Textured RepTile[™] Backlight

Requirements

Models: None

Properties: None

Editions: TracePro Expert

Introduction

There are a number of optical systems that use small, repeated optical geometry to perform. Examples include the structure for backlights, brightness enhancement films, and lenslet arrays. RepTile within TracePro allows repetitive structure to be placed on planar surfaces in a number of different patterns without the need to develop each one of the geometry elements. This not only saves time during the development phase, but also time during the ray trace analysis since the computation of intercepts with the RepTile geometry is computed analytically rather than through intersections with geometry. RepTile till now (i.e., prior to Version 4.0 of TracePro) has three cases:

- Constant: the RepTile geometry (e.g., sphere radius) is constant over the Tiles (or cells) that extend across the RepTile boundary,
- Variable Rows: the RepTile geometry (e.g., sphere radius) can vary as a function of the row number over the Tiles (or cells) that extend across the RepTile boundary, and
- Parameterized: the RepTile geometry (e.g., sphere radius) can vary as a function of both the row and column numbers over the
- Tiles (or cells) that extend across the RepTile boundary.

All three of these make a single piece of geometry (e.g., a sphere) within a Tile (or cell) that has both a width and height assigned to it. The cases allow more control of the variation of the geometry as one goes down the bulleted list. However, in all cases the RepTile geometry, in a sense, is deterministic, meaning there is no ability to have a random array of RepTile geometry, multiple RepTiles per cell, and/or more complex parameterizations for the placement and shape of the RepTiles.

The development of backlights for LCD displays is typically based on proprietary and often complex algorithms. These types of backlights are getting larger and more complex to ensure transfer efficiency to the viewer while maintaining illuminance uniformity over a prescribed range of angles. The rigorous demands of optical performance enforce a sizable amount of desired control of the luminance function of the backlight. Simply said, the three previously described methods may be too limiting for the development of large, complex, state-of-the-art backlit LCD displays. A new tool that allows the TracePro user to call upon previous designs that incorporate tailored structure that can be applied to surfaces in a backlit display are required. This new tool is called Textured RepTile.

Textured RepTile allows the user to import a RepTile property from a text file. This text file includes the type of RepTile geometry, the parameters for describing each of the RepTile features, positioning of each feature, and the orientation of the feature (i.e., hole or bump). In Version 4.0 of TracePro, this new RepTile method is introduced, and in its initial implementation it is limited to the Sphere RepTile geometry.

The remainder of this tutorial discusses how to create, import, apply, and ray trace a Textured RepTile that is applied to a backlight for a LCD. A constant pattern Texture pattern is applied to the back surface of the backlight, while a single cold cathode fluorescent lamp (CCFL) and injector reflector are used. This model provides the first iteration in the development of a Textured RepTile backlight – the user must optimize the performance of it separately. Optimized performance implies a uniform luminance distribution over a prescribed set of angles (e.g., $\pm 45^{\circ}$). In the next section, the development of the backlight is discussed. In the third section, the development of the Texture is presented. Finally, in the last section the ray-trace results are given.



Backlight Geometry

A backlight for an LCD is at first level made of the following components:

- A thin sheet of plastic, such as acrylic, on which the back surface has structure placed. A reflective coating can be added on three of the four edges, while the remaining thin edge is at worst bare (i.e., anti-reflection coatings could be placed here).
- A reflector is placed on the one bare edge such that it runs the length of the plastic backlight. This reflector is some type of conic, such as circular, elliptical, or parabolic. Its output aperture is matched to the size of the bare edge of the plastic.
- A CCFL of small diameter is placed within the reflector. Positioning of the CCFL is typically not critical except for its absorption of rays re-incident upon it.
- A highly reflective diffuser is placed below the plastic backlight. The bottom of the backlight is the surface on which the Texture is placed.
- Finally, an observation plane is placed just above the output surface of the backlight plastic. The output surface is the one opposite of the Textured surface.

