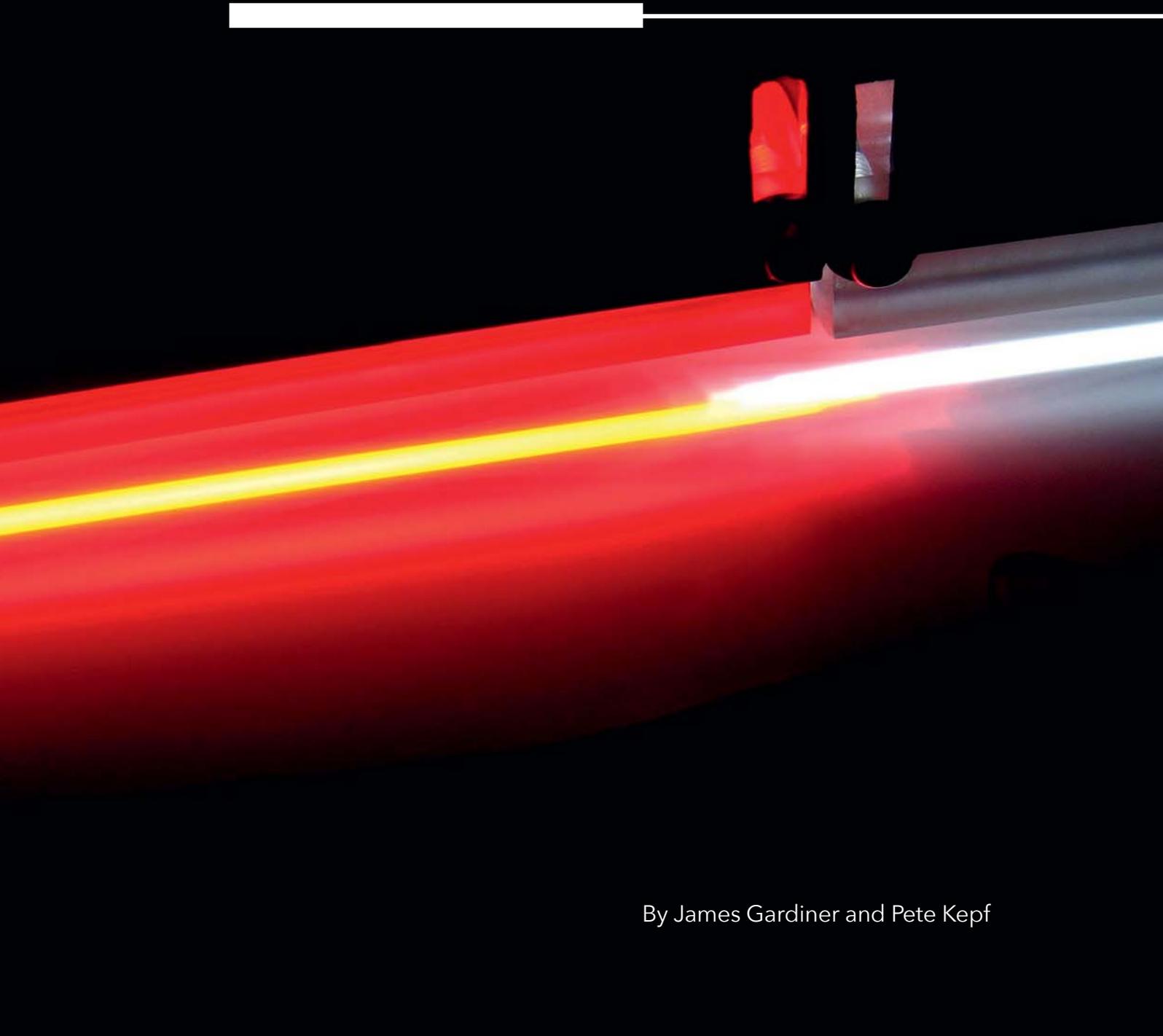


Metaphase
Technologies, Inc.

Line Scan Illumination
The Art of Line Scan



By James Gardiner and Pete Kepf

Line Scan Illumination: *The Art of Line Scan*

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Across the globe, nearly every industry continues to place greater efficiency and productivity at the forefront. From the latest smart phone that provides more functionality while using less power to the steel mill producing more, better, faster, cheaper- highly competitive global markets continue to demand more for less. Today's machine vision technology is no different. Increased productivity drives the need to image, inspect and verify parts at faster rates and with greater accuracy. One of the fastest growing machine vision segments and techniques in the market today is line scan technology. Line scanners allow higher inspection speeds and greater accuracy without sacrificing product integrity and quality.

