Application & Technical
# NOTES & TIPS

## A **New, Effective Large-Area Diffuse** Lighting Solution

ADVANCED ILLUMINATION

November 7, 2008

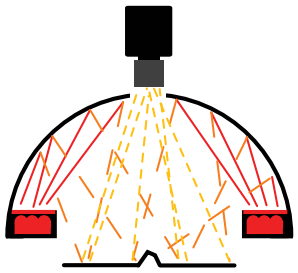

**Fig. 1a Multi-Directional Light from a Diffuse Dome**

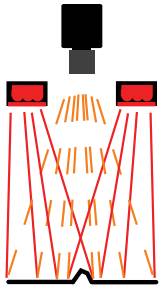

**Fig. 1b Directional Point Source Light**

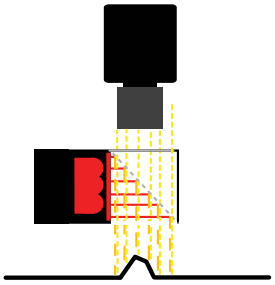

**Fig. 1c Large Solid Angle Light**

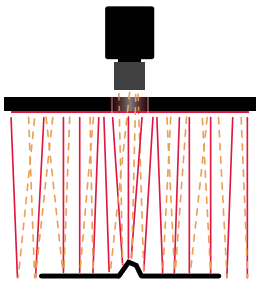

**Fig. 1d**

Diffuse lighting has taken several forms historically. It has been employed by photographers for over a century to generate portraits that are pleasing to the eye – creating images free from harsh glare, or specular reflections. It has also been used effectively in machine vision for many years, albeit on a smaller scale, with a very similar goal: to provide even contrast over areas prone to uneven reflectivity from bright-field point sources.

Recall that diffuse lighting, as currently used in machine vision applications can be classified as full bright-field, as opposed to partial bright-field, otherwise known as a directional point source lighting. The underlying concept behind full bright-field is that light is sourced from a large area, and incident on the surface from many different directions and thus angles (Fig. 1a). Compare this to a directional partial bright-field source (Fig. 1b). Specifically, as illustrated in Fig 1a, a diffuse dome illuminates from nearly an entire hemisphere; therefore it is said to have a large "solid angle." Finally, the axial diffuse light, also full bright-field, is a hybrid technique, exhibiting even light from a wide area, largely straight down onto the sample (Fig. 1c).

Whereas the diffuse dome light is very effective on specular, curved and topographic surfaces, and the axial diffuse light is effective on specular, but flat surfaces, both techniques have very specific application criteria that, under some lighting circumstances, can present a challenge. To maintain sufficient intensity and light uniformity, we must place these lights close to the sample, and we must also pair the lens focal length correctly to prevent vignetting or "port-holing" - this is particularly true of the dome light. Additionally, these lights don't adapt well to large areas, and can be expensive and hard to obtain if a large version is required.

Advanced illumination has developed a new diffuse source, the flat diffuse light (DL083) that addresses some of the application envelope short-comings of the other diffuse, bright-field lighting techniques. It is a highly diffuse source with a viewing port in the center that allows it to be used as front, or projection light (Fig. 2).

We can view images from samples that illustrate the advantages of applying the flat diffuse light, comparing other diffuse lights as well as a standard geometry directional point source – a coaxial ring light. PCBs can be challenging to light correctly, particularly those with large or odd-shaped components, like capacitors or heat sinks. Figure 3