There are a multitude of additional items that can be included in the model, including, brightness enhancement films, a wedge on the plastic backlight, the liquid crystal elements, additional diffusers, and the packaging around the backlight. For the purposes of this tutorial, we will "simplify" the development to only include the elements listed in the bulleted list above. Optimization of the system would include additional elements, structure, and optical properties. The purpose is to show how to implement Textured RepTile, and leave the optimization of the backlight to the user for their desired application. For the remainder of this tutorial, the following terms are used:

- Backlight = the thin sheet of plastic,
- Injector = the reflector that injects the light into the plastic,
- CCFL = the source placed within the injector,
- Feature = the individual spheres that are within the Texture file,
- Textures = the complete set of Features comprised by the Texture file,
- Diffuser = the highly reflective diffuser placed below the Textured surface of the backlight, and
- Screen = the surface on which we sample the output distribution from the backlight, where the term Observation indicates the surface on which we do this sampling.



Creating the Backlight

We first create a square acrylic backlight with dimensions of 100 mm x 100 mm x 5 mm (XYZ). This solid is centered along the z direction. Figure 1 shows the dialog, Insert>Primitive Solid...>Block, for this structure. We retain, at this time, the default bare surfaces on the two large surfaces and the edge in the +y direction. As shown in Fig. 2, for the three remaining surfaces we place the Mirror Surface property within the Default Catalog. Here are the steps for the process described here:

- I. Open a New model window,
- 2. Select Insert>Primitive Solid...>Block,
- 3. Enter the values as shown in Fig. 1,
- 4. Select Insert from the dialog,
- 5. Rescale the model window by first selecting the backlight and then View>Zoom>Selection,
- 6. Select Backlight Surfaces 2, 3, and 5 with CTRL left clicks,
- 7. Right click on one of these three surfaces and select Properties... from the pop-up menu, or select the icon,
- 8. Select the Surface tab,
- 9. Enter the parameters as shown in Fig. 2,
- 10. Select Apply from the dialog,
- II. Select the Material tab,
- 12. Enter the parameters as shown in Fig. 3,
- 13. Select Apply from the dialog,
- 14. You can Close the open dialogs, but it is not necessary,
- 15. Rename Surface 1 to Texture. To do this select it twice with a left click. When a rectangle appears around its current name, enter the new name. This is the surface on which we will later apply the Texture File, and
- 16. As per Fig. 4, inspect the System Tree such that the properties for Backlight are as shown (Note: Fig. 4 also shows all of the other objects that we will define in this section.)



🗖 Insert Primitive Solids 🛛 🔲 🔀
Block Cylinder/Cone Torus Sphere Thin Sheet
Name: Backlight
Width X: 100 Y: 100 Z: 5
Center Position Rotation
X: 0 X: 0
Y: 0 Y: 0
Z: 0 Z: 0
in Degrees
Insert Modifu

Figure 1. Parameters to Insert the Backlight.

Apply Properties
Importance Sampling Exit Surface Diffraction Raytrace Flag Mueller Matrix Gradient Index Bulk Scatter Temperature Class and User Data RepTile Temperature Distribution Fluorescence Material Surface Surface Source Prescription Color
Catalog: Default Name: Mirror
Description: Standard Mirror Scatter: ABo Scatter
Reference Data
Angles measured in Air - Refractive Index = 1.0 Angles are corrected by Snell's law and the refractive index on either side of the Surface Property. Select measured index reference of Surface Property data.
Apply View Data

Figure 2. Apply properties for Mirror application.

Apply Properties	
Importance Sampling Exit Surfa Mueller Matrix Gradient Index Class and User Data RepTile T Material Surface Surface	ace Diffraction Raytrace Flag Bulk Scatter Temperature emperature Distribution Fluorescence Source Prescription Color
Catalog: PLASTIC	
Name: Acrylic	•
Display of index and absorptanc	e for given wavelength
Wavelength: 0.5461	um
Index: 1.49309	Absorption Coef: 0
Transmission 1	through 10 mm
The wavelengths use are set using the Ra	ed during the Raytrace ytrace Options dialog
_ ⊂ Current Material on selected Obj	ect
Acrylic from: PLASTIC	
If <none> is displayed: Check the TracePro Database For the catalog and name.</none>	
Ap	ply View Data

Figure 3. Apply properties for the Backlight Material.



TracePro Expert - [Model:[Backlight_TextureTest1.oml]]	
🌒 Eile Edit View Insert Define Analysis Reports Iools Macros Window Help	_ = ×
Impector Impector	
For Help, press F1	X:0.0000 V:-8.4207 7:-86.2116 millimeters
ronnop, proser a	A.0.0000 1.00.7207 2.700.2110 mmm0/clcs

Figure 4. System Tree results for the surfaces of Backlight (except Texture).



