

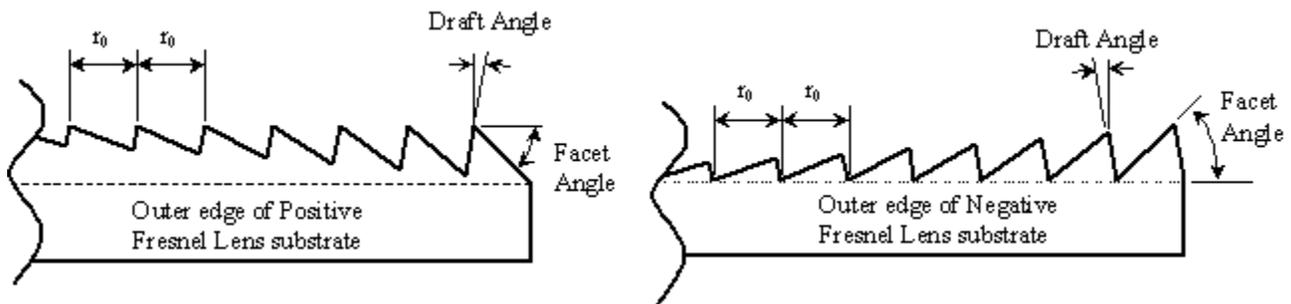
# FRESNEL LENS

## RepTile Examples Expert

In general, the steps involved in using RepTile surfaces consist of first creating a RepTile surface property within TracePro and then applying that property to a plane surface in your TracePro model. All the examples in this section are similar in construction. You should choose an example that is most like the model you wish to create and follow through the steps for creating the example.

### Fresnel lens

In this example we will create a Fresnel lens. Some of the important features of a Fresnel lens are shown in Figure 9.1



**FIGURE 9.1 - Important construction features of positive and negative Fresnel lenses.**

In order to begin analyzing a Fresnel lens, you will need to acquire data about the desired facet angles. If you are analyzing a lens that has already been fabricated, this data will be available from the manufacturer. If you are analyzing a Fresnel lens that is in its design stage, you will have to get the facet angle data from calculations (possibly from a specialized optical design program) outside of TracePro.

For purposes of this exercise, we have supplied an example file containing facet angle data. The data for the angular facets of the Fresnel lens example is contained in the *TracePro\Examples\Demos\Fresnel Lens Arcsecs.txt* file. This text file contains one whole number per line – the number is the Fresnel lens facet angle in arcseconds. In order to use this file, we will need to convert the angles to degrees. To examine this file, open it using a spreadsheet program such as Microsoft Excel. The facet angles increase from the center to the edge of the lens. In order to calculate the minimum thickness we need for the substrate, we need to know the largest facet angle. This is the last angle in the file. You can quickly go to the last row in the spreadsheet in Excel by pressing <Ctrl - ↓> on your keyboard. The Excel screen should look like Figure 9.2, showing that there are 333 rows in the spreadsheet and the last facet angle is 171682 arcsec or 47.68944 degrees. Assuming that each facet has a width of 0.5 mm, the depth of the last facet is  $0.5 \text{ mm} \times \tan(47.68944^\circ) = 0.549 \text{ mm}$ . We can make the substrate 2 mm thick, and

