smart vision lights
Where Innovation and Lighting Begin

TECH NOTE
PATTERNED AREA LIGHTING™
By: Jeremy Brodersen

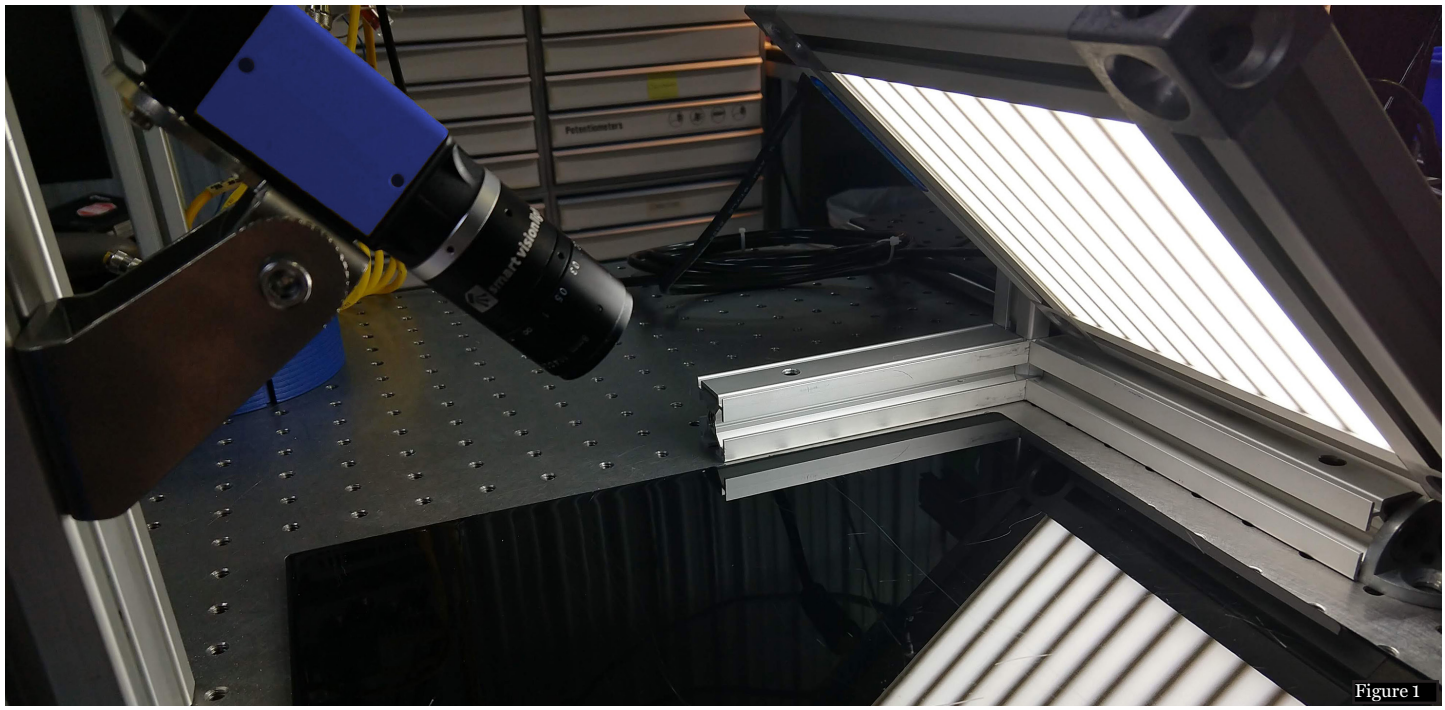

Figure 1: Patterned Area Lighting™ being used to locate flaws on a high-gloss painted surface.

PATTERNED AREA LIGHTING™ PROVIDES A SIMPLER WAY TO LOCATE FLAWS ON REFLECTIVE, TRANSPARENT, AND SEMITRANSPARENT SURFACES

Lighting selection and setup play a key role in the success of machine vision applications. When dealing with reflective, transparent, and semitransparent surfaces, locating flaws — such as chips, dents, scratches, scruffs, and even peeling paint — is a difficult task. Patterned Area Lighting™ (PAL) was developed to help simplify this task by combining 2D and 3D qualitative methods into one image. Patterned Area Lighting™ is patent pending.

