

## Nano-Lens and micro-lens simulation in OptiFDTD

When optical lens size is compatible with the working wavelength, the traditional lens analysis tools such as ray-tracing method will lose the accuracy. FDTD method shows the advantage for the nano-lens simulation. OptiFDTD software also provided tools so that beam focus size, focus distance, and far-field transform can be obtained directly. The following two samples show the nano-lens simulation.

### 1. SMF28 fiber lens Simulation.

#### Layout Introduction

When fiber is tapered and polished in the termination as shown in Figure 1, a fiber lens can be created. The lens size can be exactly fiber's core size or smaller than the core. In fact OptiFDTD can scan the lens size so that focus beam size and focus distance can be optimized.

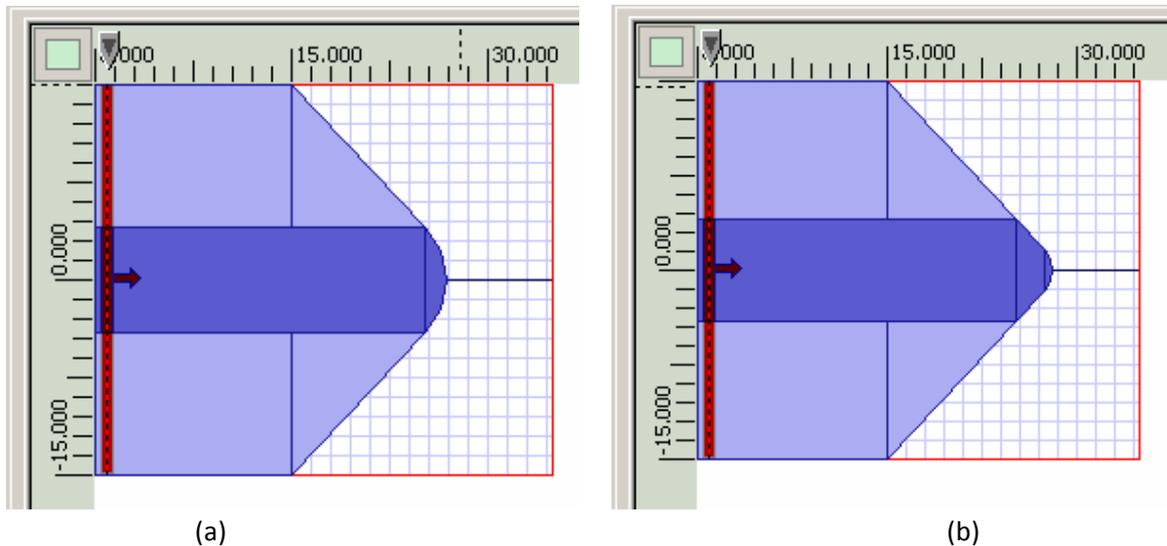


Figure 1 SMF28 fiber lens (a)  $R=6\ \mu\text{m}$ ; (b)  $R=2.4\ \mu\text{m}$

Related layout can be found in OptiFDTD sample folder with the project name as "Sample22\_VBscript\_2D\_Lens.FDT"

#### Simulation results

After the simulation, the field pattern and the Poynting vector can be plotted for each lens size (see figure 2), based on the field pattern the beam size and the focus distance can be measured by the slice viewer (see figure 3)