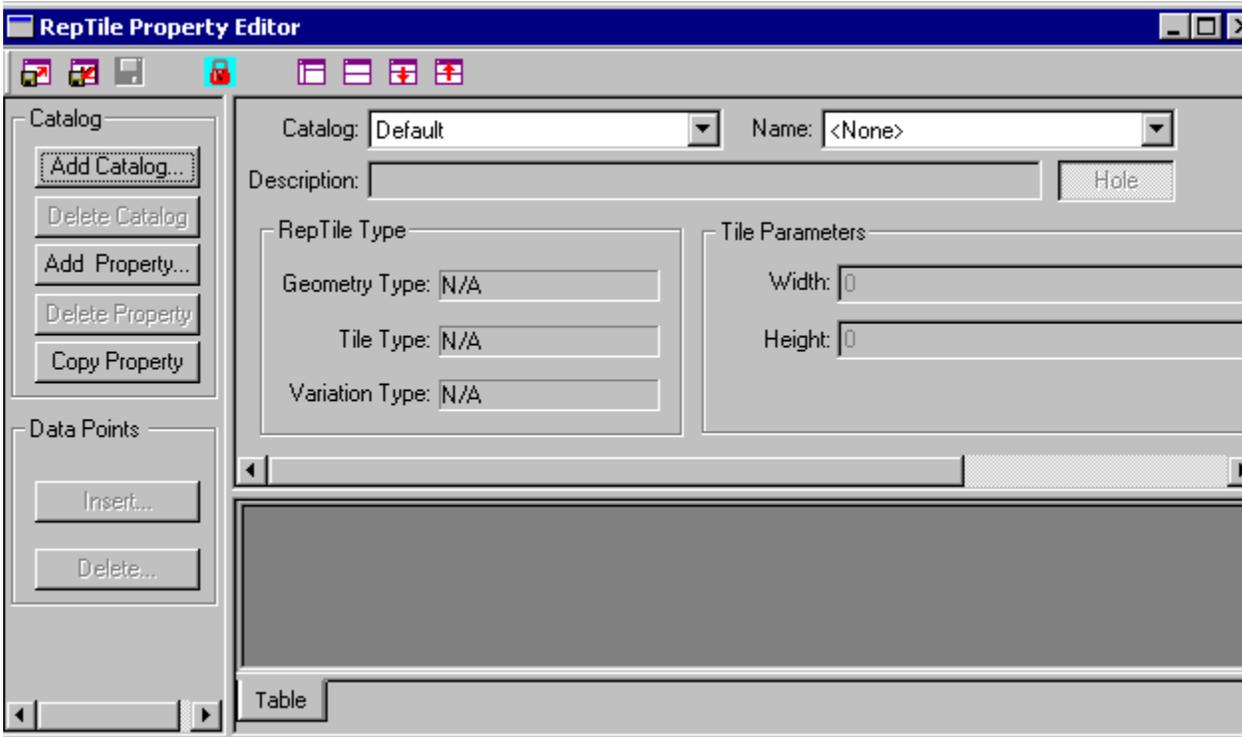
## Examples

the last facet will still have a base thickness of almost 1.5 mm (substrate thickness – tallest facet height = base thickness).

	A	B	C	D	E	F	G	H
305	163337							
306	163648							
307	163959							
308	164269							
309	164577							
310	164885							
311	165191							

**FIGURE 9.2 - The Fresnel Lens Arcsecs.txt file as it appears in Microsoft Excel.**

First we will create a RepTile Surface property that describes the Fresnel lens. Open the Reptile Property Editor by selecting **Define | EditPropertyData | RepTile Properties**. The editor appears as in Figure 9.3.