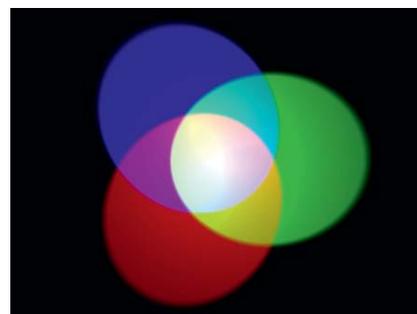
A line scan camera, as its name implies, is a single line of light sensors ("pixels"), one pixel wide by as many as 16000 long. The light sensors are similar to those of standard digital cameras in that they are sensitive to shades of gray. Unlike a standard, 2D camera, however, the line scan camera scans a product moving before it and builds up an image line by line, similar to that of a copy machine, but of course much faster and with far greater detail. Ultra high resolution snapshots allow the detection of defects as small as a micron at production speeds.

One of the most important and misunderstood aspects of line scan vision is the lighting. When most people think of line scan lighting, they usually think of a traditional line light. While a line light is a very powerful line scan illumination tool, it is not the appropriate illumination technique for every application. Recent improvements in optics, lens manufacture, and LED efficiency have brought about the development of new line scan illumination systems with previously unknown capabilities. Using its breakthrough LED and optics technology, Metaphase provides high quality LED based illumination systems that are able to solve emerging Line Scan applications typical of today's competitive markets. Following are descriptions of some of these illumination techniques and systems, their benefits, examples of applications, and guidance on specifying the correct light for the application.

The Importance of Wavelength

Visible Light and the Power of RGB Control

As with conventional vision systems, the color of light provided by the line scan illumination system can have a huge impact on image contrast and rendering. 6000K (degrees Kelvin) visible white light, currently the most popular choice, is neutral and great for enhancing product detail. A close second is the warmer 3000K, suitable for applications requiring high color rendering index (CRI) for accurate color rendering and accuracy. Although visible white light is popular and flexible, the use of specific wavelengths (colors) can often improve contrast and feature extraction. For example, the use of red (620-750nm) light enhances blue text (the complement of red) on an object, enhancing the contrast and making the text more readable. This technique is frequently used in the printing and packaging industries. Metaphase manufactures variable RGB line lights, whose output can be quickly and easily changed from any of its individual components (Red, Green, Blue) to white (R+G+B).

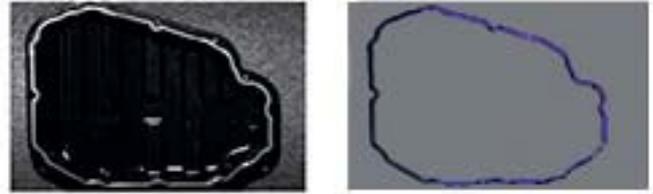


Nonvisible, Near IR Lighting

Near IR illumination has garnered significant popularity with the increased use of security cameras. Near IR illumination produces very high apparent brightness at lower power levels across significant distances. This technology has been adopted for line scan applications. Reasons to use near IR include are low cost, the invisibility (to humans) of near IR wavelengths (850nm, 880nm, 940 nm), and that the camera sensor chips have reasonable sensitivity in this range. Note that silicon, hence most types of glass, is invisible to near IR. So, special lenses must be employed to properly focus the light onto the camera sensor. Some inks are also rendered invisible to near IR. Because near IR utilizes a single wavelength, it is intensity-based (rather than color-based). Thus, near IR is particularly useful when color variations need to be ignored on web applications, such as printing and rolling metal stock.

