ADVANCED ILLUMINATION

Application Notes & Technical Tips

Illumination Techniques for Inspecting PCBs

Fig. 1a
PCB Inspection
w/Coaxial Ring

Depending on the requirements, appropriately illuminating populated circuit boards (PCBs) for vision inspection can be challenging. PCBs are manufactured in a wide variety of sizes, shapes, finishes, colors, and with a whole host of different components, each with its own characteristics. And each board may require multiple inspections, often at multiple stations along the assembly process.

Even relatively straight-forward presence/absence (PA) surface inspections can be difficult given all the differences. If we examine a typical PCB, component and fastener PA is the most common inspection. Others include label and/or print and bar code OCR/OCV, as well as connector pin locations. In this example, the inspection process verifies the presence of a brass-colored metal screw, holding the board in place on the base of a hard-drive disk.

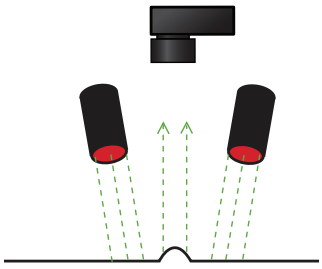

Fig. 1b
Coaxial Direct
Lighting Diagram

Fig. 1a illustrates an image taken with a typical vision system configuration using a coaxial ring light. Clearly, there are multiple difficulties in usingthis image for the inspection – whereas the human visual system can see that a screw is missing in the lower right, the vision system software may be more challenged. Finally, because the board surface is coated and thus reflective, a direct, coaxial lighting technique (Fig. 1b) was unsuitable forspecular reflective surfaces.

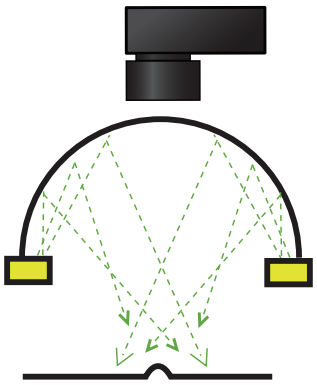

Fig. 2a
Diffuse Dome Light
Function

How might we improve on the coaxial direct lighting geometry given that the surface is specular? There are two full bright field lighting techniques for verifying the presence of a component – in this instance, the brass-colored screw – diffuse dome or axial diffuse (Figs. 2a & 2b, respectively).

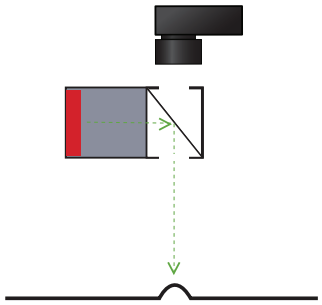

Fig. 2b
Axial Diffuse Light
Function

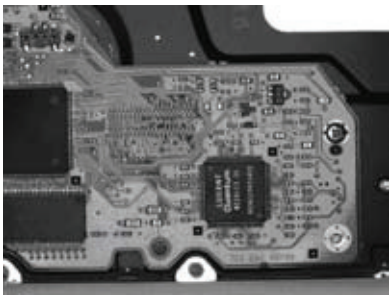

Fig. 2c
All Color Diffuse
Dome

We can examine the results of using the dome and axial diffuse lights in this sample in Figs. 2c and 2d, respectively. The diffuse dome illumination pattern is more uniform, making it more useful

Illumination Techniques for Inspecting PCBs

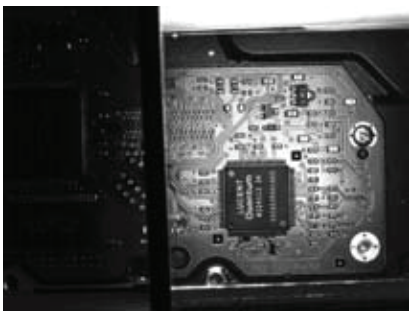

Fig. 2d
Axial Diffuse Light

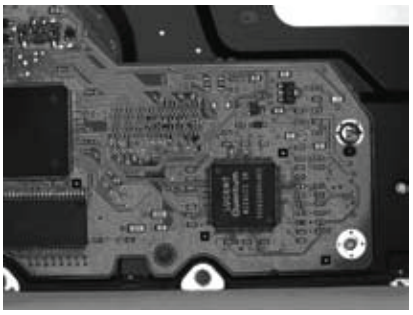

Fig. 2e
Red Diffuse Dome

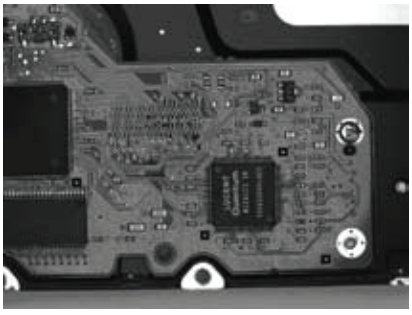

Fig. 3a
Blue Diffuse Dome

for inspecting features of interest other than the screw, and it doesn't suffer from specular reflection generated from the axial diffuse light (Fig. 2d.).