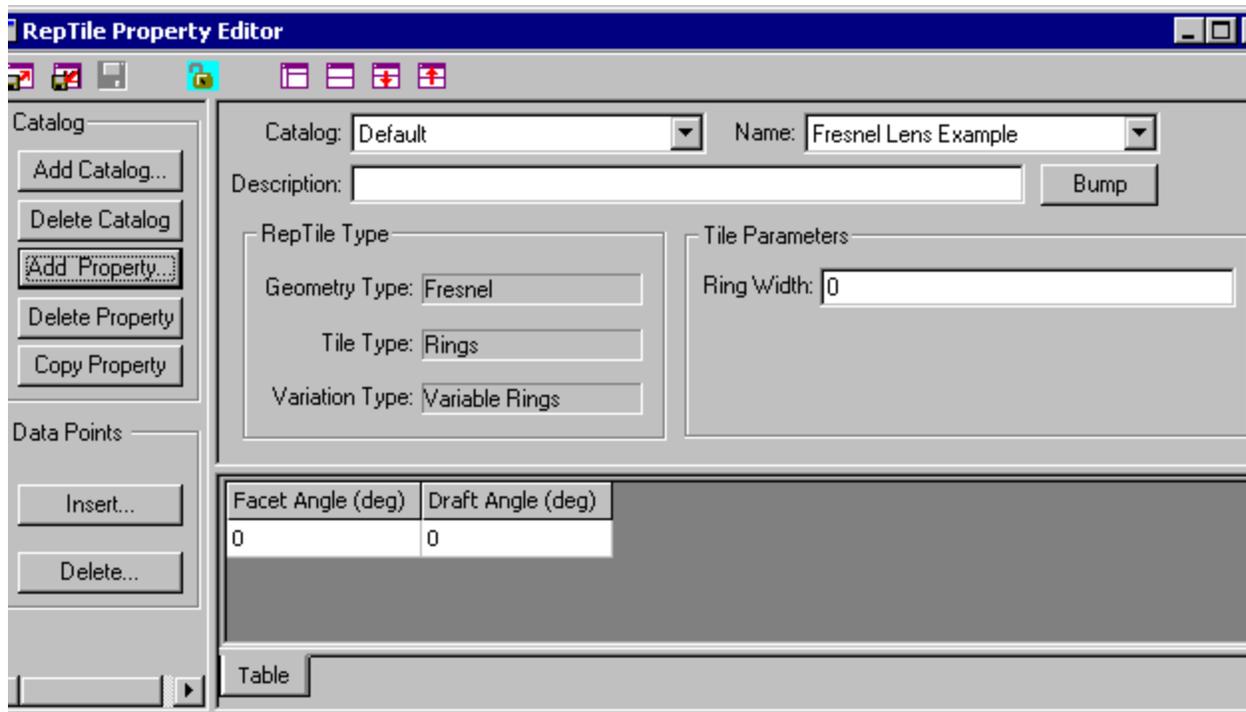


**FIGURE 9.3 - The RepTile Property editor with no property selected.**

To add the new property:

1. Press *Add Property*, and enter a name, for example *Fresnel Lens Example*,
2. select *Fresnel* from the *Geometry Type* drop-down list in the pop-up dialog,
3. select *Rings* from the *Tile Type* drop-down list in the dialog,
4. select *Variable Rings* from the *Variation Type* drop-down list in the dialog,
5. press OK to create the property.

The RepTile Property Editor will display the property and provide additional inputs as shown in Figure 9.4.



**FIGURE 9.4 - A template for the Fresnel Lens Example RepTile property.**

6. Continue to enter the property data by entering 0.5 in the *Ring Width* box (the ring width in mm).

We now have a template for creating the Fresnel Lens RepTile property. To fill in the facet angle and draft angle data, we will export this property to a text file and use a spreadsheet program.