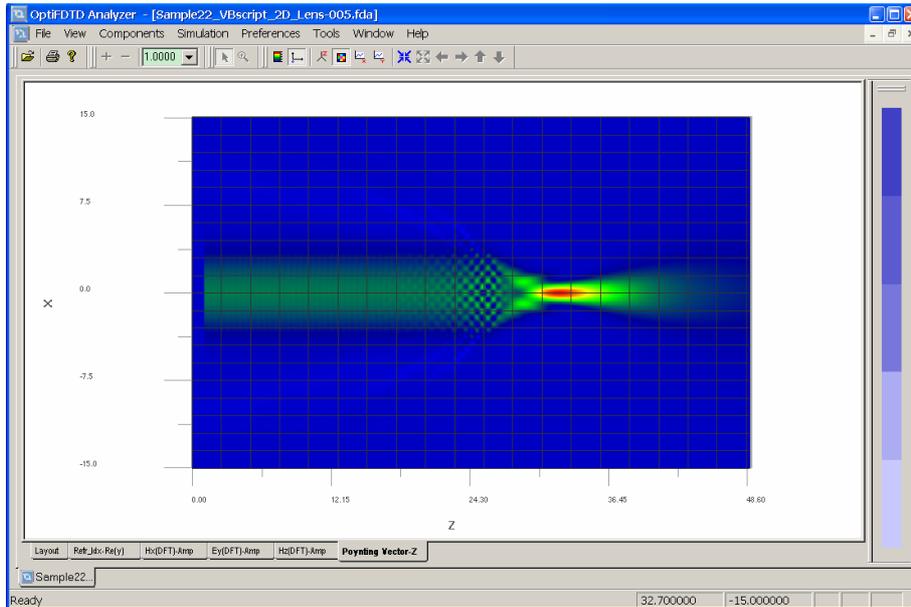


Figure 2. Poynting vector for Fiber lens

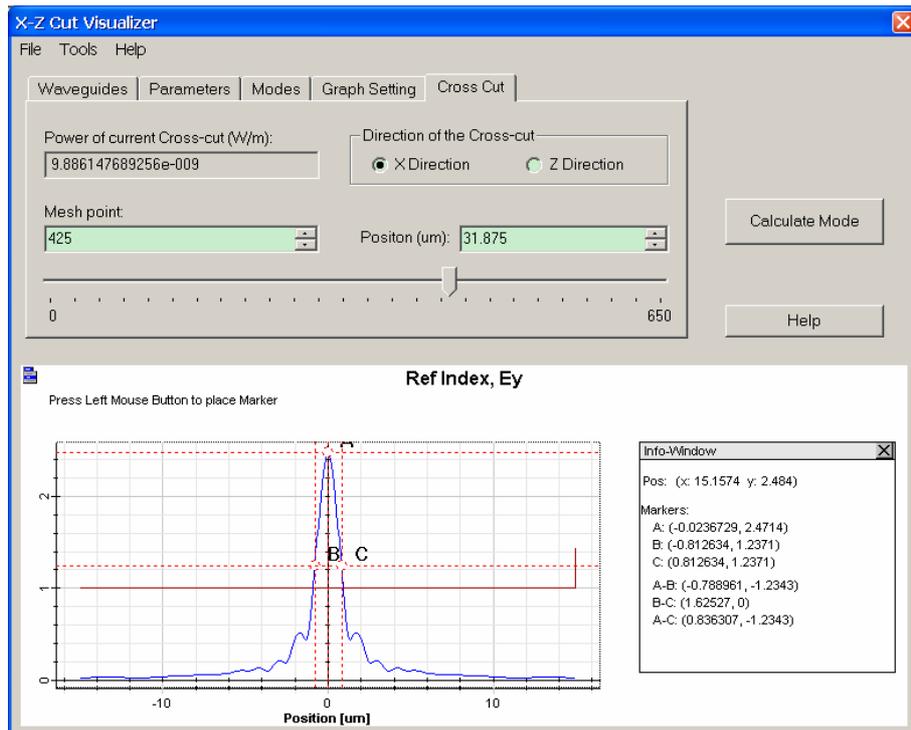


Figure 3 Beam size measurement in OptiFDTD

## 2. Nano Lens Array

In this 3D sample, we discuss a micro-lens array, the lens dimension is marked in Figure 1, and Figure 2 is xy plane refractive index distribution

