High-Contrast Projection Screen

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Abstract
We have developed a high-contrast ambient-light rejection projection screen with surface micro-structures for front and rear projection displays with an oblique-angle projector. We have fabricated prototype screens that show a better than 10x improvement in contrast compared to a matte-white screen under various ambient lighting conditions and screen luminance.

I. Introduction
The projection screen is one of the major components that can influence drastically the quality and the cost of a projection display system. Typically the screen accounts for approximately one third of the total cost of a rear projection system. An elaborate multi-layer laminate is usually used to obtain a good compromise among efficiency of light transmission, viewing angle and ambient light rejection. The rejection of the ambient illumination is more difficult for a front projection display due to the fact that the projector and the ambient light illuminate the same side of the screen. Several screen designs using combined surface and embedded microstructures have been shown to improve contrast [1], [2]. Recent interests in ultra-portable projectors for handheld devices [3], [4] further accentuate the need for high-contrast projection screens.

II. Our Solution
We propose an inexpensive and high-contrast micro-structured screen (HPLouver) which can be used for both the front and rear projection displays using oblique incident-angle projectors. A schematic of the projection display systems using the HPLouver Screen is depicted in Figure 1 for both a rear projection display and a front projection display.

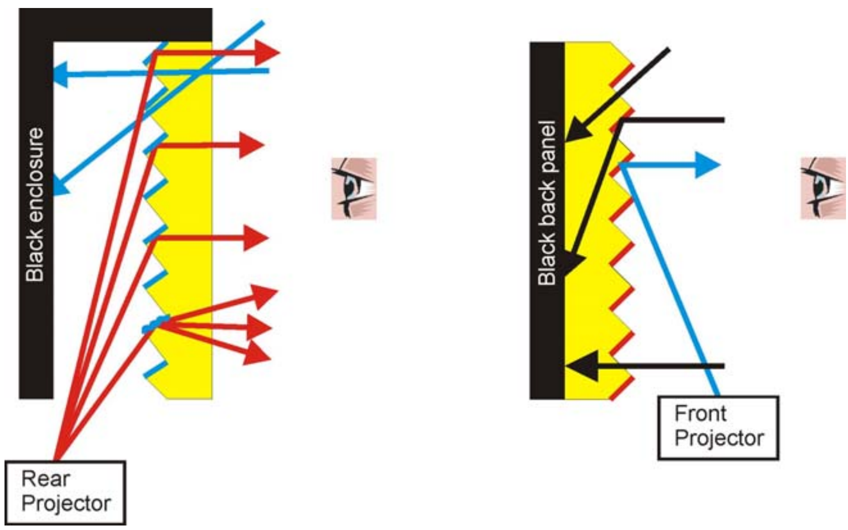


Figure 1. HPLouver Screen used with a rear projection display (left panel) and a front projection display (right panel.)

The fabrication of the HPLouver Screen starts with a sheet of clear plastic or other transparent material. An opaque material could be used for the front projection screens. Microstructures in the form of curvilinear grooves or other shapes of 3D surface reliefs with a periodicity of ~>100 µm are formed onto one of the surfaces. A thin reflecting layer, e.g., ~0.25µm of aluminum, is deposited on the downward facing sidewalls of the microstructures to form a set of reflecting surfaces for front projection applications as shown in the right panel of Figure 1. These micro-structured reflecting surfaces redirect and redistribute most of the illumination from the projector into designated viewing zones as depicted in Figure 1. Significant portion of the ambient light passes through the screen and is absorbed by the black absorber behind the screen. Some of the ambient light is reflected in directions away from the observers. A much-improved contrast is thus achieved. For rear projection applications, the reflective material is deposited on the upward facing sidewalls of the grooves as shown in the left panel of Figure 1. The viewing zone can be further tailored by controlled roughness on the reflecting surfaces as shown in Figure 1. It can also be tailored by controlling the shapes of the reflecting surfaces. The example depicted in Figure 2 shows a set of louvers consisting of sinusoidal reflecting surfaces and the effect of the shape of the louvers on the viewing angles.

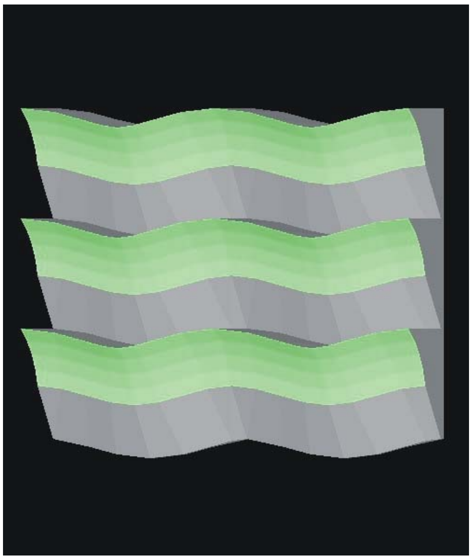


Figure 2a. Sinusoidal microstructures of the HPLouver screen.