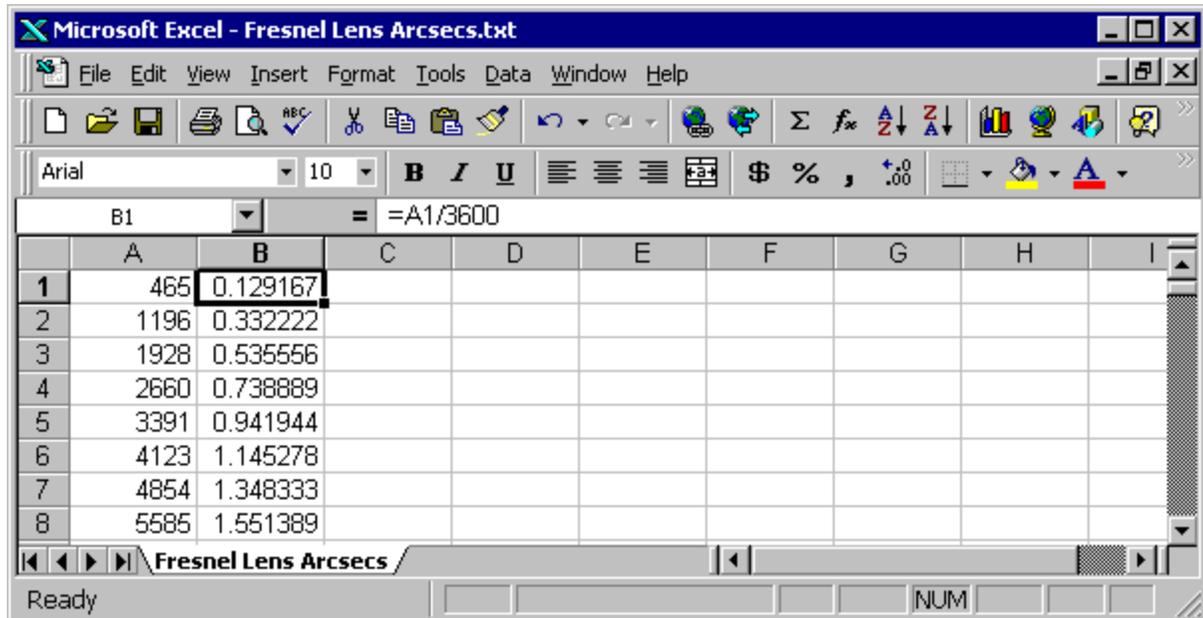


To export the property, first select **File | Save** to save the property, then select **File | Export Property** to save the property in a text file. Open the text file using a spreadsheet program (Microsoft Excel was used in this example). The opened file should appear as in Figure 9.5

	A	B	C	D	E	F	G	H
1	TracePro	RepTile Property Data						
2	File Name	C:\Program Files\Lambda Research Corporation\TracePro\TracePro.mdb						
3	TracePro Release:	3 3 0						
4	Database Version:	3 3 0						
5	Data generated at	08:50:50 March 11, 2005						
6								
7	Name	Fesnel Lens Example						
8	Catalog	Default						
9	Description							
10	Geometry_	1						
11	Tile_Type	1						
12	Vary_Row:	1						
13	Bump_Type	0						
14	Parameter	0						
15	Width_X	0.5						
16	Width_Y	0						
17	User_Data	1						
18								
19	Facet Ang	Draft Angle (deg)						
20		0 0						
21								
22								

FIGURE 9.5 - The *Fresnel Lens Example* RepTile property exported text file after opening in Excel.

With the *Fresnel Lens Arcsecs.txt* file open in Excel, make a second column that is calculated from the first column. The second column should be the facet angle in degrees, obtained by dividing the first column by 3600. The first few rows of the *Fresnel Lens Arcsecs.txt* file should appear as in Figure 9.6.



The screenshot shows the Microsoft Excel interface with the file *Fresnel Lens Arcsecs.txt* open. The spreadsheet displays the following data:

	A	B	C	D	E	F	G	H	I
1	465	0.129167							
2	1196	0.332222							
3	1928	0.535556							
4	2660	0.738889							
5	3391	0.941944							
6	4123	1.145278							
7	4854	1.348333							
8	5585	1.551389							