The Rapid Expansion of UV

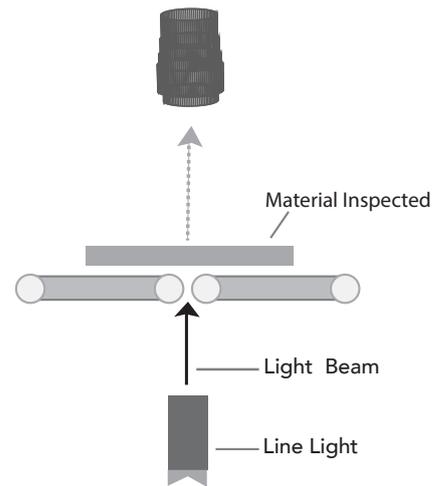
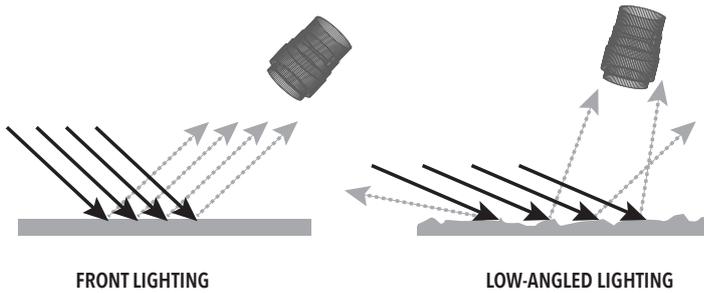
UV (365nm, 395nm) has seen huge strides and very large up ticks in market penetration over the last few years. As UV LED suppliers have made significant strides in improving the lifetime and reliability of their products, UV lighting is being applied much more frequently, particularly in Line Scan. High intensity and tight focusing of the line scan illumination optimize the output of the UV LEDs. This illumination then excites UV-sensitive material or is absorbed, releasing visible light, often either blue or green depending on the material and excitation wavelength. When the UV light is removed, the material in question no longer radiates visible light, permitting the application of bar codes and other special markings that are invisible in visible light.



The Right Light for your Application

Front and Back Line Lights

Traditional line light like the Metaphase UL and Metabright series are the preferred illumination for line scan applications. The narrow, structured beam delivers high intensity and concentrated light for the also narrow field of view of a traditional line scan camera. Intensity and uniformity are vital to producing proper part illumination. Most line scan applications are high-speed with low exposure times and insufficient light levels prevent the camera from acquiring a usable image.



Additionally, the flexibility of the beam structure allows the use of the line light for a wide variety of applications. It may be used as a front light to inspect for material defects; it may be used at an angle to obtain an off-axis effect to highlight surface defects; or, it may be placed beneath the object for a backlight effect to inspect for holes, voids, or containments. The versatility of the line light makes it a popular choice for line scan applications. Below are examples of some common Line Light applications.

The Metaphase UL and Metabright Line Lights (UL-LL & MB-LL) are available in lengths varying from 5" (127mm) to 150" (4 Meters) and options for White, Red, Green, Blue, RGB,UV or IR LEDs.

- Applications:**
- Front lighting for Webs and Objects
 - Back lighting for voids or transmission inspection
 - Surface flaw detection

Collimated Line Lights

One of the limitations of today's line lights is the ability to project a line onto far-away objects. Standard line lights are not be able to provide the tight and structured light beam across long working distances. In fact, the beams of most traditional line lights widen and lose their effectiveness beyond a 1 foot working distance. This has restricted the application of light lines to those applications where the illumination could be placed within approximately 12 inches of the object to be





inspected. Metaphase encountered this issue 5 years ago when asked to solve an application involving a projected light onto the tall ceilings of a European tunnel to inspect for cracks and voids. Oliver Szeto, President of Metaphase and 20 year veteran of LED illumination system design, created an innovative optics solution to overcome the challenge of this unique application. "With machine vision moving into new markets and inspecting a bigger variety of products, LED Illumination technology is a key component in these markets. With more and more unique applications, LED Illumination systems also need to grow to provide targeted solutions for these unique applications. Metaphase is capable and willing to provide and develop these specialized lighting solutions". Fresh from the success of Mr. Szeto's solution, the Metaphase team began equipping their Line Lights with new the optics to enable them to project more powerful structured beams at greater distances. With a new proprietary design, the Metaphase team was able to create a new lens and optics package that collimated the emitted light at a very low divergent angel. The light spreads out less over long distances.

