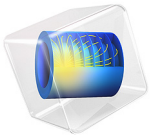


Model created in COMSOL Multiphysics 6.4

Designing a Metasurface Beam Deflector Using Shape Optimization

Introduction

This model is inspired by the *Metasurface Beam Deflector* model in the Wave Optics Module Application Library. In this example, optimization is applied to maximize the deflection by using shape optimization to change the position and radii of the pillars.

Model Definition

Figure 1 shows the initial geometry used for the topology optimization.

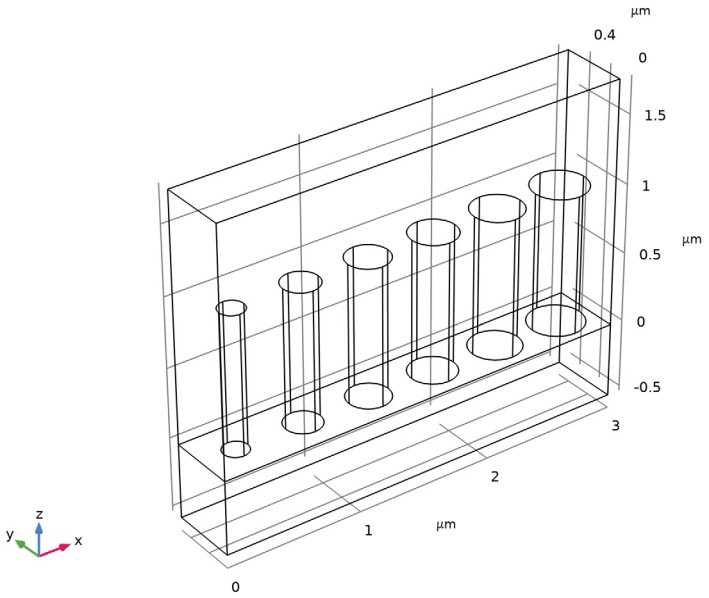


Figure 1: The initial geometry with the six cylindrical pillars.

The pillars are scaled and moved using the Transformation feature in the Shape Optimization interface, while the built-in variable for the reflection is used as the objective function.

Results and Discussion

The model performs 50 optimization iterations increasing the reflection from 85% to 92%, but the actual design changes are subtle as illustrated in Figure 2.

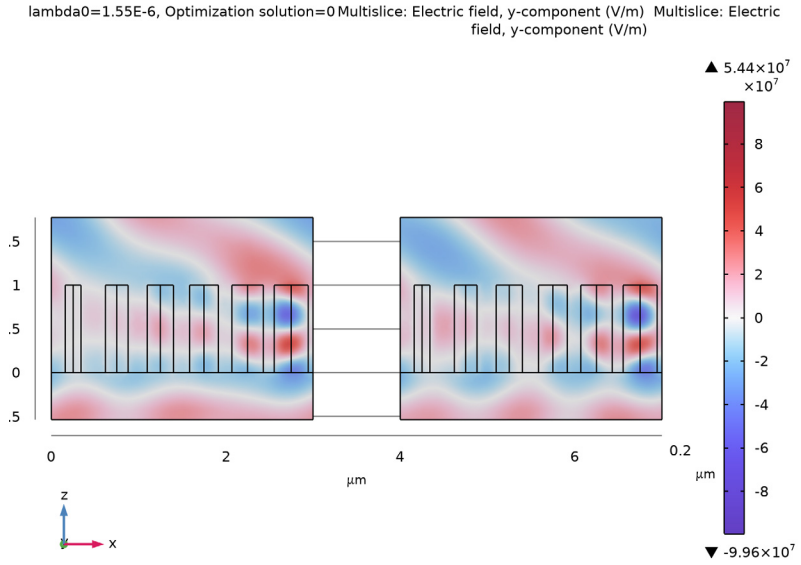


Figure 2: The shape optimization changes the design marginally.