**Fig. 2 Flat Diffuse Light (DL083)**

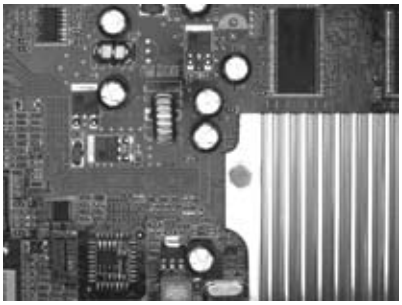

**Fig. 3a PCB, DL9160 Red Dome**

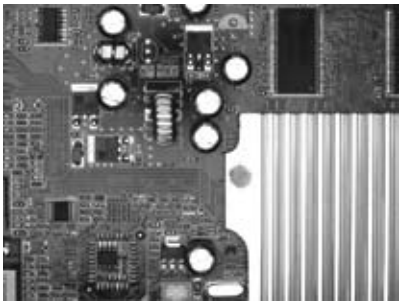

**Fig. 3b PCB, DL083 Red Flat Diffuse**

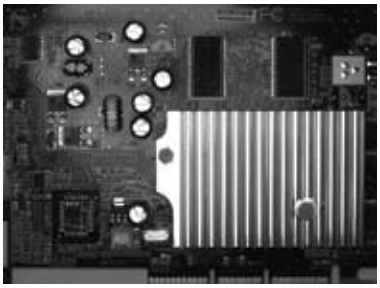

**Fig. 3c PCB, DL9160 Long Working Distance**

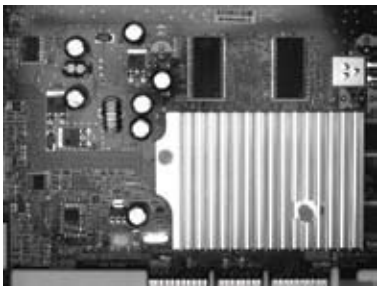

**Fig. 3d PCB, DL083 Long Working Distance**

illustrates the differences among the 3 diffuse techniques - dome, axial and flat: We see that the dome and flat techniques work equally well for relatively small areas of the PCB (Figs. 3a & 3b), but even the large diffuse dome is less effective on larger fields-of-view (Figs. 3c & 3d).

Figure 4 illustrates the limited size application of the 2"x2" axial diffuse light, where large size and set working distance is critical.

Another typically challenging sample to illuminate effectively is the biomedical culture or sample well. These samples are often presented on a tray w/ a matrix of regularly spaced wells of varying size and depth. In this particular sample, the wells are relatively small (2.5 mm wide) and shallow (1.5 mm deep), and spaced at approximately 5 wells per inch in X and Y. Additionally, each well has a laser-etched 2-D matrix code that must be read and verified by a vision system as part of an FDA-required sample correlation and history.

For illustration purposes, we can see the 2-D matrix code in close-up views (See Fig. 5) necessary for the code to be read and verified with a standard resolution CCD camera, and typical of the working distances also required for effective diffuse and coaxial point source lighting. We see also that this short working distance (2") is an