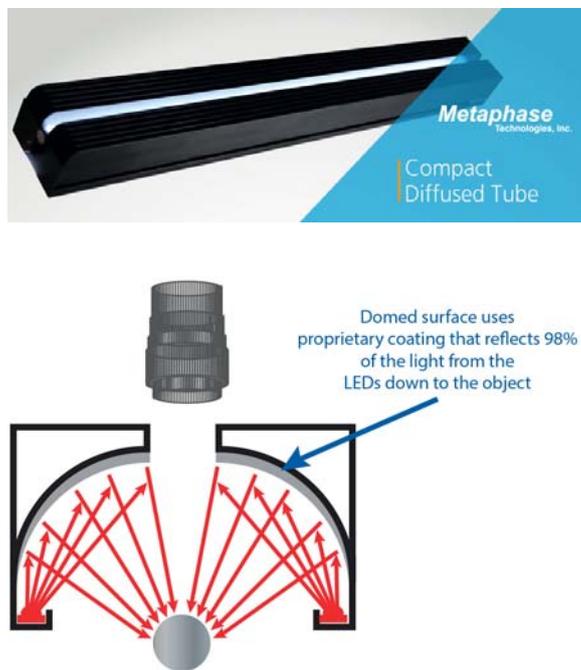
Thus, the Collimated Line Light was born.

The new, collimated line light solution greatly expanded the potential application base for line scan technology. Long working distances permit the use of a line light where spatial restrictions exist, such as in robotic work cells and high-temperature applications. Additionally, the low divergence angle is ideal for applications that are very sensitive to the angle of the light such as certain type of glass or plastic inspection. The collimated line light was a huge breakthrough for knocking down barriers of traditional line scan.

The Metaphase Collimated Line Lights (CLL) is available in lengths varying from 5" (127 mm) to 150" (4m) and options for White, Red, Green, Blue, RGB, UV or IR LEDs.

Compact Diffused Tube; Shadow-free illumination

The Compact Diffused Tube (CDT) may be one of the best kept secrets in line scan. While most people usually think of a line light as the answer for their line scan application, most people are not aware of other line scan lighting techniques. Many applications involve a shiny, reflective metallic or curved surface, and for these inspections direct line lighting is often not the optimal solution. If an area scan camera were to be employed, the use of a diffused dome, diffused tube, or flat dome would be appropriate to reduce glare and spectral reflections. But until recently these techniques were not available for line scan cameras. However, the Compact Diffused Tube now provides a diffuse lighting scheme in a high intensity, compact, on-axis design applicable to the narrow field of view of a Line Scan camera. High-intensity LEDs project their light onto a curved dome-like surface. This light is reflected onto the object to be inspected from a multi-directional source, thus providing a clear, glare-free and shadow-free image. Below you will see two images, 1 showing the object being illuminated with a traditional line light, and an image showing the improvements with the Compact Diffused Tube.



The Metaphase Compact Diffused Tube is available in lengths varying from 5" (127mm) to 120" (3 Meters) and options for White, Red, Green, Blue, UV or IR LEDs.

- Applications:**
- Reflective mirror-like surfaces
 - Metallics
 - High-gloss finishes
 - Curved or round objects

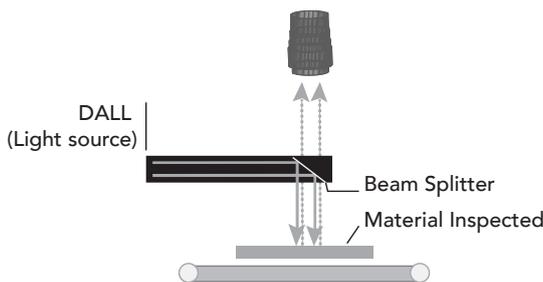
Co-Axial / DALL Illumination

Infrequently used, but irreplaceable when needed is the Co-Axial line light, or Diffused Axial Line Light (DALL). These lights incorporate a 50/50 beam splitter or mirror. The mirror permits light to enter the camera directly from the surface of the part to be inspected (illustration 1). The DALL is ideal in applications with long or varying working distances. For example, bar code reading on shipping boxes. Box height may vary, with some boxes height being taller or shorter. With the appropriate lens, the height difference need not affect the FOV, thus permitting the bar code on the top of the box to be read. The 50/50 beam splitter/mirror provides significant advantages, but it also has some limitations. The primary limitation is the loss of 50% of the illumination intensity. This is due to the fact that when the



source light passes through the beam splitter/mirror, half of the light is directed to the object and the other half is directed to the camera. Even with today's high-intensity LEDs, the DALL is not effective for very fast production lines or applications where a high amount of intensity is required.

The Metaphase Diffused Axial Line Light (DALL) is available in lengths varying from 5" (127mm) to 120" (3m) and options for White, Red, Green, Blue, or IR LEDs.