Creating the Injector

We will now create the reflector called the Injector, which injects all of the emitted rays into the backlight. The steps for doing this are:

- I. Select Insert>Reflector...>Trough(Cylinder),
- 2. Enter the values as shown in Fig. 5,
- 3. Select **Insert** from the dialog,
- 4. Select Insert>Primitive Solid...>Block,
- 5. Enter the values as shown in Fig. 6,
- 6. Select Insert>Primitive Solid...>Block,
- 7. Enter the values as shown in Fig. 6, but set X: to 50.25 and Name: to Endcap2,
- 8. With CTRL left clicks, first select Injector, then the two End Caps,
- 9. Select Edit>Boolean>Unite,
- 10. Rescale the model window by first selecting Injector and then View>Zoom>Selection,
- II. Select all Injector surfaces or the Injector object,
- 12. Right click on one of the selected objects or surfaces and select **Properties**... from the pop-up menu, or select the icon,
- 13. Select the **Surface** tab,
- 14. Enter the parameters as shown in Fig. 7,
- 15. Select Apply from the dialog,
- 16. You can **Close** the open dialogs, but it is not necessary, and
- 17. As per Fig. 8, inspect the System Tree such that the properties for Injector are as shown (Note: Fig. 8 also shows all of the other objects that we will define in this section.)



🗖 Insert Reflector
Compound Trough Rectangular Concentrator Facetted Rim Ray Conic 3D Compound Trough (Cylinder)
Name: Trough Reflector 1
Shape: Parabolic
Length: 100 Slit width: 0
Thickness: 0.5 Slit length: 0
Depth: 5
Foci
Focal length: 0.3125 N/A 0
Origin
X: 0 X: 90
Y: 55 Y: 0
Z: 0 Z: 0
in Degrees
Insert Modify

🗖 Insert Primitive Solids
Block Cylinder/Cone Torus Sphere Thin Sheet
Name: Endcap1
Width X: 6 Y: 5.5 Z: 0.5
Center Position Rotation X: -50.25 X: 0 Y: 52.75 Y: 90 Z: 0 Z: 0 in Degrees In Degrees In Degrees
Insert Modify

Figure 6. Parameters to Insert the 2 Endcaps.

Figure 5. Parameters to Insert the Backlight.

🗖 Apply Properties 📃 🗖 🔽
Importance Sampling Exit Surface Diffraction Raytrace Flag Mueller Matrix Gradient Index Bulk Scatter Temperature Class and User Data RepTile Temperature Distribution Fluorescence Material Surface Surface Source Prescription Color
Catalog: Default Name: Mirror Description: Standard Mirror
Scatter: ABg Scatter
Reference Data Type: Table, no polarization, no retroreflector Reference Material
Angles measured in Air - Refractive Index = 1.0
Angles are corrected by Snell's law and the refractive index on either side of the Surface Property. Select measured index reference of Surface Property data.
Apply View Data

Figure 7. Apply properties for Mirror application.





Figure 8. System Tree examples for the surfaces of the injector.



Creating the CCFL

We will now create the source called the CCFL, which is a tubular fluorescent lamp. The steps for doing this are:

- I. Select Insert>Primitive Solid...>Cylinder/Cone,
- 2. Enter the values as shown in Fig. 9,
- 3. Select **Insert** from the dialog,
- 4. Rescale the model window by first selecting CCFL and then **View>Zoom>Selection**,
- 5. Select all CCFL surfaces or the CCFL object,
- 6. Right click on one of the selected objects or surfaces and select **Properties**... from the pop-up menu, or select the icon,
- 7. Select the **Surface** tab,
- 8. Enter the parameters as shown in Fig. 10,
- 9. Select **Apply** from the dialog,
- 10. Select Surface 0 of the CCFL,
- II. Select the **Surface Source** tab,
- 12. Enter the parameters as shown in Fig. 11,
- 13. Select **Apply** from the dialog,
- 14. You can **Close** the open dialogs, but it is not necessary, and
- 15. As per Fig. 12, inspect the System Tree such that the properties for CCFL are as shown (Note: Fig. 12 also shows all of the other objects that we will define in this section.)