Application Library path: `Optimization_Module/Shape_Optimization/metasurface_beam_deflector_optimization`

Modeling Instructions

This example starts from an existing model from the Wave Optics Module Application Library.

APPLICATION LIBRARIES

1 From the **File** menu, choose **Application Libraries**.

2 In the **Application Libraries** window, select **Wave Optics Module** > **Gratings and Metamaterials** > **metasurface_beam_deflector** in the tree.

3 Click **Open**.

GLOBAL DEFINITIONS

Parameters 2

1 In the **Home** toolbar, click **Parameters** and choose **Add** > **Parameters**.

2 In the **Settings** window for **Parameters**, locate the **Parameters** section.

3 In the table, enter the following settings:

Name	Expression	Value	Description
moveMax	30[nm]	3E-8 m	Maximum translation
scaleMax	0.2	0.2	Maximum scaling

COMPONENT 1 (COMP1)

Free Shape Domain 1

In the **Physics** toolbar, click **Optimization** and choose **Shape Optimization**.

Symmetry/Roller 1

1 In the **Shape Optimization** toolbar, click **Symmetry/Roller**.

2 Select Boundary 6 only.

Transformation 1

1 In the **Shape Optimization** toolbar, click **Transformation**.

2 In the **Settings** window for **Transformation**, locate the **Geometric Entity Selection** section.

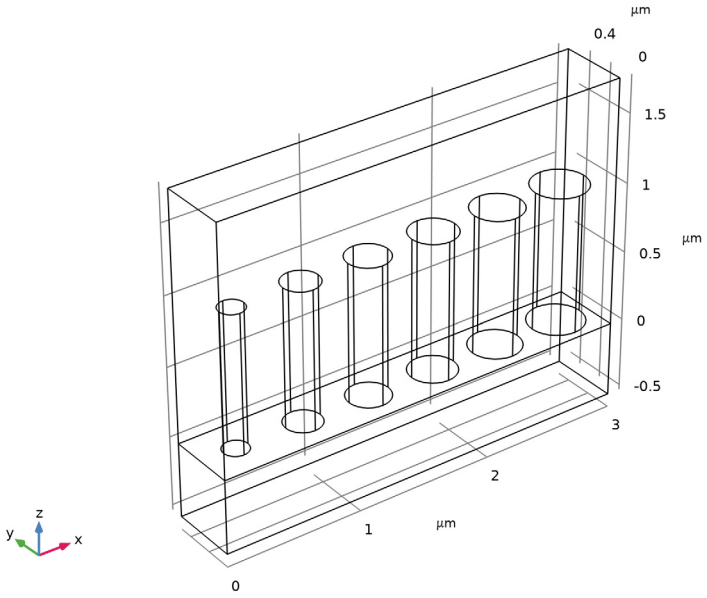
3 From the **Selection** list, choose **Posts**.

4 Locate the **Translation** section. In the table, enter the following settings:

	Lock	Lower bound (m)	Upper bound (m)
X		-moveMax	moveMax
Y		-moveMax	moveMax

5 Locate the **Scaling** section. From the **Scaling type** list, choose **Isotropic (XY)**.

6 In the table, enter the following settings:



	Lock	Lower bound	Upper bound
XY		`1-scaleMax`	`1+scaleMax`

STUDY 1

Shape Optimization

1 In the **Study** toolbar, click **Optimization** and choose **Shape Optimization**.

2 In the **Settings** window for **Shape Optimization**, locate the **Optimization Solver** section.

3 In the **Maximum number of iterations** text field, type 50.

4 Click **Add Expression** in the upper-right corner of the **Objective Function** section. From the menu, choose **Component 1 (comp1)** > **Electromagnetic Waves, Frequency Domain** > **Ports** > **Transmittance, by order** > **comp1.ewfd.Torder_p1_0_op - Transmittance, order [1, 0], out-of-plane**.