Applications:

- Application requiring light and camera to on-axis and/or the products height varies.
- High-speed bar code reading
- PCB inspection

Oblique Line Light

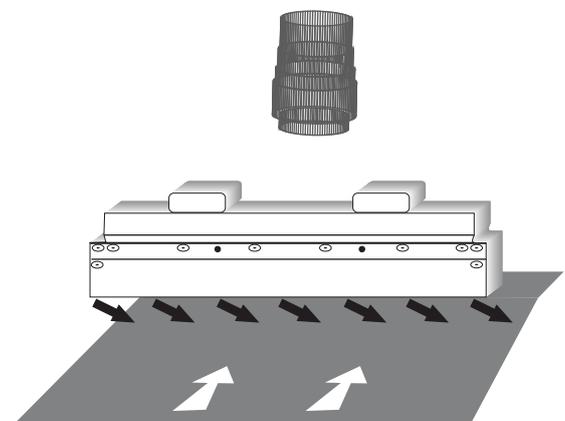
The Oblique Line Light or "wrinkle line light", is used for cross-web, dark field illumination. The light sources are angled to project the light at approximately a 30 degree angle, which is directed across the web. Light that encounters a flat surface is reflected away from the camera. Light that encounters a rise or "wrinkle" in the web is reflected into the camera and is detected as a bright spot, indicating a defect. The Oblique Line Light is effective in inspecting for cross machine direction flaws, or when a low angle line light is not suited for the application.



The Metaphase Oblique Line Light (OLL) is available in lengths varying from 5" (127mm) to 120" (3m) and options for White, Red, Green, Blue, or IR LEDs.

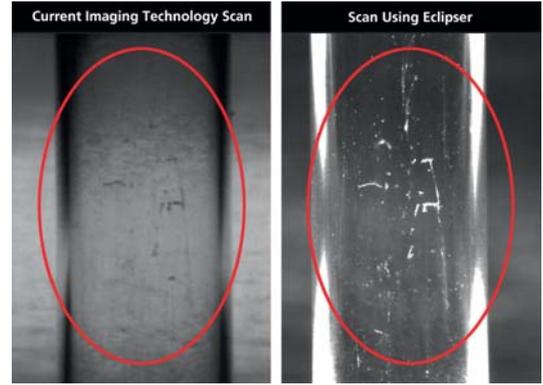
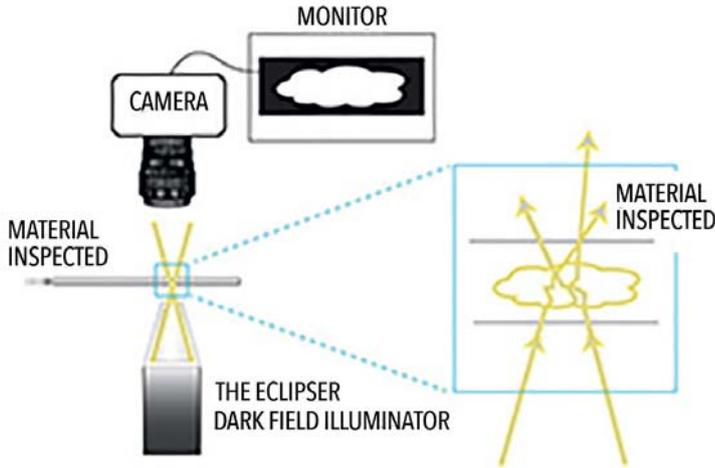
Applications:

- Cross machine direction Dark Field for flat materials such as cloth, plastics, or even coiled steel.



Dark Field Line Light - The Eclipser™

This unique, patent pending technique bends light from two parallel LED strips through specially developed optics, infusing formerly undetectable particles with illumination. The combination of strategically positioned LED lights on innovative dark strips and light projected through innovative light ray forming optics allows the discovery of previously overlooked imperfections in optically



clear glass and plastic. Much as the rays of the sun form a halo effect during a total eclipse of the moon, the tiniest particle suspended in the material being scanned "glows" as the light passes behind it. The black background of the LED strip enhances contrast amplifying even sub-micron defects.

The Eclipser™ is available in lengths varying from 5" (127mm) to 150" (3810mm) and options for White, Red, Green, Blue, or IR LEDs.

Applications:
Transparent parts such as glass or extruded or molded plastic.

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