Eight Tips for Optimal Machine Vision Lighting

**Tips for Choosing the Right Lighting
for Machine Vision Applications**

MICROSCAN®

Eight Tips for Optimal Lighting

This white paper provides tips for choosing the optimal lighting solution for a machine vision application. Proper lighting is critical to the success of a machine vision application, and should be the first consideration when setting up a system. A well planned lighting solution will result in better system performance and save time, effort, and money in the long run. This paper presents the following tips:

1. *Use Bright Light to Detect Missing Material*
2. *Use Appropriate Wavelength for Accurate Component Placement*
3. *Use Non-Diffused Light to Detect Cracks in Glass*
4. *Use Diffused Light to Inspect Transparent Packaging*
5. *Use Color to Create Contrast*
6. *Use Strobed Light for Rapidly Moving Parts*
7. *Use Infrared Light to Eliminate Reflections*
8. *Use Infrared Light to Diminish Color Variation*

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How Does Lighting Affect a Vision Application?

Machine vision systems rely on quality images for quality output. High quality images enable the system to accurately interpret the information extracted from an object under inspection, resulting in reliable, repeatable system performance. The quality of the image acquired in any vision application is highly dependent on the lighting configuration: the color, angle, and amount of lighting used to illuminate an object can mean the difference between a good image, resulting in good performance, and a poor image, yielding poor results.

Machine vision lighting should maximize feature contrast while minimizing contrast of the rest, thereby allowing the camera to clearly "see" the part or mark. High contrast features simplify integration and improve reliability; images with poor contrast and uneven illumination require more effort from the system and increase processing time. The optimal lighting configuration is dependent on the size of the part to be inspected, its surface features and part geometry, and the system needs. With a broad range of wavelength (color), field of view (size), and geometry (shape) options available, machine vision lighting can be tailored to specific application requirements.

Five Considerations When Choosing Lighting:

- **Is the surface flat, slightly bumpy or very bumpy?**

- **Is the surface matte or shiny?**

- **Is the object curved or flat?**

- **What is the color of the barcode or mark?**

- **Are you inspecting moving parts or stationary objects?**

BEFORE
CORRECT LIGHTING
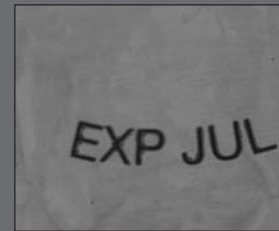
AFTER
CORRECT LIGHTING

Effects of lighting techniques on a ball bearing

| The ball bearing | Fiber optic ring light | Fluorescent ring light | Diffused dome light | NERLITE DOAL | NERLITE CDI |

▶ Tip #1: Use Bright Light to Detect Missing Material

Identifying "Short Shots" in Plastic Molding

Are your shots falling short?

Identifying missing material from plastic molding applications is important to ensure good sealing surfaces. When material is missing, you have a "short shot" condition (i.e. insufficient quantity of material injected into the mold). To identify short shots, a NERLITE® DOAL® (Diffuse On-Axis Light) illuminator is used to highlight missing material on the sealing surface.

Illumination Technique: Bright Field

The bright field lighting technique relies on surface texture and flat topography. Light rays hitting a flat specular surface reflect light strongly back to the camera, creating a bright area. Roughly textured or missing surfaces scatter the light away from the camera, creating dark areas.

Problem:

Material is absent during the molding operation (short shot), presenting a failure in the bottle sealing surface.

Solution:

NERLITE® DOAL® light source reflects brightly off the flat sealing surface of a good bottle. This presents the camera with a well-defined bright annular area. A short shot eliminates the flat specular surface, scattering the light away from the camera and allowing easy identification.
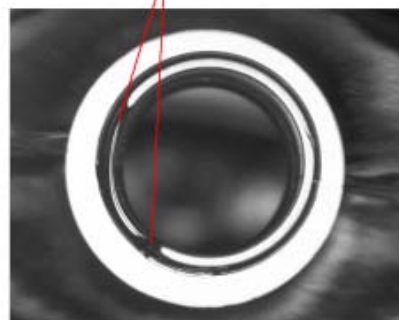
Illumination Example:
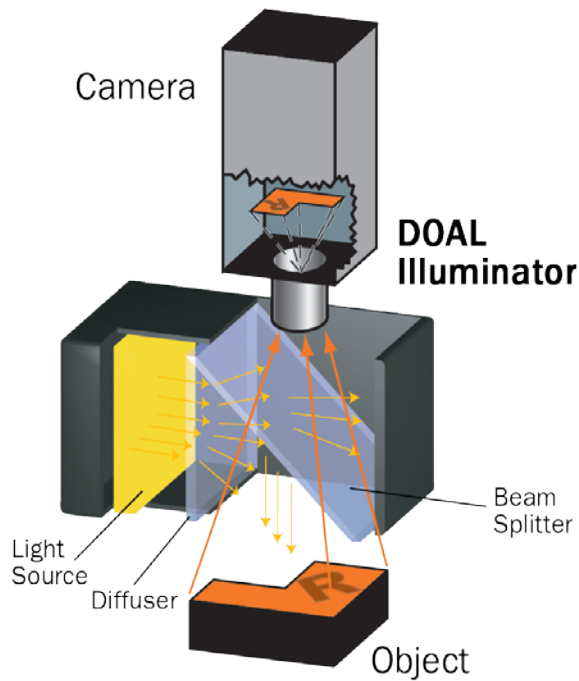
Good part presents a bright, well-defined annular area to the camera
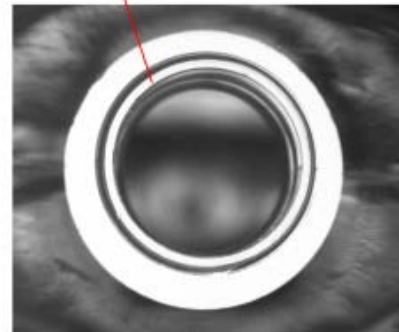
Bad (short shot) part reflects light away from camera, presenting dark areas that indicate rejects

▶ Tip #2: Use Appropriate Wavelength for Accurate Component Placement

Inspecting "Flipped Chips"

Are your chips flipped?

Identifying proper component orientation is a common machine vision application in PCB assembly. In this example, chips were incorrectly "flipped" in an automated assembly step. Instead of being placed onto the substrate with copper side down for proper electrical connection, the chip is flipped over, silver side down, causing component and assembly failure.

Illumination Technique: Bright Field

To identify problem assemblies, a NERLITE® DOAL® illuminator with a blue wavelength is used to highlight chip orientation. This lighting technique relies on wavelength and coaxial lighting geometry. The blue wavelength (460 nm) sharply differentiates the silver and copper surfaces: copper absorbs the blue light and appears dark, silver reflects the blue light and appears bright. The unique NERLITE® coaxial lighting geometry eliminates the root cause of false rejects: unwanted glare, reflections and dark spots.

Problem:

During circuit assembly, chips can be accidentally "flipped" upside down on the circuit boards, resulting in both component and assembly failure.

Solution:

A NERLITE® DOAL® light source in the proper color will reflect brightly off of properly installed components, while improperly installed components absorb the light and appear dark. The sharp difference in contrast is quickly recognized by the machine vision system, enabling real-time process corrections.
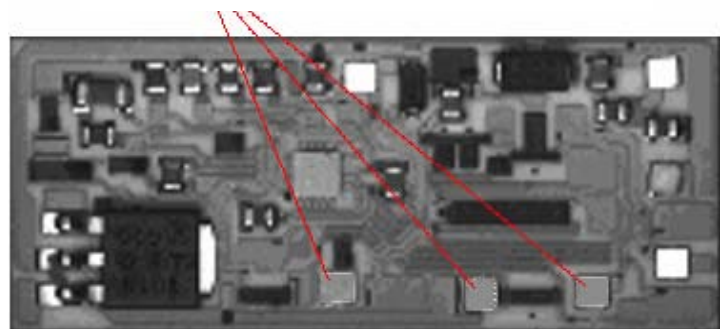
Illumination Example:
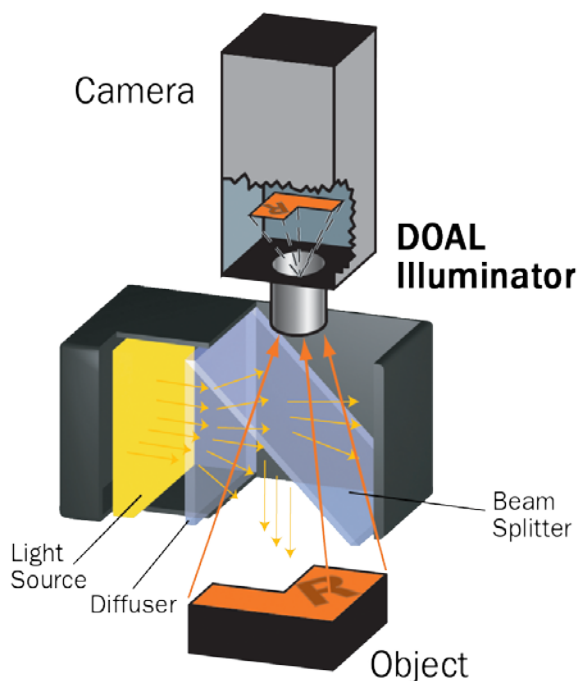
Proper placement easily identified by bright appearance of components
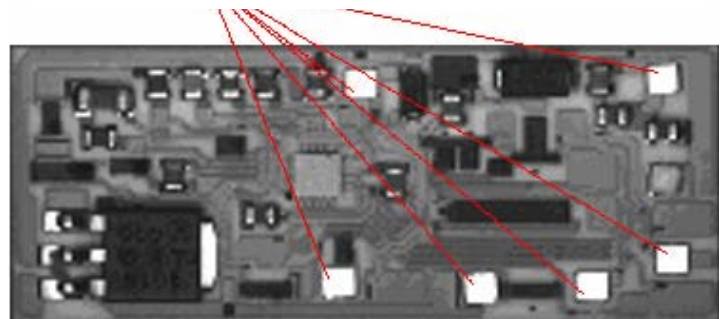
"Flipped" components appear dark, enabling reject detection

Tip #3: Use Non-Diffused Light to Detect Cracks in Glass
Detecting Cracks in Glass Containers

You've had your fill of glass defects

Detecting cracks during sidewall inspection of glass containers prior to packaged-goods shipment is an important way to minimize waste, decrease returns and increase consumer confidence. To detect cracks in transparent material, a NERLITE® Area Array is used to highlight the imperfection.

Illumination Technique: Dark Field

In this application, dark field lighting is used to create a bright, easily detectable feature of interest within a dark background. Light rays are directed at the transparent bottle from a dark field region (i.e. from outside the camera's field of view). Most of the rays pass through the transparent object undetected by the camera. If a material irregularity such as a crack exists, some light rays strike that irregularity. Cracks, in particular, create an internal void, where light rays refract and reflect, scattering in many directions including back to the camera. These are the rays that turn an otherwise difficult to detect crack into a bright feature on the dark background.
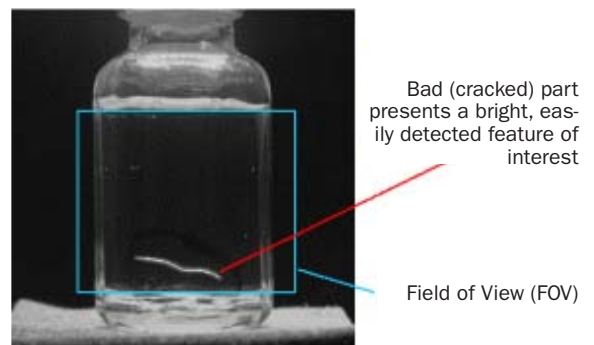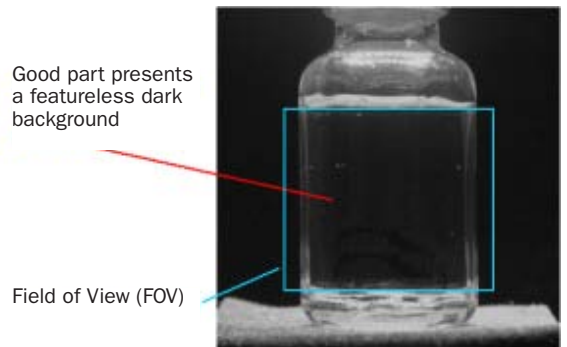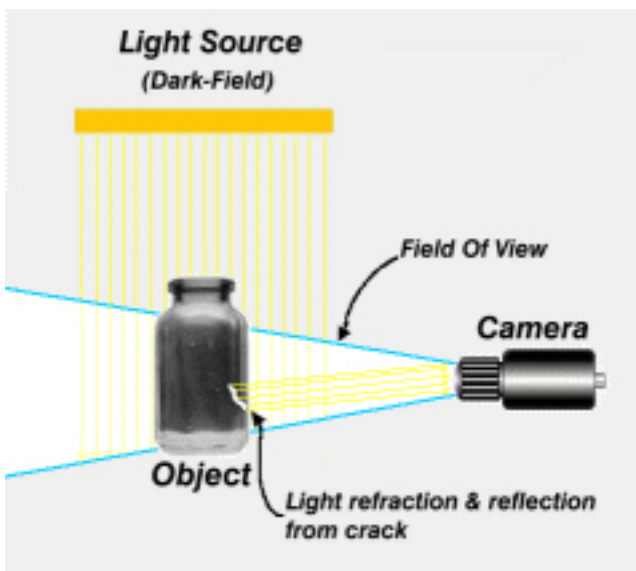
Problem:

Cracks in glass containers occurring during manufacturing and handling must be identified prior to fill operations.

Solution:

Use of a non-diffused NERLITE® Area Array in the dark field region provides light which will refract and reflect off cracks in the glass. The resulting image depicts a bright feature (the defect) on a dark background.

Illumination Example:

Good part presents a featureless dark background

Field of View (FOV)

Bad (cracked) part presents a bright, easily detected feature of interest

Field of View (FOV)

Tip #4: Use Diffused Light to Inspect Transparent Packaging

Verifying Contents of Blister Packs

What's inside that blister?

Detecting missing, damaged and/or incorrect contents in the cells of blister packages is an important inspection step for ensuring the quality of finished pharmaceutical goods. Illuminating the packages to avoid reflections from cell coverings can often be a tough challenge.

To present an accurate image of the cells and their contents to the machine vision camera, a NERLITE® CDI® (Cloudy Day Illuminator) employing white LEDs is used. The CDI eliminates reflections from the clear cell coverings, making them virtually disappear, while at the same time providing a high contrast, neutral color view of the cell contents.

Illumination Technique: Continuous Diffuse

The continuous diffuse lighting technique de-emphasizes surface textures and changes in elevation. It provides a very large solid angle of illumination to guide light rays to the object from a multitude of angles, thereby eliminating the reflections and shadows typical of unidirectional or single-plane light sources.

Problem:

Manufacturer needs to detect missing, broken and/or incorrect objects (by their shape or color) in the cells of blister packages.

Solution:

Use NERLITE® CDI® light source to bathe the object in uniform white light from every angle. This presents the camera with a glare-free image of blister pack cell contents and the clear blister coverings virtually disappear from view.

Illumination Example:

Camera
CDI Illuminator
Light Source (on-axis)
Beam Splitter
Light Source (off-axis)
Object
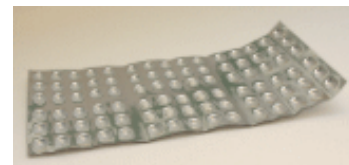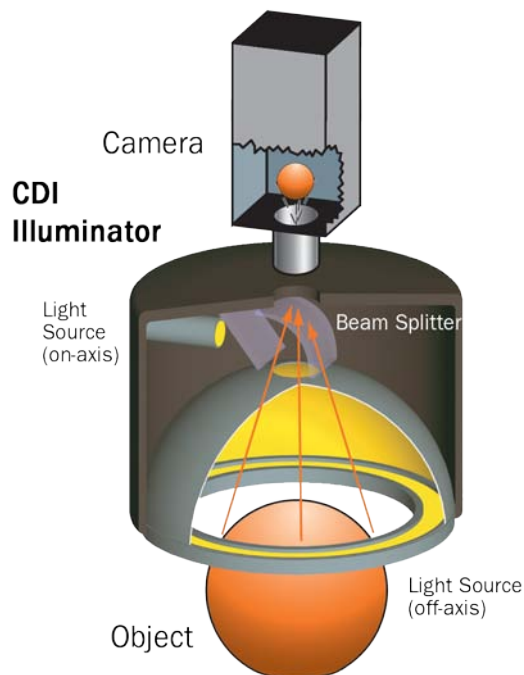
Empty wells appear dark and are easily detected by the vision system
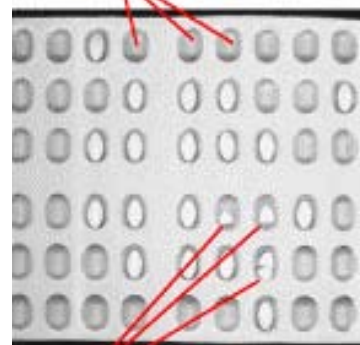
High contrast enables detection of misshapen (damaged) contents

