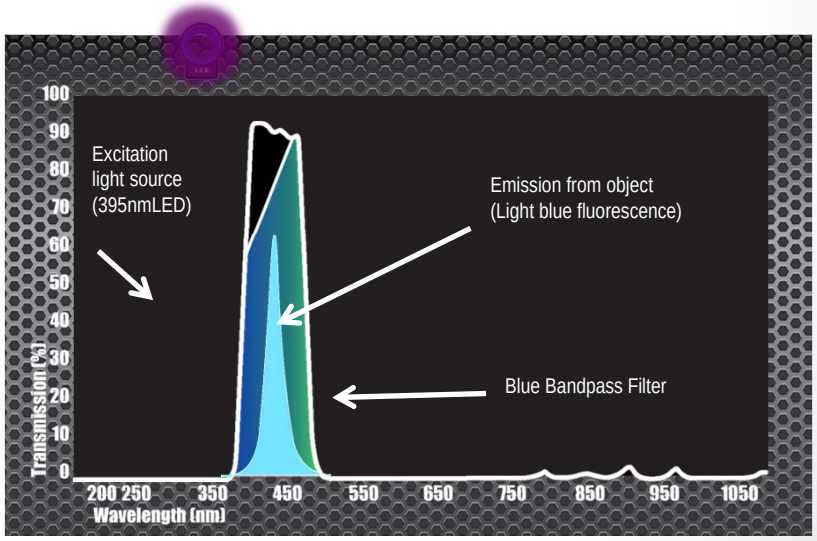
Fluorescence and Optical Filters



No Filter, 395nm UV Light

395nm UV Light With Blue Bandpass Filter





Increase Image Quality Through Optical Filters

Additional Optical Filters

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Lens Protection

Protective / UV Blocking Filters

Protect lenses from dust and harsh industrial environments

Anti-reflection coatings to maximize transmission

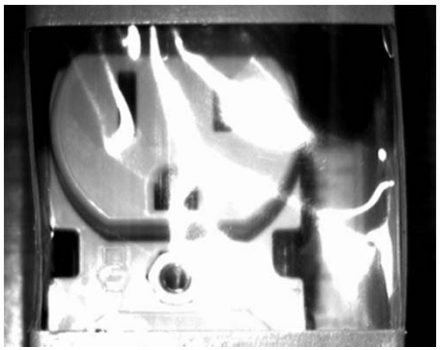
Anti-abrasion acrylic protective window that is approved for EFSA & FDA applications

Reduce Specular Glare

Polarizing filters for the lens and light source

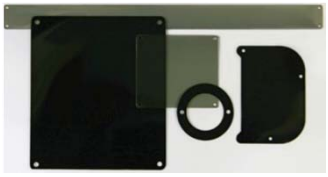
Utilize a polarizer over the **lens and light source** to maximize the reduction of specular glare

- Polarizing filters for infrared and the visible spectrum
- Visible Polarizing Filter Effective Range: 400-700nm
- Infrared Polarizing Filter Effective Range: 400-1200nm
  For imaging above 700 nm a infrared polarizer must be used

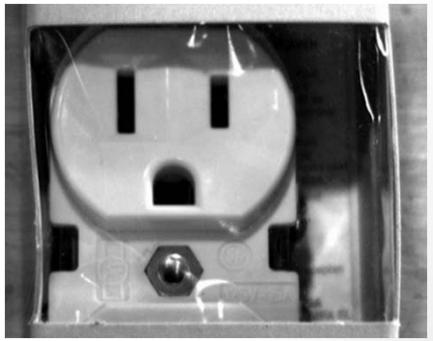


No Filter, Specular Glare

Includes locking thumb screw to prevent change of orientation



Custom sheet shapes & sizes available to fit the light source



Linear Polarizer for Lens & Linear Polarizer Film for Light Source

Reduce Glare and Increase Contrast

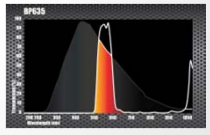
Reduce Glare & Increase Contrast with Bandpass and Polarization Filters