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Figure 9. Parameters to Insert the CCFL.

Apply Properties
Importance Sampling Exit Surface Diffraction Raytrace Flag Mueller Matrix Gradient Index Bulk Scatter Temperature Class and User Data RepTile Temperature Distribution Fluorescence Material Surface Surface Source Prescription Color
Catalog: Default
Name: Fluor White
Description:
Scatter: ABg Scatter
Reference Data Type: Table, no polarization, no retroreflector Reference Material
Angles measured in Air - Refractive Index = 1.0
Angles are corrected by Snell's law and the refractive index on either side of the Surface Property. Select measured index reference of Surface Property data.
Apply View Data

Figure 10. Apply properties for Fluor White.

Apply Properties
Importance Sampling Exit Surface Diffraction Raytrace Flag Mueller Matrix Gradient Index Bulk Scatter Temperature Class and User Data RepTile Temperature Distribution Fluorescence Material Surface Surface Source Prescription Color
Source Type: Flux
Flux: 1000 lumens Total Rays: 1000000
Total Power: 0
Wave. (um) Weight Power (lm)
0.5461 1 0
Angular Distribution: Lambertian
Color:
Suppress random rays (Requires Source Importance Sampling)
Apply Calculate Power

Figure 11. Setting the Surface Source Parameters for the CCFL.





Figure 12. System Tree for the surfaces of the CCFL.



Creating the Diffuser

We will now create the Diffuser, which is placed below the Backlight>Texture surface. The steps for doing this are:

- I. Select Insert>Primitive Solid...>Block,
- 2. Enter the values as shown in Fig. 13,
- 3. Select **Insert** from the dialog,
- 4. Rescale the model window by first selecting Diffuser and then View>Zoom>Selection,
- 5. Select all Diffuser surfaces or the Diffuser object,
- 6. Right click on one of the selected objects or surfaces and select Properties... from the pop-up menu, or select the icon,
- 7. Select the **Surface** tab,
- 8. Enter the parameters as shown in Fig. 14,
- 9. Select Apply from the dialog,
- 10. You can **Close** the open dialogs, but it is not necessary, and
- 11. As per Fig. 15, inspect the System Tree such that the properties for Diffuser are as shown (Note: Fig. 15 also shows all of the other objects that we will define in this section.)

Insert Primitive Solids	
Block Cylinder/Cone Torus	Sphere Thin Sheet
Name: Diffuser	
Width X: 100 Y: 100	Z: 0.1
Center Position Ro	tation X: 0 Y: 0 Z: 0
2: [-2.30]	in Degrees
Insert	Modify

Figure 13. Parameters to Insert the Diffuser.

Apply Properties	
Importance Sampling Exit Surface Diffraction Raytrace Flag Mueller Matrix Gradient Index Bulk Scatter Temperature Class and User Data RepTile Temperature Distribution Fluorescence Material Surface Surface Source Prescription Color	
Catalog: Default	
Name: Flat white paint	
Description: 90% diffuse reflecting	
Scatter: ABg Scatter	
Reference Data	
Reference Material	
Angles measured in Air - Refractive Index = 1.0 Angles are corrected by Snell's law and the refractive index on either side of the Surface Property. Select measured index reference of Surface Property data.	
Apply View Data	

Figure 14. Apply properties for Diffuse White.





Figure 15. System Tree for the surfaces of the Diffuser.



Creating the Screen

We will now create the Screen, which is placed above the Backlight>Surface 0 surface. The steps for doing this are:

- I. Select Insert>Primitive Solid...>Block,
- 2. Enter the values as shown in Fig. 16,
- 3. Select **Insert** from the dialog,
- 4. Rescale the model window by first selecting Diffuser and then **View>Zoom>Selection**,
- 5. Select all Screen surfaces or the Screen object,
- 6. Right click on one of the selected objects or surfaces and select **Properties**... from the pop-up menu, or select the Apply Properties icon.
- 7. Select the **Surface** tab,
- 8. Enter the parameters as shown in Fig. 17,
- 9. Select Apply from the dialog,
- 10. Select Surface 1 of the Screen twice with left clicks,
- II. Rename Observation,
- 12. Select the **Exit Surface** tab,
- 13. Enter the parameters as shown in Fig. 18,
- 14. Select Apply from the dialog,
- 15. You can **Close** the open dialogs, but it is not necessary, and
- 16.As per Fig. 19, inspect the System Tree such that the properties for Screen are as shown (Note: Fig. 19 also shows all of the other objects that we will define in this section.)