**FIGURE 9.6 - The *Fresnel Lens Arcsecs* file with a second column containing facet angles in degrees.**

## Examples

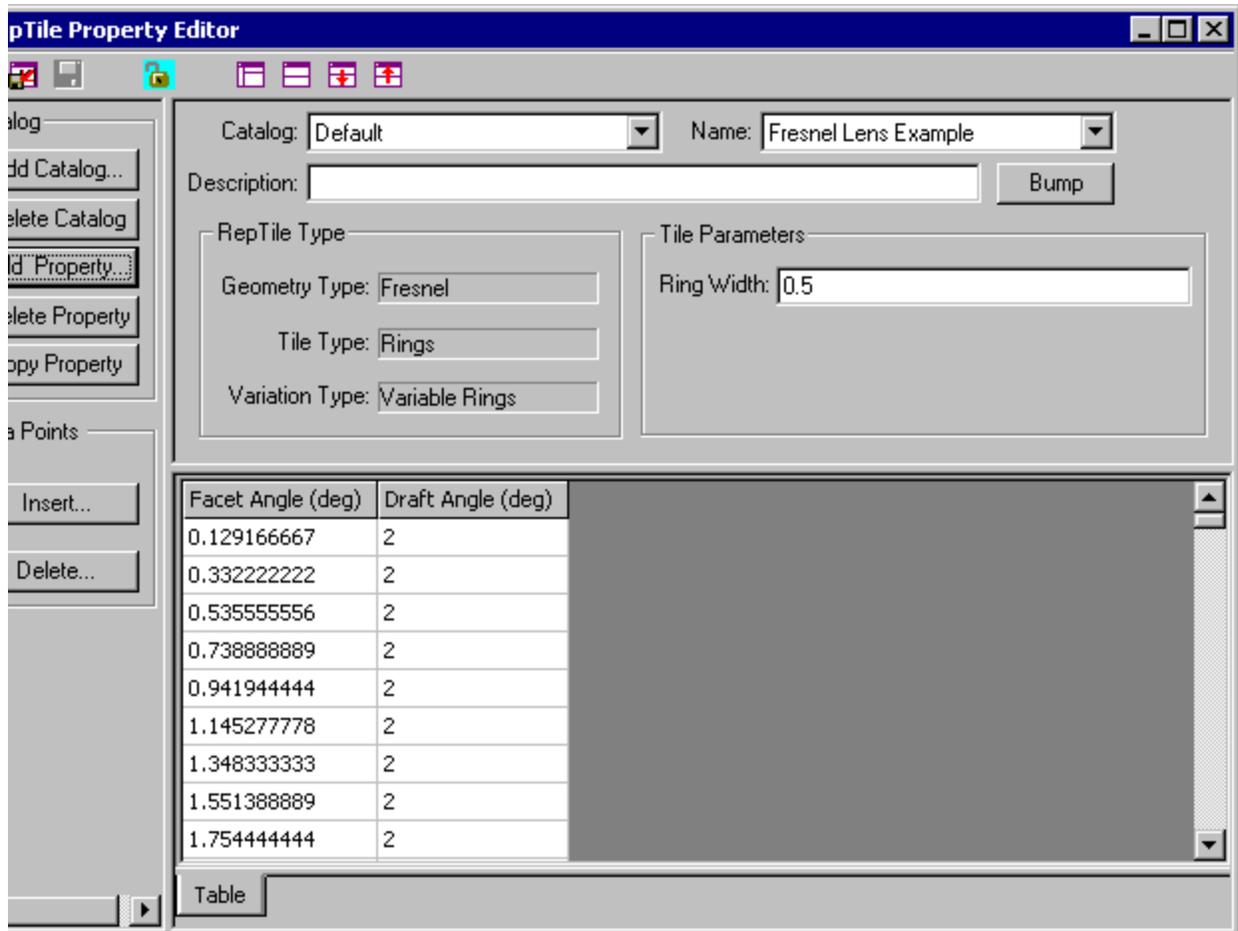
Select the entire column B, copy it, and paste it to cell A19 of the *Fresnel Lens Example* property file using *Paste Special* and specifying *Values*. (You can select the column quickly by selecting cell B1 in *Fresnel Lens Arcsecs* and pressing <Shift - Ctrl - ↓> to select the column). Enter an angle of 2 in the second column for the *Draft Angle*. Each facet can have a different angle but we will use a constant 2 degrees for this example. The property should appear in Excel as shown in Figure 9.7

	A	B	C	D	E	F	G	H
7	Name	Fresnel Lens Example						
8	Catalog	Default						
9	Description							
10	Geometry	1						
11	Tile_Type	1						
12	Vary_Row	1						
13	Bump_Type	0						
14	Parameter	0						
15	Width_X	0.5						
16	Width_Y	0						
17	User_Data	1						
18								
19	Facet Ang	Draft Angle (deg)						
20	0.129167	2						
21	0.332222	2						
22	0.535556	2						
23	0.738889	2						
24	0.941944	2						

FIGURE 9.7 - The completed Fresnel Lens Example as shown in Excel.



Now save the *Fresnel Lens Example.txt* file from Excel and close it. Switch back to TracePro and select **File|Import Property** with the RepTile Property Editor open. Open the *Fresnel Lens Example.txt* file to import it. The editor window should appear as in Figure 9.8.