No Filter

Polarizer Filter on the Lens, Not on Light Source

Polarizing Filter on Lens and Polarizing Film on Light Source

Polarizing Filter on Lens and Polarizing Film for the Light Source combined with a Red Bandpass Filter



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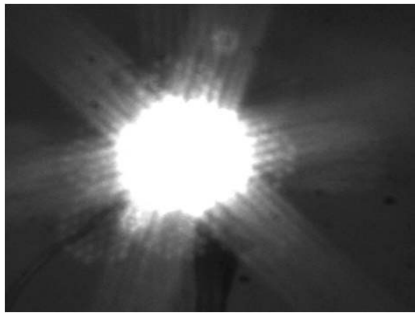
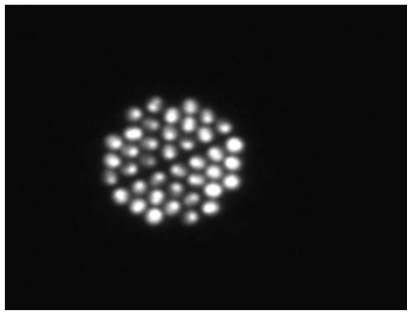
Reduce Light Intensity

Neutral Density Filters

- Reduce light intensity without affecting color
- Achieve shallow depth of field
- Can be used with monochrome and color cameras in the visible spectrum



Iris set to smallest aperture to f/16, no filter



Iris set to smallest aperture to f/16, with (1% transmission) Neutral Density Filter

Visible Neutral Density Filters (Standard Absorptive)

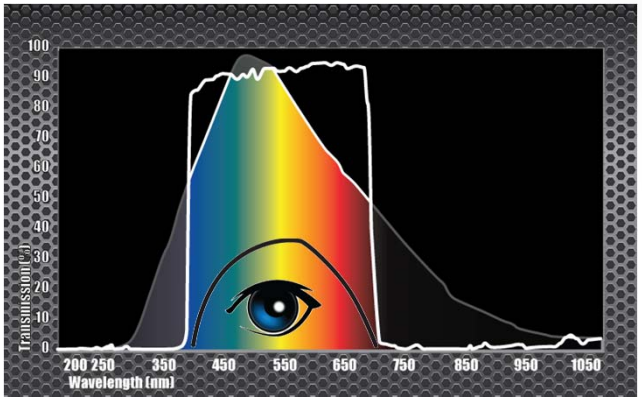
- Effective Range: 400-700nm

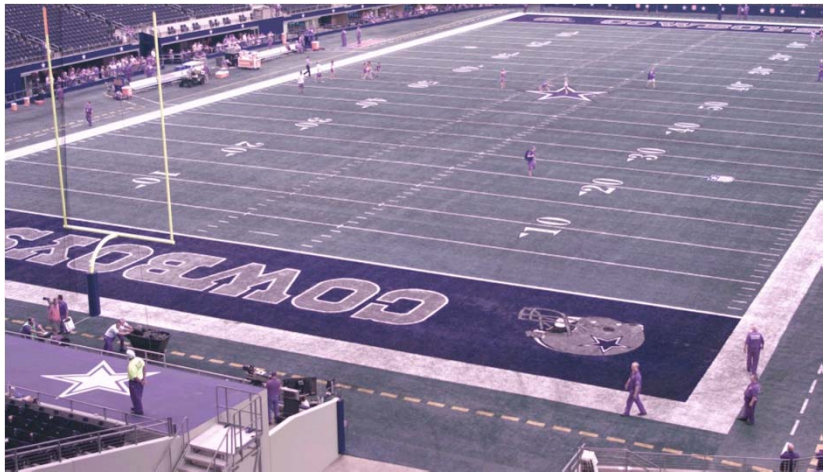
Infrared Neutral Density Filters (Low-Reflectivity Visible/Near IR)

- Reduce light intensity neutrally through visible and near IR spectrum
- Effective Range: 400-1200nm