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🗖 Insert Primitive Solids
Block Cylinder/Cone Torus Sphere Thin Sheet
Name: Screen
Width X: 100 Y: 100 Z: 0.1
Center Position X: 0 Y: 0 Y: 0 X: 0 Y: 0
Z: 2.551 Z: 0 in Degrees
[Insett] Modify

Figure 16. Parameters to Insert the Screen.

Apply Properties			
Mueller Matrix Gradient Index Bulk Scatter Temperature Class and User Data RepTile Temperature Distribution Fluorescence Material Surface Surface Source Prescription Color Importance Sampling Exit Surface Diffraction Raytrace Flag			
Check to make selected surface(s) to be used to collect data during Simulation Mode raytrace. 🔽 Exit surface			
Reverse raytrace Number of reverse rays: 0			
Predefined irradiance map orientation			
Name:			
Normal Vector:			
Up Vector:			
Add Modify Delete			

Figure 18. Setting of Exit Surface for Screen > Observation.

Apply Properties		
Importance Sampling Exit Surface Diffraction Raytrace Flag Mueller Matrix Gradient Index Bulk Scatter Temperature Class and User Data RepTile Temperature Distribution Fluorescence Material Surface Surface Source Prescription Color		
Catalog: Default Name: Perfect Absorber		
Description: 100% absorbing, no reflectance or transmittance		
Scatter: No Scatter		
Reference Data Type: Table, no polarization, no retroreflector Reference Material		
Angles measured in Air - Refractive Index = 1.0		
Angles are corrected by Snell's law and the refractive index on either side of the Surface Property. Select measured index reference of Surface Property data.		
Apply View Data		

Figure 17. Apply properties for Perfect Absorber.



TracePro Expert - [Model:[Backlight_TextureTest1.oml]]	
III Edit View Insert Define Analysis Reports Tools Macros Window Help	_ 8 ×
	🗧 號 🔤 🖬 🖾 🐘 🕵 🕵
B: UCFL B: Backlight B: Uffuser B: Surface D Surface Dotat from: Default - Surface Property: Perfect Absorber - Plane B: Ufface Property: Perfect Absorber - Plane B: Surface Data from: Default - Surface Property: Perfect Absorber - Plane B: Surface Data from: Default - Surface Property: Perfect Absorber - Plane B: Surface Data from: Default - Surface Property: Perfect Absorber - Plane B: Surface A - Surface Property: Perfect Absorber - Plane B: Surface Property: Perfect Absorber - Plane B: Surface A - Surface Property: Perfect Absorber - Plane B: Surface Property: Perfect Absorber - Plane B: Surface Data from: Default - Surface Property: Perfect Absorber - Plane B: Surface Data from: Default - Surface Property: Perfect Absorber - Plane B: Surface Data from: Default - Surface Property: Perfect Absorber - Plane B: Surface Data from: Default - Surface Property: Perfect Absorber - Plane B: Surface Data from: Default - Surface Property: Perfect Absorber - Plane B: Surface Property: Perfect Absorber - Plane - Surface Data from: Default - Surface Property: Perfect Absorber - Plane - Surface Property: Perfect Absorber - Plane - Surface Data from: Default - Surface Property: Perfect Absorber - Plane - Surface Property: Perfect Absorber - Plane - Surface Property: Perfect Absorber - Surface Property: Perfect Absorber - Plane - Surface Property: Perfect Absorber - Surf	
For Help, press F1	X:-50.2454 Y:52.7500 Z:-2.9890 millimeters X:0.0000 Y:37.4898 Z:-88.0394 millimeters

Figure 19. System Tree for the surfaces of the Screen.

You have now completed the geometry, except for the setup and designation of the Textured RepTile surface on the Backlight>Texture surface. In the next section we describe how to do this.



Setup and Application of the Textured RepTile

There are two steps to this process: creation of the Textured RepTile property and application of the Textured RepTile to a planar surface. Each of these steps is described in the following sections.