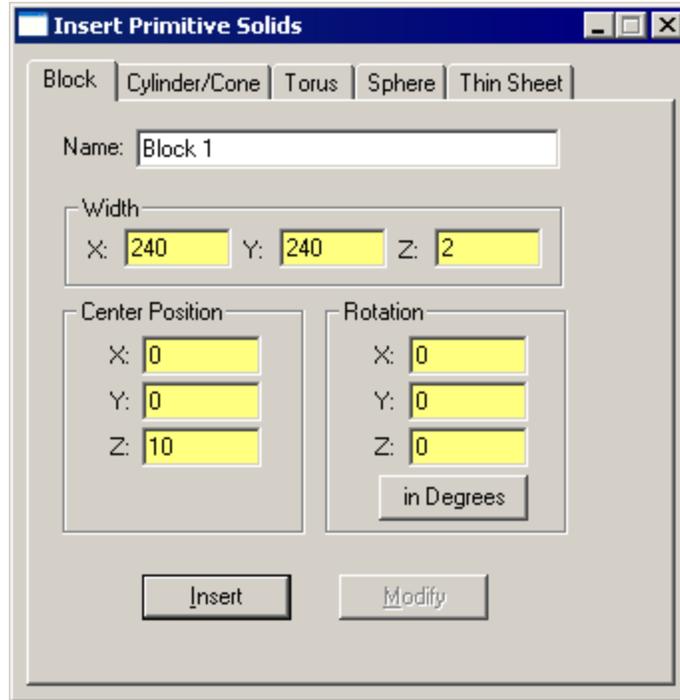


**FIGURE 9.8 - The completed Fresnel Lens Example property after importing into the Property Editor.**

This completes the definition of the Fresnel Lens Example in the Property Editor. Close the Property Editor, and choose to save your data when the appropriate pop-up window appears.

Now we are ready to make an object and apply the RepTile property we have just created. First we need to figure out the dimensions the object should have. We already know that it should be 2 mm thick. We also know that there are 333 facets of width 0.5 mm, so the radius of the outermost facet is  $333 \times 0.5 \text{ mm} = 166.5 \text{ mm}$ . If we use a square boundary for the Fresnel lens, the largest it can be is  $166.5 \text{ mm} \times \sqrt{2} = 235 \text{ mm}$  on a side. We also must have a margin around the RepTile Surface cell boundary to allow rays to escape properly. Therefore we will make an object that is 240 mm x 240 mm, and 2 mm thick.