However, we notice that while there is some contrast difference in the upper right where the screw is present vs. the lower right, where it is missing, the contrast from the axial diffuse image is more pronounced. Why is this? Can we combine the best features of both lights? The primary contrast differentiator between the screw tap and the surrounding green board is which color illumination is used – in this case, the board is green, but the screw pads are copper-colored.

Based on our understanding of relationships on a color wheel of absorption vs. reflectivity (see application note, http://www.advill.com/uploads/applications/Print-Color.pdf for a review), we can infer that the red axial diffuse light was more effective than the broad-spectrum white dome light as illustrated in Fig. 2c. for enhancing copper red vs. green contrast. Fig. 2e demonstrates high contrast for a red diffuse dome light as well. However, are other colors better suited to different inspections on this PCB? Or perhaps different light techniques altogether? A blue diffuse dome light differentiates the board surface traces better than red, but as we might expect, less effectively than green (Figs. 3a & 3b).

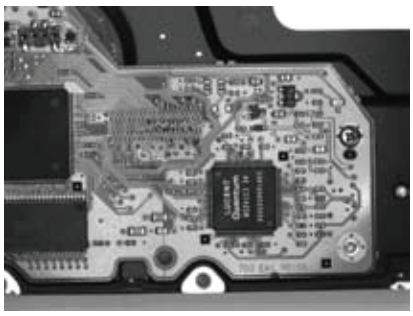

Fig. 3b
Green Diffuse Dome

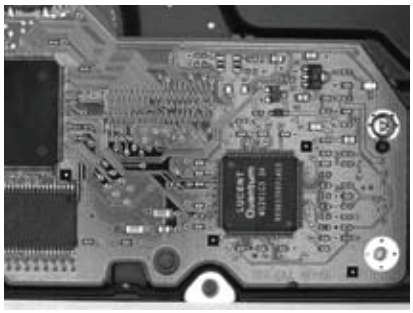

Fig. 3c
Red Flat Diffuse Dome

Fig. 3d
Flat Diffuse Light
DL083

Illumination Techniques for Inspecting PCBs

Fig. 4a
Red Coaxial DL2449

A relatively common obstacle when using a diffuse dome light, is the requirement for the light and camera to be in close proximity to the sample (See Fig. 1), and often this geometry configuration is not optimal for either ergonomic or access considerations. A flat diffuse light (Fig. 3c, DL083-660) is effective for illuminating the PCB from a longer working distance, thus allowing better near sample access.

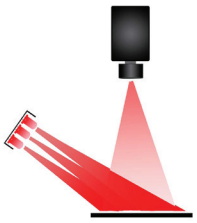

Fig. 4e
BALA Light Function

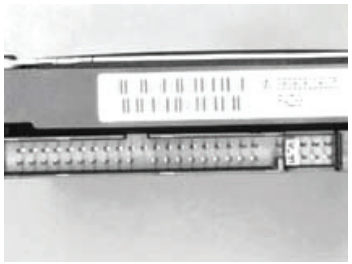

Fig. 4b
RGB Diffuse Dome
DL9160

Another typical PCB inspection is verifying connector block pin location and counts, as well as label bar codes and OCR. The challenge is to illuminate the pins uniquely, making them stand out against the background. If we review the images taken with various techniques, we see that whereas diffuse techniques work well for the board surface inspections, these techniques may not be Fig. 2e adequate for inspecting pins (Figs. 4a & 4b), particularly as they are typically recessed into the block. An effective lighting technique for this application is low angle dark field, which can be circular (Fig. 4c) or linear (Fig. 4d).

Fig. 4f
BALA AL4424

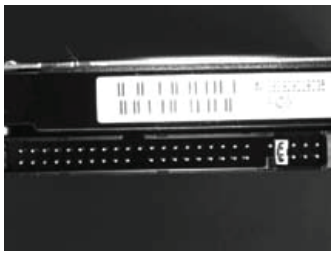

Fig. 4c
360° Low Angle Dark Field

Fig. 4d
Directional Low Angle Dark Field

If we examine the images more closely, we see that whereas the diffusetechniques (See Figs. 4a & 4b) illuminate the label well, they are largely ineffective for uniquely lighting the pins. The low angle techniques are very effective for pin count location, and also PA of bent pins, which would either show up out of the expected position, reflect differently, or perhaps be missing altogether. One obstacle to using any diffuse or circular dark field lighting technique is that the light must be directly above and relatively close to the sample, blocking potential part access by personnel or robots. The use of a BALA angled linear

Fig. 5a
Pin Block at 30° From 18”

Illumination Techniques for Inspecting PCBs

Fig. 5b
LL068E

array, however, allows for illuminating the pin block from the side (Figs. 4e & 4f), and although the pin contrast is not as intense, this technique is more effective for also illuminating the label. Thus, in this instance, this approach offers dual advantages – part access flexibility and more efficient use of the system resources - by mounting the light to the side, and by permitting 2 inspections from 1 image, respectively. Finally, the angled side lighting technique can also be used from longer distances with a more intense linear, focused light from the LL068-WHI (Figs. 5a & 5b) when more part access flexibility is needed.