Creating the Textured RepTile Property

We will now create the Textured RepTile Property, which is placed on the Backlight>Texture surface. The steps for doing this are:

- I. Select Define>Edit Property Data...>RepTile Properties...,
- 2. Select Add Property... (in the desired Catalog) in the left-hand part of the RepTile Editor (see Fig. 22),
- 3. Enter the data as shown in Fig. 20,
- 4. Left click on **OK**,
- 5. Select the browse button (...) to the right of the File: line in the upper part of the RepTile Editor (see Fig. 22),
- 6. From the Open dialog (Fig. 21), navigate to the location of TextureTest I,
- 7. Select it and left click on **Open**,
- 8. Enter the **Def. Width** and **Def. Height** parameters as shown in Fig. 22.
- 9. Click on **Save** and click **OK** on the confirmation dialog.
- 10. Exit the RepTile Editor.

Enter New RepTile Property	×
RepTile Property Name:	
TextureTest1	
Adding to Catalog: Default	
Geometry Type: Texture File	•
Tile Type: Rectangles	•
Variation Type: Constant	•
OK Cancel	

Figure 20. Enter New RepTile Property dialog.

Open					? 🗙
Look jn:	Canal Texture Tutori	ials	•	- 🗈 💣 🎟 -	
My Recent Documents Desktop My Documents My Computer	TextureTest1.t	xt xt xt xt			
My Network Places	File <u>n</u> ame: Files of type:	TextureTest1.txt Texture File (*.txt)		•	<u>O</u> pen Cancel

Figure 21. Open Texture File dialog.



🕼 TracePro Expe	ert - [RepTile Property Editor]			- 7 🛛
Eile Edit View	Define Window Help			- 8 ×
		8 0 • • • • • • • • • • • •		
		* 🖉 🖌 💊 💥		
Catalog	Catalog: Default Name: TextureTest1			
Add Catalog	Description:Bump_			
Add Property	RepTile Type Tile Parameters			
Delete Property	Geometry Type: Texture File Def Width: 1			
Copy Property	Tile Type: Rectangles Def Height: 1			
Data Points	Variation Type: Constant File: C:\Texture Tutorials\TextureTest1.txt			
Terrent 1				
Inser				
Delete				
<	Table			
For Help, press F1		X:-50.2454 Y:52.7500 Z:-2.9890 millimeters	X:0.0000 Y:37.4898 Z:-88.0394 millimeters	

Figure 22. The final RepTile Property Editor for TextureTest I Property.



Applying the Textured RepTile Property

We will now apply the Textured RepTile Property, which is placed on the Backlight>Texture surface. The steps for doing this are: 1. Select the surface **Backlight>Texture** as defined in Step 12 of Creating the Backlight,

- 2. Right click on **Backlight > Texture** and select **Properties**... from the pop-up menu, or select the Apply Properties icon.
- 3. Select the **RepTile** tab,
- 4. Enter the parameters as shown in Fig. 23,
- 5. Select **Apply** from the dialog,
- 6. You can **Close** the open dialogs, but it is not necessary, and
- 7. As per Fig. 24, inspect the System Tree such that the properties for Backlight are as shown (Note: Fig. 24 also shows all of the other objects.)

Apply Properties				
Importance Sampling Exit Surface Diffraction Raytrace Flag Mueller Matrix Gradient Index Bulk Scatter Temperature Material Surface Surface Source Prescription Color Class and User Data RepTile Temperature Distribution Eleverance				
Property Data				
Catalog: Default				
Name: TextureTest1				
Texture File				
Surface Catalog: Default				
Surface Name:				
Boundary and Orientation				
Rectangular Vidth: 99 Height: 99 Depth: 0.5				
Boundary Center Texture Origin Texture Up Boundary Up				
x 0 x 0 x 0				
Y: 0 Y: 0 Y: 1 Y: 1				
Z: <mark>-2.5</mark> Z: <mark>-2.5</mark> Z: 0 Z: 0				
Pixel Dimensions				
Width: 1 Height: 1				
Export Apply View Data				

Figure 23. Apply Texture Test I to the Backlight > Texture surface.