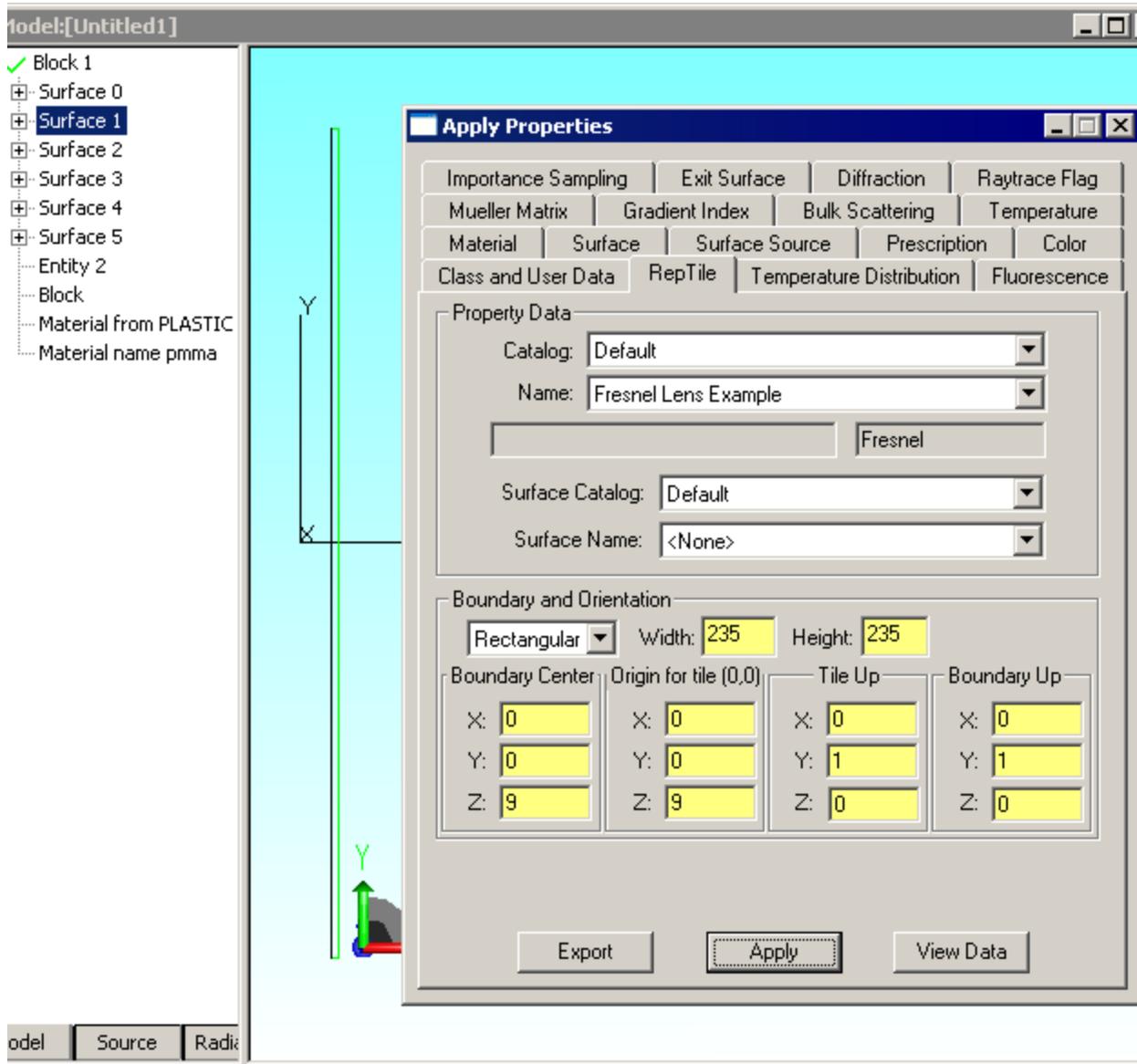
7. In TracePro, using the **Insert|Primitive Solid** dialog box, insert a block with dimensions as shown in Figure 9.9.



**FIGURE 9.9 - Insert a block into a TracePro model as a substrate for the Fresnel lens.**

8. Using the *Apply Properties* dialog box, apply the material property *pmma* from the *Plastic* catalog to the block.
9. Now select the  $-z$  surface of the block and apply the RepTile surface property using the *RepTile* tab in the *Apply Properties* dialog box. Fill in the values shown in Figure 9.10.

This puts the center of the Fresnel lens at the center of the block surface.



**FIGURE 9.10 - Insert a block and apply the Fresnel Lens Example RepTile property to it.**

The Fresnel lens is now complete. Note that there will be no visual indication in the model window that the RepTile surface properties have been applied unless the **View|Display RepTiles** option is enabled. The System Tree will show the *Fresnel Lens Example* property on the appropriate surface. The facets are defined over a 235 mm x 235 mm square area within a 240 mm x 240 mm surface.

Next, we'll trace some rays through the Fresnel lens.

10. Define a square grid of rays 119 x 119 mm half-widths with a rectangular grid of 100 x 100 rays as shown in Figure 9.11.

The completed ray-trace is shown in Figure 9.12. We see that the focal length of this lens is about 310 mm.

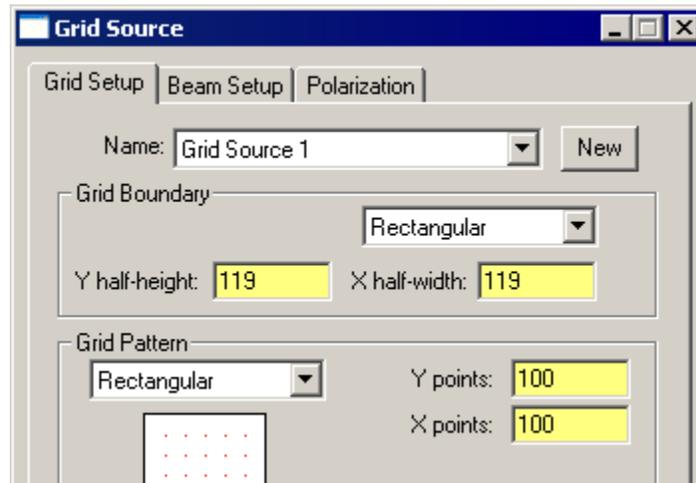


FIGURE 9.11 - Modified portion of Grid Source dialog for Rectangular raytrace.