5 Locate the **Objective Function** section. From the **Type** list, choose **Maximization**.

6 In the **Study** toolbar, click **Get Initial Value**, so that a default plot is generated, which can be shown while optimizing.

RESULT TEMPLATES

1 In the **Home** toolbar, click **Windows** and choose **Result Templates**.

2 Go to the **Result Templates** window.

3 In the tree, select **Study 1/Solution 1 (sol1)** > **Transformation 1** > **Shape Optimization**.

4 Click the **Add Result Template** button in the window toolbar.

5 In the **Results** toolbar, click **Result Templates** to close the **Result Templates** window.

STUDY 1

1 In the **Settings** window for **Shape Optimization**, click to expand the **Output** section.

2 From the **Keep solutions** list, choose **First and last**.

3 Select the **Plot** checkbox.

4 In the table, enter the following settings:

Plot group	Plot window
Shape Optimization	Graphics

5 In the **Study** toolbar, click **Compute**.

RESULTS

Electric Field (ewfd)

1 In the **Settings** window for **3D Plot Group**, locate the **Data** section.

2 From the **Optimization solution** list, choose **0**.

Multislice 2

1 In the **Model Builder** window, expand the **Electric Field (ewfd)** node.

2 Right-click **Results** > **Electric Field (ewfd)** > **Multislice 1** and choose **Duplicate**.

3 In the **Settings** window for **Multislice**, locate the **Data** section.

4 From the **Dataset** list, choose **Study 1/Solution 1 (sol1)**.

5 Click to expand the **Inherit Style** section. From the **Plot** list, choose **Multislice 1**.

Transformation 1

1 Right-click **Multislice 2** and choose **Transformation**.

2 In the **Settings** window for **Transformation**, locate the **Transformation** section.

3 In the **X** text field, type 4.

4 Click the **Go to XZ View** button in the **Graphics** toolbar.

5 Click the **Orthographic Projection** button in the **Graphics** toolbar.

6 Click the **Zoom Extents** button in the **Graphics** toolbar.

Polarization Plot (ewfd)

Finally, display the polarization plot for each optimization solution.

1 In the **Model Builder** window, under **Results** click **Polarization Plot (ewfd)**.

2 In the **Settings** window for **1D Plot Group**, locate the **Data** section.

3 From the **Optimization solution** list, choose **From list**.

4 In the **Optimization solution** list box, select **0**.

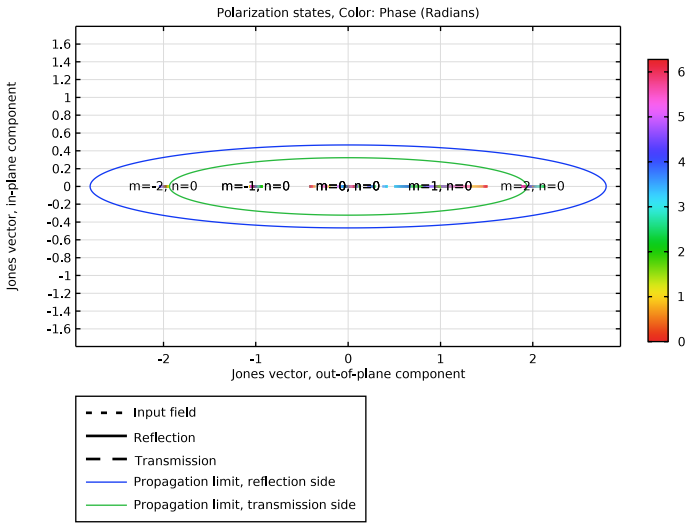
5 Locate the **Legend** section. From the **Layout** list, choose **Outside graph axis area**.

6 From the **Position** list, choose **Bottom**.

7 In the **Number of rows** text field, type 5.

8 In the **Polarization Plot (ewfd)** toolbar, click **Plot**.

9 Click next to **cycle_plot_level**, then choose **Optimization solution**.



10 Click → **Plot Next**.