🚯 TracePro Expert - [Model:[Backlight_TextureTest1.om1]]	
🜒 Eile Edit View Insert Define Analysis Reports Iools Macros Window Help	_ @ ×
Image: Surface 0 Image: Surface 0 Image: Surface 0 Image: Surface 0 Image: Surface 1 Image: Surface 3 Image: Surface 3 Image: Surface 3 Image: Surface 3 Image: Surface 4 Image: Surface 3 Image: Surface 4 Image: Surface 4 Image: Surface 4 Image: Surface 5 Image: Surface 7 Image: Surface 7 Image: Surface 7 Image: Surface 8 Image: Surface 9 Image: Surface 9	
For Help, press F1	X:0.0000 Y:53.7586 Z:-95.3902 millimeters

Figure 24. System Tree for the Backlight > Texture surface.

You have now completed all aspects of the setup of the geometry and optical properties for this tutorial. In the next and final section, we discuss the setup of the **Raytrace Options**... and the actual ray tracing and analysis. It is also a good time (if you have not been doing so already) to save your model. In this example, we have named the OML to be **Backlight_TextureTest1.oml**.



Raytrace Setup and Analysis

There are two steps to this section: setup of the raytrace and the actual raytrace and analysis. Each of these steps is described in the following sections.

Raytrace Options

We will now setup the raytrace using **Raytrace Options**.... Note that most of the data entered below are factory defaults for the parameters. Reset them as provided in Fig. 25 if you have **Set Defaults** in the past:

- I. Select Analysis>Raytrace Options...,
- 2. Select the **Options** tab,
- 3. Enter the parameters as shown in Fig. 25a,
- 4. Select Apply from the dialog,
- 5. Select the **Wavelengths** tab,
- 6. Enter the parameters as shown in Fig. 25b,
- 7. Select Apply from the dialog,
- 8. Select the Thresholds tab,
- 9. Enter the parameters as shown in Fig. 25c,
- 10. Select Apply from the dialog,
- 11. You can **Close** the open dialogs, but it is not necessary, and
- 12. Select Analysis>Simulation Mode.

Raytrace Options	Raytrace Options		Raytrace Options	
Simulation & Output Advanced Options Wavelengths Thresholds Radiometric Units: Photometric Ray Splitting Specular Rays Only. Importance Sampling Aperture Diffraction 1000000 distance (mm) Random Rays: 1 (per scatter) Fluorescence Insert file source Immediately trace emission wavelengths Polarization Detect Ray Starting in Bodies Random Seed 1	Simulation & Output Options Wavelengths Type Discrete wavelengths Selection 0.5461 Wavelengths Value (um) Weight 0.5461 1	Advanced Thresholds	Simulation & Output Options Wavelengths Flux Threshold: 005 (fractional value of starting flux) Intercept Limits Total Intercepts: 1000 Total Scatters: 1000 Optical Scatters: 1000	Advanced
Apply Set Defaults	Apply	<u>S</u> et Defaults		Set Defaults

Figure 25. Raytrace Options... setup (a) Options, (b) Wavelengths, and (c) Thresholds.



Raytrace and Analysis

We are now ready to do the raytrace and then analyze the results:

- 1. Verify that the source is setup correctly by selecting the **Source** tab at the bottom of the System Tree,
- 2. Expand the Surface sources item in the list (see Fig. 26),
- 3. Double click on CCFL/Source 0,
- 4. Verify that the resulting dialog (as within Fig. 26) agrees with that of Fig. 11,
- 5. Close the **Apply Properties** dialog,
- 6. Select Analysis>Trace Rays...,
- 7. Ensure that the resulting dialog is as per Fig. 27,
- 8. Click **Trace Rays**,
- 9. Click on Yes within the Simulation Mode confirmation dialog,
- 10. The ray may take some time dependent on the speed of your computer, what else you are doing on the computer, and so forth. You can Cancel the ray trace and reduce the number of rays, if you desire to look at the results sooner,
- 11. Upon completion of the ray trace, select Screen>Observation from the Model System Tree,
- 12. Select Analysis>Irradiance/Illuminance Map,
- 13. Right click in the resulting **Irradiance/Illuminance Map** window, and select **Irradiance/Illuminance Options**... or select from the menus **Analysis>Irradiance/Illuminance Options**...,
- 14. Set the values within this dialog as shown in Fig. 28,
- 15. Click on Apply,
- 16. Figure 29 shows the resulting illuminance distribution for this model,
- 17. Select Analysis>Candela Plots>Rectangular Iso-Candela,
- 18. Right click in the resulting **Rectangular Iso-Candela Map** window, and select **Candela Options**... or select from the menus **Analysis>Candela Options**...,
- 19. Set the values within the two shown tabs of the dialog as per Fig. 30,
- 20. 2Click on Apply within each tab of the Candela Options... dialog, and
- 21. Figure 31 shows the resulting intensity distribution for this model.