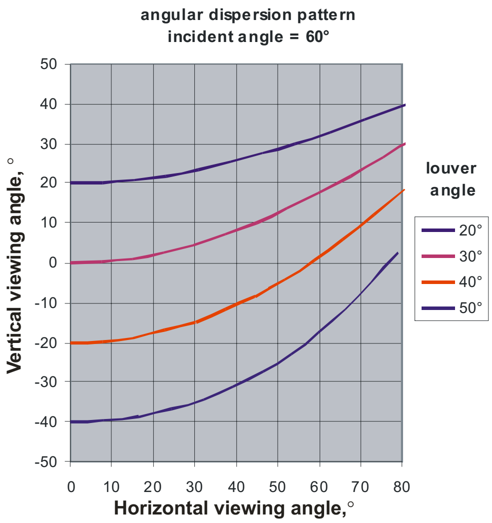


Figure 2b. Viewing angles as functions of the angle of the reflecting louvers

The improved contrast on the HPLouver Screen is accomplished without embedded microstructures used be other researchers [1], [2]. The HPLouver Screens can thus be fabricated through inexpensive hot embossing processes. We have fabricated test samples of the HPLouver Screen with several types of surface micro structures on both rigid and flexible substrates. Figure 3 shows photographs of some sample screens.

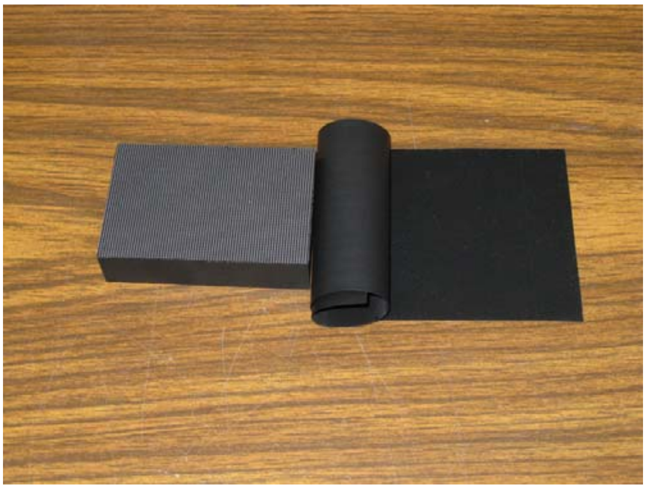


Figure 3. Sample screens on rigid (left) and flexible (right) substrates. The screens appear dark grey under typical indoor lighting conditions since the ambient light is “rejected”.

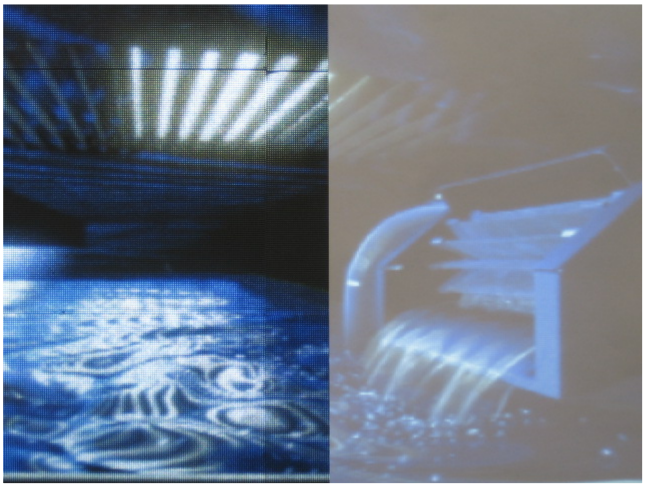
III. Results

We measured the characteristics of the HPLouver Screen in a brightly lighted environment with an illuminance of ~600 lux and ~500 lux on horizontal and vertical surfaces respectively. An NEC WT610 short-throw oblique-angle front projector is used to project images onto a ~4'x3' screen positioned vertically. Figure 4 illustrates qualitatively the visual perception of the improvement in contrast on a split-screen composed of a tiled HPLouver screen and a Daylite® matte white screens. The images on the HPLouver Screen show distinctively better contrast, darker black level and more vivid colors than the images on the matte-white screen.

On the HPLouver Screen, the luminance of the white level is ~1200 cd/m^2 and the black level is ~ 6 - 15 cd/m^2. The black level is comparable to that of an LCD monitor. On a Daylite® matte white screen, the luminance of the white level is ~850 cd/m^2 and the black level is ~120 cd/m^2. The contrast of HPLouver is ~120, while the contrast of the reference Daylite® matte white is ~8. We have achieved a ~15X improvement of the contrast.

HPLouver Screen Matte White Screen

Figure 4a



HPLouver Screen Matte White Screen

Figure 4b

IV. Summary

In conclusion, we have developed the HPLouver Screen that has superior ambient-light rejection capability and have achieved a >10x improvement in contrast over a matte-white screen. We have fabricated samples of the HPLouver Screen on both rigid and flexible substrates. Our investigation indicates that the HPLouver Screen could be manufactured inexpensively. We will demonstrate small samples of the screens at the conference.

V. References

[1] Clarex® Blue Ocean Screen, http://blueoceanscreen.com/

[2] DNP Black-Bead Screen, http://www.en.dnp.dk/get/468.html

[3] Microvision Pico Projector, http://www.microvision.com/pico_projector_displays/index.html

[4] Mint Wireless V10 Pocket Projector, http://www.mnw.com.au/default.asp?PageID=82