Vision systems are set up to make decisions based on only what they have been programmed to evaluate, according to a very discrete set of rules or parameters. The differences between a scratch and a scuff may be simple to determine to the human eye but can be very challenging for a vision system to detect and evaluate. PAL was developed to enhance difficult-to-image flaws, allowing machine vision systems to more easily evaluate and make decisions with these types of defects.

HOW PAL WORKS

PAL works by introducing spatial variations into an area light emitter such as a backlight or front panel light. When this pattern is reflected off of a defect, the distorts the pattern causing it to show up in high contrast to the background pattern.

The biggest difference between PAL and other lighting methods is that PAL can reveal both shapes and more subtle variations, such as scratches and pits, with a single image acquisition. Depending on the application, patterns such as lines, circles, squares, checkerboards, and even zigzag lines can be selected to optimize flaw detection. Patterns are printed directly on the surface of a standard Smart Vision Lights backlight diffuser. For transparent materials, PAL is used as a backlight, where the object is placed between the light and the camera. For reflective surfaces, PAL is used as an area light, where the light is oriented at an angle to the object so the camera can capture a reflection of the PAL pattern form the object's surface. The surface of the object being inspected can be either flat or curved.

Printing the pattern directly on the diffuser allows the light to be very versatile. PAL backlights can be either area or edge lit. The light can be used as a traditional backlight or positioned at various working distances or angles from the inspected

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objects and camera to project the right-size pattern/reflection. Various sizes of lines and patterns also allow PAL to locate flaws, whereas in the past, one typically needed to use multiple lights and cameras to capture multiple images. By capturing multiple types of flaws in a single exposure, PAL helps reduce the time needed to process multiple images and reduces the cost of setting up a system to detect difficult-to-locate flaws.

REFLECTIVE SURFACES

Detecting flaws in high-gloss or semi-gloss surfaces can be a challenge. In the example to the right (Figures 2.1 and 2.2), a MOBL backlight — a 200 x 200 mm white PAL light with a gradient line pattern — was set with the light pattern reflecting at an angle of a highly glossed painted surface. The goal was to locate small pits on the painted surface. As shown in the images, a small pit is easily distinguished from the background pattern. For demonstration purposes, one can see that shifting the painted surface to the left reveals the small pit in high contrast to the background for both positions; the pit shows up as a bright spot when overlapped with a dark line and as a dark spot when overlapped with a bright line. High contrast is achieved for any position of the pit on the reflected pattern, including the gray transition area of the gray transition areas of the gradient pattern.

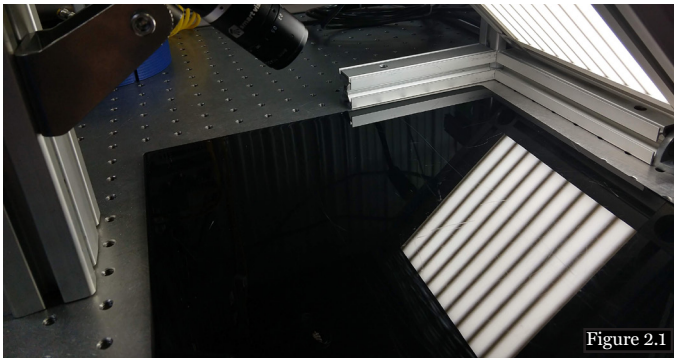
Figure 2.1

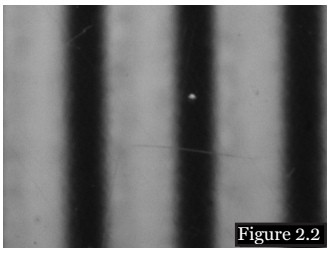
Figure 2.2

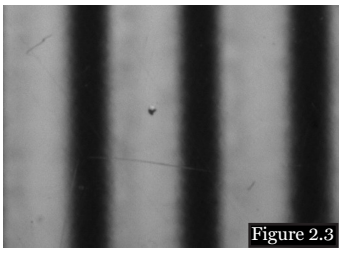
Figure 2.3

Reflective Surface: Figure 2.1 shows the setup for PAL lighting. Figure 2.2 and 2.3 show the same defect, but with the pattern shifted to show how defects appear in high contrast to both the dark (Figure 2.1) and light (Figure 2.2) lines in the background pattern.