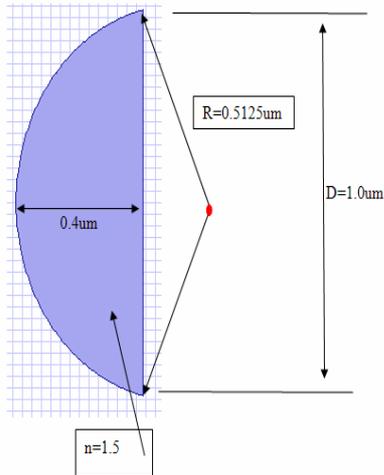


Figure 1 lens size

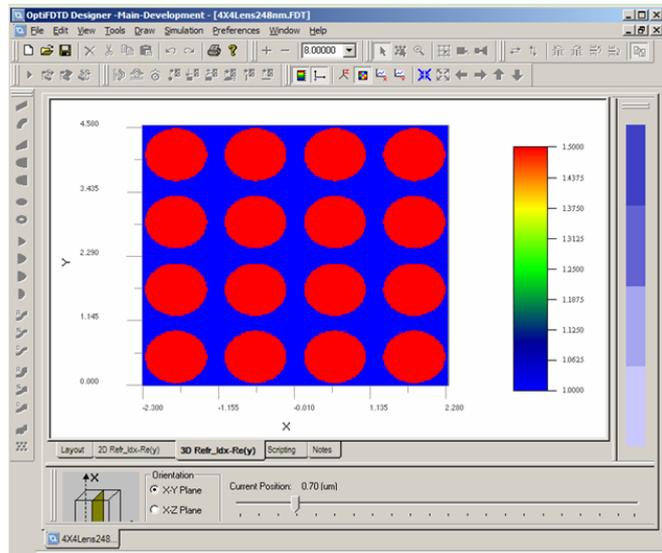


Figure 2, top view if the lens Array

### Simulation Parameters

- Mesh size :  $0.02\mu\text{m} \times 0.02\mu\text{m} \times 0.02\mu\text{m}$
- Run for 1248 time step +
- 10 additional cycle to get the steady state field
- Calculate steady state field for  $E_y$  and  $H_x$  (Discretized Fourier transform)
- x-y boundary use the upper-lower symmetric boundary condition. Z-direction user the APML as the boundary condition

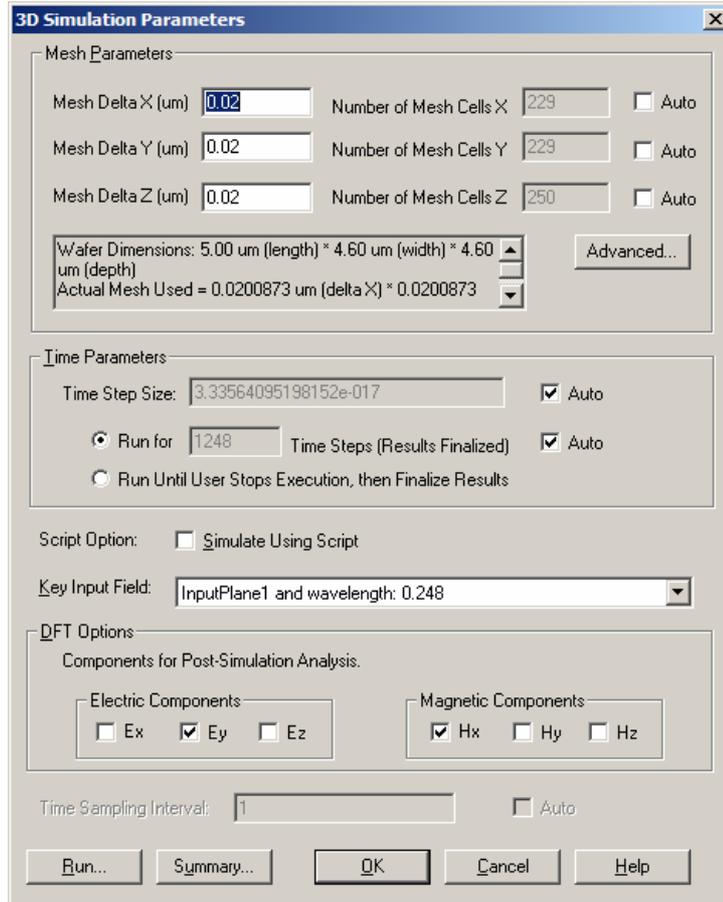


Figure 3 Simulation parameters

### Simulation results

As shown in figure 4, in the simulation we can observe the time domain response in each slice in three orientations ( xy plane, yz plane, xz plane)