▶ Tip #5: Use Color to Create Contrast

A useful method for creating a high contrast image in a machine vision application is to illuminate the object with light of a particular wavelength (color). A light's wavelength can make features with color appear either bright or dark to the monochrome camera. Using the color wheel as a reference, choose light of an opposing color to make features dark; choose light of the same color to make features light.
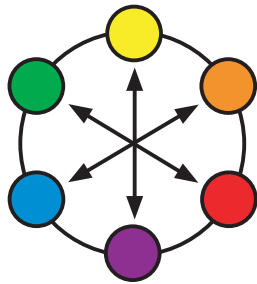
Examples:

- If the feature you want to make darker is red, use a green light.
- Use a green light to make a green feature appear lighter.
- Note the differences in red and blue lighting on printed aluminum below:

Red Illumination

Blue Illumination

▶ Tip #6: Use Strobed Light for Rapidly Moving Parts

A light should be strobed when a part is moving quickly and the image captured appears blurred. Use the formula on the right to calculate Strobe Pulse Width (maximum acceptable blur image = 1 pixel).

In the formula, field of view (FOV) and pixels are from the axis of travel. For example, assuming a typical 1 inch FOV and a 640 pixel frame, and a part speed of 500 inches per second, a strobe pulse width of 3.1 µs is needed.

$$\text{Strobe Pulse Width} = \frac{\text{Field of View (in)} \div \text{Pixels}}{\text{Part Speed (in/s)}}$$

NERLITE® strobe models are available for high speed applications

▶ Tip #7: Use Infrared Light to Eliminate Reflections

Machine vision systems rely on transitions of gray levels in a digital image. In many vision applications, ambient light (i.e. overhead room lighting) sources contribute unwanted bright reflections that make it difficult or impossible for the vision system to detect the features of interest. An infrared (IR) light source can be used to eliminate this problem.

Original Part
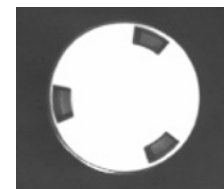
Reflection from Ambient Light Results in Inaccurate Cap Measurement

Infrared Light Removes Unwanted Reflection

▶ Tip #8: Use Infrared Light to Diminish Color Variation

Infrared light can be used to diminish the grayscale difference between colored objects. Dark objects absorb infrared light waves, thereby creating uniformity in objects of otherwise varying shades. This lighting solution facilitates detection of inconsistencies where color or shade variation is expected and should not affect inspection.

White Light
Grayscale Camera
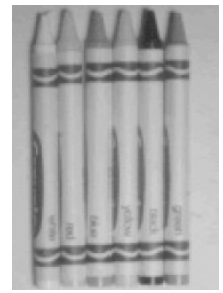
Infrared Light
Grayscale Camera

Machine Vision Lighting solutions from Microscan

Microscan's innovative NERLITE® line of products is the longest established brand of machine vision lighting, enabling machine vision and auto ID systems to perform reliably in thousands of applications worldwide.

A global technology leader with extensive solutions for ID tracking, traceability and inspection, Microscan's line of 1D and 2D barcode readers, machine vision systems, and machine vision lighting is backed by one of the world's most robust patent portfolios and years of proven performance in the field. Supported by a highly skilled global integrator network, Microscan products are known and trusted by customers worldwide for their high precision and reliability in industrial automation and control applications, with solutions ranging from basic barcode reading to complex machine vision inspection, gauging, and measurement.

More information on Microscan is available at www.microscan.com.

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