PAL lighting is not limited to scuffs, dents, and light scratches. Deep scratches, stamped letters or slight bends can also be found in the same manner as the aforementioned defects. Stamped letters and surface bends distort the reflected pattern, while a deep scratch shows up in both the dark and light lines. This effect is due to a spatial distortion of the light path as it is deflected from features that make up the defect and can be easily discerned from the regular pattern background.

PAL can be used to look for defects on paints and coatings, including pits, scratches, pinholes, digs, orange peel, and foreign materials. It can also be used during inspection of large or very small metal parts for dents, bends, cracks, and scratches.

TRANSPARENT SURFACES

When used as a transmission light source, PAL is used like a backlight, but with the addition of high-contrast patterns that reveal subtle variations and defects in transparent objects, such as clear glass bottles. Transparent objects refract transmitted light, whereby defects distort the pattern in contrast to the regular pattern background. Defects from the transmitted pattern will show up in high contrast to the background pattern, as was the case with the reflected patterned.

In the transparent surface example shown in Figure 3,

Figure 3.1

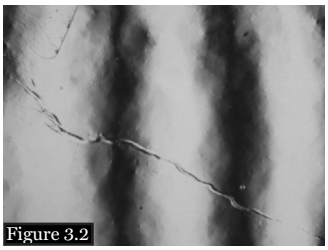
Figure 3.2

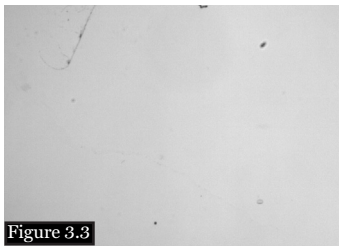
Figure 3.3

Transparent Surface: Figure 3.1 shows a setup using a SOBL PAL backlight looking for defects in a glass bottle. Figure 3.2 shows a fold in the glass bottle seen using the PAL light. In Figure 3.3, using a standard SOBL backlight, the fold is not visible.

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inspection using a PAL backlight (Figure 3.1) shows a fold in a glass bottle. As shown in Figure 3.2, for comparison, the same bottle was inspected using a standard backlight. The defects are barely discernible from the resulting image background. By using the PAL as a backlight, spatial featuring is introduced into the lighting scheme which reveals flaws in high-contrast from the background.

When inspecting transparent surfaces using a PAL backlight, dirt, scratches, bubbles, and other flaws can be detected.

USING FILTERS WITH PAL

When post processing an image using a spatial FFT bandpass filter to remove the reflected (or transmitted) pattern from the background, defects stand out for easy detection from a mostly uniform background. In the example to the right, Image J image processing software was used to remove the background pattern by applying a spatial FFT bandpass filter. A chip in the shot glass is visible with a PAL SOBL backlight (Figure 4.2). With a standard backlight, the chip is not seen, even when the same digital spatial filter is applied (Figure 4.2). By applying a spatial filter to the acquired image, the chip can easily be spotted by a vision system with the pattern removed from the background.

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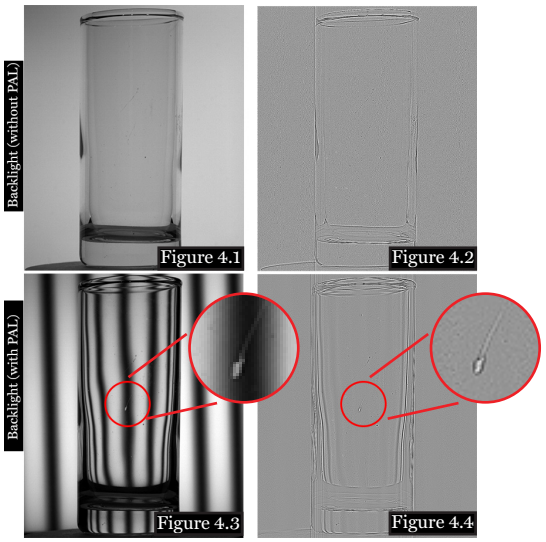

PAL and Filters: Inspecting a shot glass for chips using a standard SOBL backlight (Figure 4.1). With a spatial FFT bandpass filter applied to the image (Figure 4.2), no chip is seen. When a PAL SOBL backlight is used to inspect the same glass (Figure 4.3), a chip is visible. Applying the same filter to the image, the chip is visible with the pattern removed from the background (Figure 4.4).