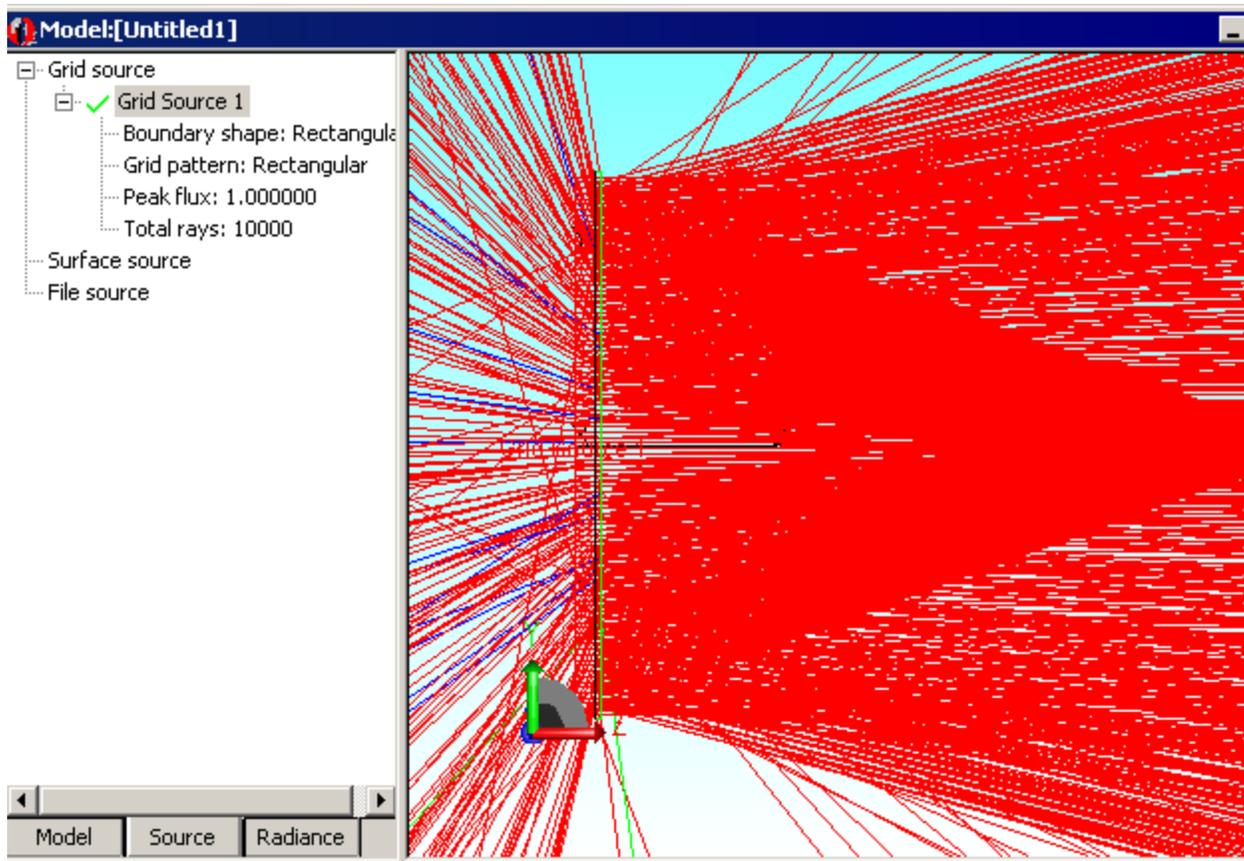


FIGURE 9.12 - Completed ray-trace of Fresnel lens example.