Shortpass Filters (Low Pass)

- Lets shorter wavelengths pass while blocking the longer ones
- Block IR light from interfering with color rendition in CCD/CMOS cameras
- Commonly placed over the image sensor





Combine Shortpass and Neutral Density Filters to remove high-temperature saturation in an image

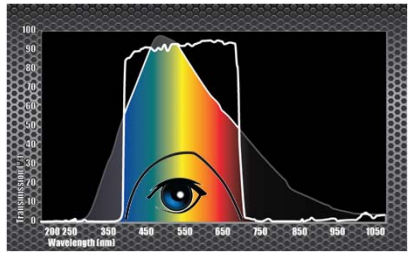
High temperature, Light Intensity and Image Saturation

Reduce intensity, saturation and interfering red channels with Shortpass and Neutral Density Filters

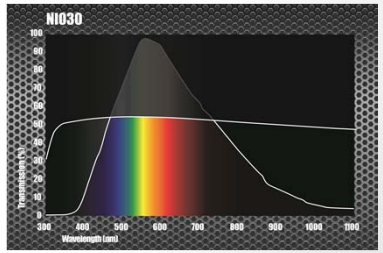
Shortpass Filters are a good solution in high-heat applications to remove saturation in an image (longer wavelengths can cause a blooming effect)

In high light intensity/temperature applications Neutral Density Filters can be combined with Shortpass Filters to lower intensity and block interfering longer wavelengths

Shortpass Filters (Low Pass)



Neutral Density Filters



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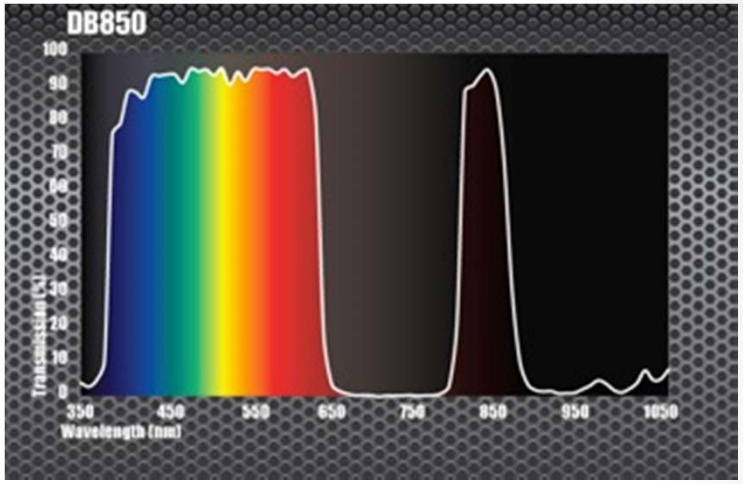
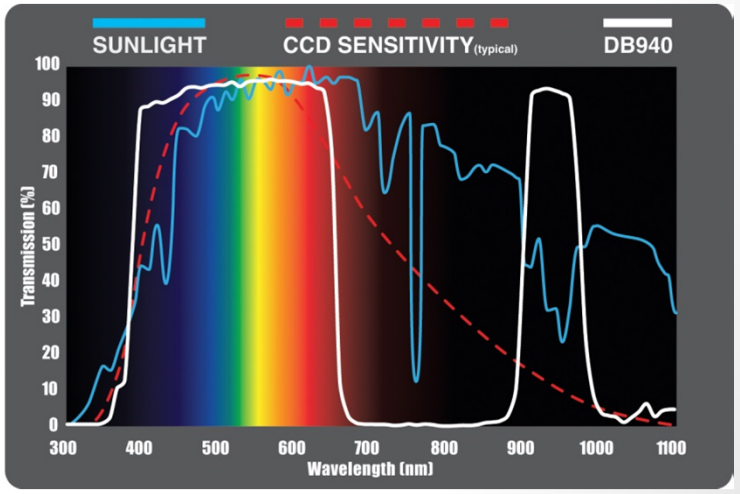
Dual (Visible + Infrared) Bandpass Filters