Note that the illuminance distribution (Fig. 29) shows a lack of uniformity across the output surface. Most of the light is emitted toward the CCFL end of the display. The intensity distribution (Fig. 31) shows that most of the rays are emitted in the negative y direction, but the intensity distribution is much more uniform than that of the illuminance. One also desires to make the intensity distribution as uniform over the angular view range ($\pm 45^{\circ}$ in this case). It is up to you to improve upon performance! This is accomplished by:

- Changing the radii, heights, and positions of the Features such that their density increases further away from the CCFL,
- Changing from Bump to Hole Features,
- Placing a wedge on the Backlight such that it thins further away from the CCFL, and
- Many other methods and techniques.

As an example consider Figs. 32 and 33, which show the illuminance and intensity distributions, respectively, for a Textured hole array rather than a Textured bump array. The parameters for the Features are the same as for that of the results shown in Figs. 29 and 31. Note that the illuminance distribution (Fig. 32) has improved, while the intensity distribution (Fig. 33) has gotten a little worse. These figures address bullet 2 in the previous list. By adjusting the other items, especially the Feature density and sizes in the Texture file you can drastically improve performance.





Figure 26. Final verification that the source is correctly defined. You can click on Calculate Power to get the Power (Im) in the table to be set correctly.



🛛 Trace Rays 📃 🗖 🗙
Trace Rays
Trace Source using discrete wavelengths
Sources to Trace
Grid: None
Surface: Checked only
File: None
Irace Rays Apply Set Defaults

Figure 27. Trace Rays dialog.

Irradiance/Illuminance Map Options			
Map Data Quantities to plot Irradiance			
Rays to plot Absorbed 💌 🗖 Normalize to emitted flux			
Set Ma <u>x</u> : Set Mi <u>n</u> :			
Display Options			
✓ Smoothing Log Scale Map Count: 51			
Contour Plot Relief Plot Resolution: 256x256			
Local Coordinates 🔽 Profiles Symmetry: None			
Gradient Display Color Map: Color(rainbow) on Black 💌			
Convert to foot-candles (fc) Auto Update is ON			
Contour Levels:			
Selection			
□ Number: 15 <			
☐ Orientation of plot plane ✓ Automatically calculate Normal and Up Vectors			
Normal Vector: X: 0 Y: 0 Z: -1			
Up Vector: X: 0 Y: -1 Z: 0			
Apply Set Defaults			

Figure 28. Irradiance/Illumination Map Options dialog.





Figure 29. Resulting illuminance distribution for the Backlight system.

Drientation and Rays Polar Iso-Candela Rectangular Iso-Candela Candela Distributions Normal Vector Up Vector Orientation X: Up Vector Normal Vector Set Defaults Y: Up Vector Orientation Normal Vector Polar Iso-Candela Rectangular Iso-Candela Rectangular Iso-Candela Rectangular Iso-Candela Candela Distributions Ray Selection X: Up Vector Normal Vector Set Mag: Se	Candela Options		Candela Options
	Orientation and Rays Polar Iso-Candela Rectangular Iso-Candela Normal Vector Up Vector X: Y: Y: Y: Y: Y: Z: Image: Candela Data Image: Candela Data G: Use incident rays from selected surface or Exit Surface Data Processing Symmetry None	a Candela Distributions Orientation Normal Up The Normal vector defines the global direction of the Zero axis for vertical angles. The Up vector defines the global direction of the Zero axis for horizontal angles.	Orientation and Rays Polar Iso-Candela Rectangular Iso-Candela Candela Distributions Rectangular Iso-Candela Plot Options

Figure 30. Two tabs from the Candela Options dialog.







Figure 31. Resulting intensity distribution for the Backlight system.



Figure 32. Resulting illuminance distribution for the Backlight system using Holes instead of bumps.





Figure 33. Resulting intensity distribution for the Backlight system using Holes instead of bumps.