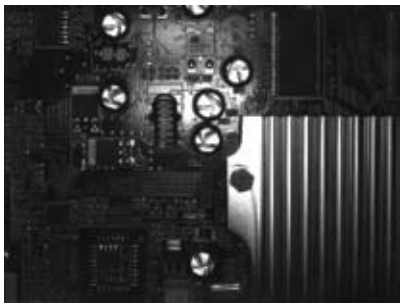

**Fig. 4 PCB, DL2449 Red Axial Diffuse**

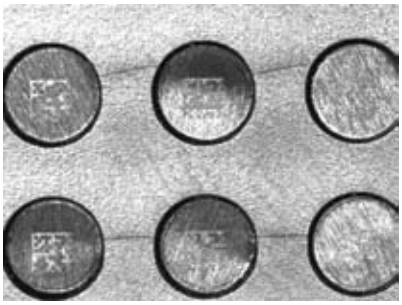

**Fig. 5a Wells, Coaxial RL1424Ring Light**

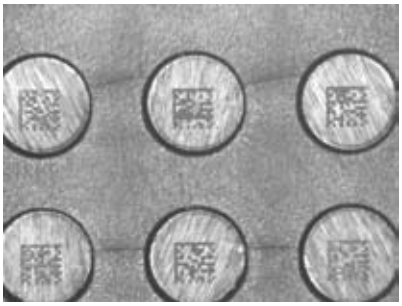

**Fig. 5b Wells, Axial Diffuse DL2449**

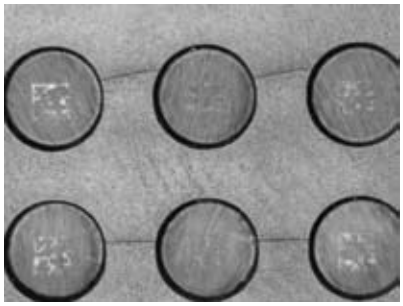

**Fig. 5c Wells, Small Diffuse Dome DL2230**

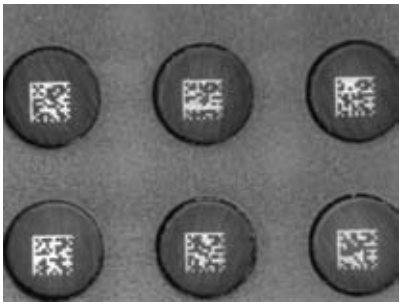

**Fig. 5d Wells, Flat Diffuse DL083**

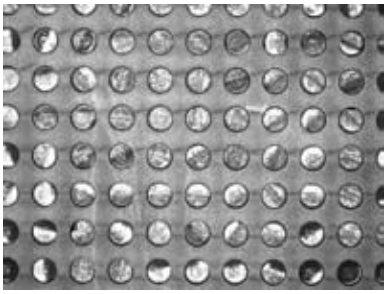

**Fig. 6a Wells, Coaxial Ring RL1424 6" Working Dstance**

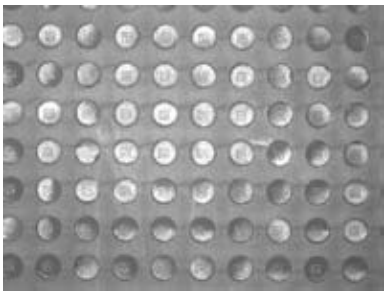

**Fig. 6b Wells, Axial Diffuse DL2449 6" Working Distance**

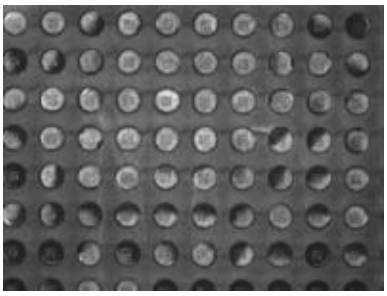

**Fig. 6c Wells, Small Diffuse Dome DL2330, 6" Working Distance**

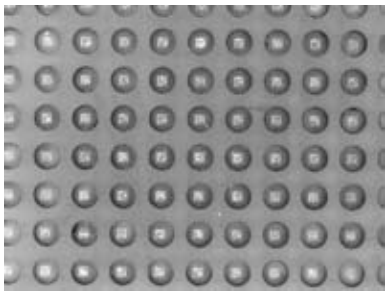

**Fig. 6d Wells, Flat Diffuse DL083 6" Working Distance**

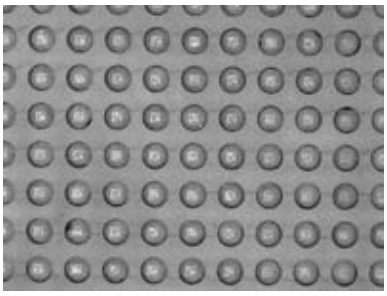

**Fig. 7a Wells, Large Diffuse Dome DL9160 6" Working Distance**

effective lighting geometry, but is not an efficient sampling strategy, as the 3" x 5" tray would require multiple X & Y traverses to inspect the entire sample.

However, if we apply the same lighting schemes to a longer working distance view, one that may only require 1-2 image frames per sample tray, we see that only the flat diffuse and the larger dome lights are effective (Figs. 6d & 7a, respectively).

Finally, the image depicted in Figure 7a demonstrates that the diffuse dome/cylinder concept effectively illuminates the cell matrices, but for larger sampling areas, we still require larger domes, which are very expensive, and often require long build times.

The DL083 light is part of the Ai "Expandable Series" of lights, and therefore we can build a light of this type from 4" x 4" to over 36" x 36" in 1" increments, all available in 2 – 4 weeks. Figure 7b illustrates the entire sample lighted using the DL083 at very long working distance, and when used in conjunction with a high-resolution CCD or CMOS camera, provides for a very robust and efficient inspection solution.

## About Ai

A lighting solutions company, Advanced illumination is based in Rochester, VT and manufactures a full line of LED-based lighting products and industry-leading control electronics, primarily for industrial vision inspection. Our technologies include Evenlite LED sorting and aiming; Signatech and Signatech 2 LED protection for maximizing both light output and LED life.

Ai sells through a world-wide network of distributors and strategic vision partners. Standard products ship same day; Standard variations offer customized options in two weeks. We also provide Free lab services and evaluation products for on-site testing.

For more information, visit us on line at the address below, or call 802.767.3830

**Fig. 7b Entire Well Tray, DL083 with Polarizer 12" Working Distance**