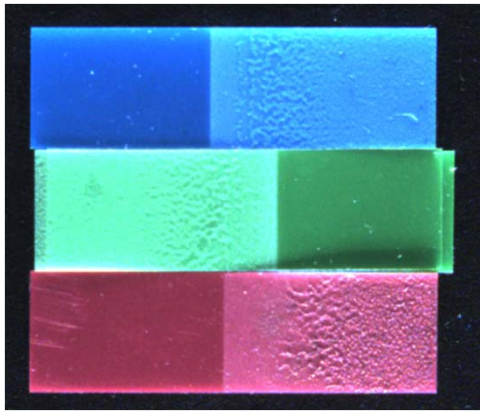
- Use for color camera day/night applications along with IR illumination
- Blocks interfering IR wavelength range to achieve accurate color rendition
- Ability to view with IR illumination at night



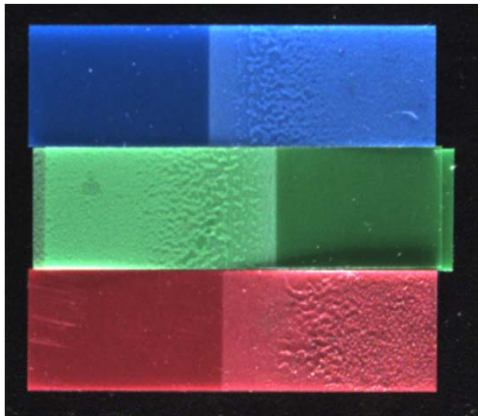


Color Light Balancing Filters

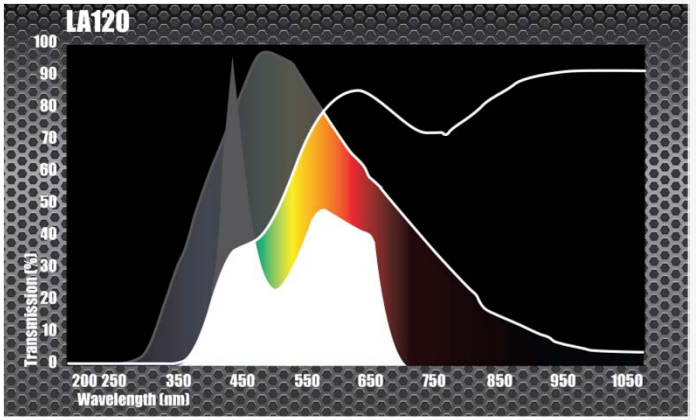
The best image quality is achieved through optics, not software processing.



No Filter, Cool White LED's can affect image quality in a color application.



After Light Balancing Filter, Image appears more natural allowing easy detection of adhesive and color sorting.



Cool White LED, with Color Light Balancing Filter

- Mimics the output of a warm LED
- Lower cost than a warm LED
- Avoid software color correction

Increase Image Quality Through Optical Filters

Things to Consider When Choosing a Filter

Define Imaging Objective Light & Wavelength
Monochrome or Color Camera Filter Mount Size

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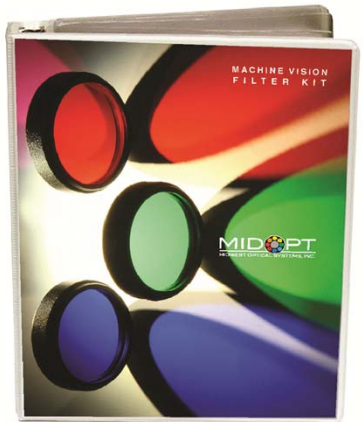
How do you find the right filter?

Filter Test Kits



- Find the most suitable wavelength to optimize image quality
- Test before investing In hardware
- Find the most suitable match for the light source
- Find the best filter to maximize contrast
- Find the best filter to control interfering light

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The Bottom Line

Optical Filters are:

The simplest, quickest & most cost effective way to improve repeatability and stability in any machine vision system!

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