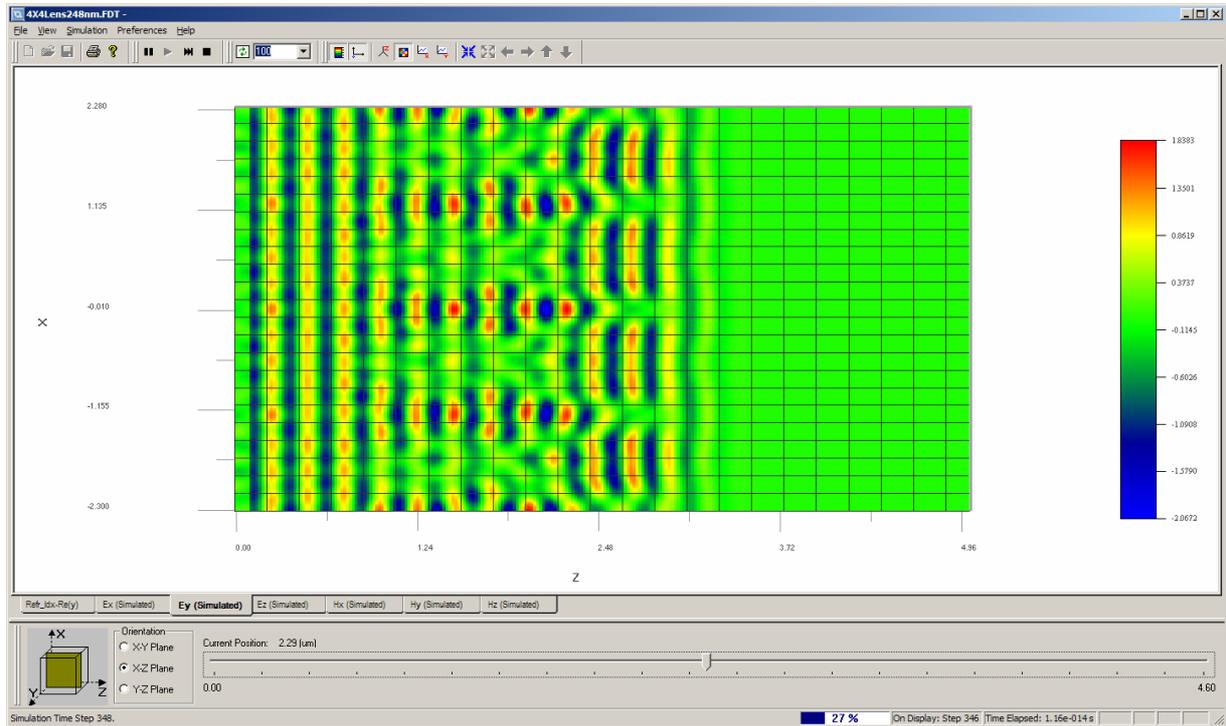


Figure 4 time domain response in xz plane

Steady state response can be observed in analyzer as shown figure 5. Beam size and focus distance can be measured in OptiFDTD as shown in figure 6

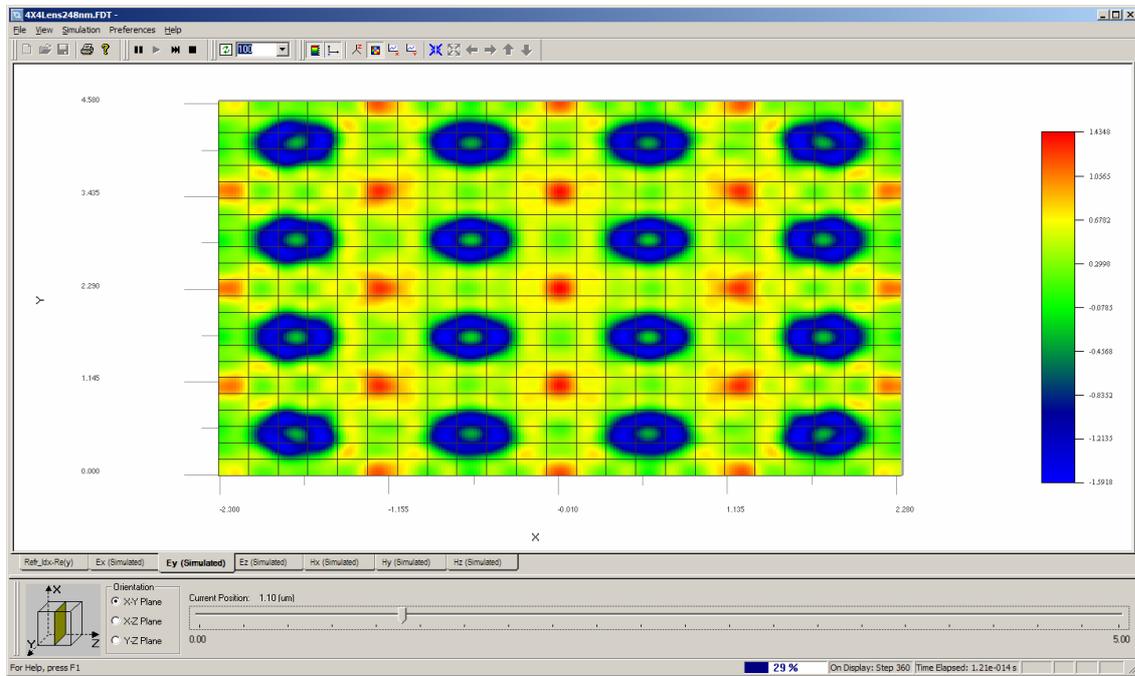


Figure 5 Field pattern in xy plane

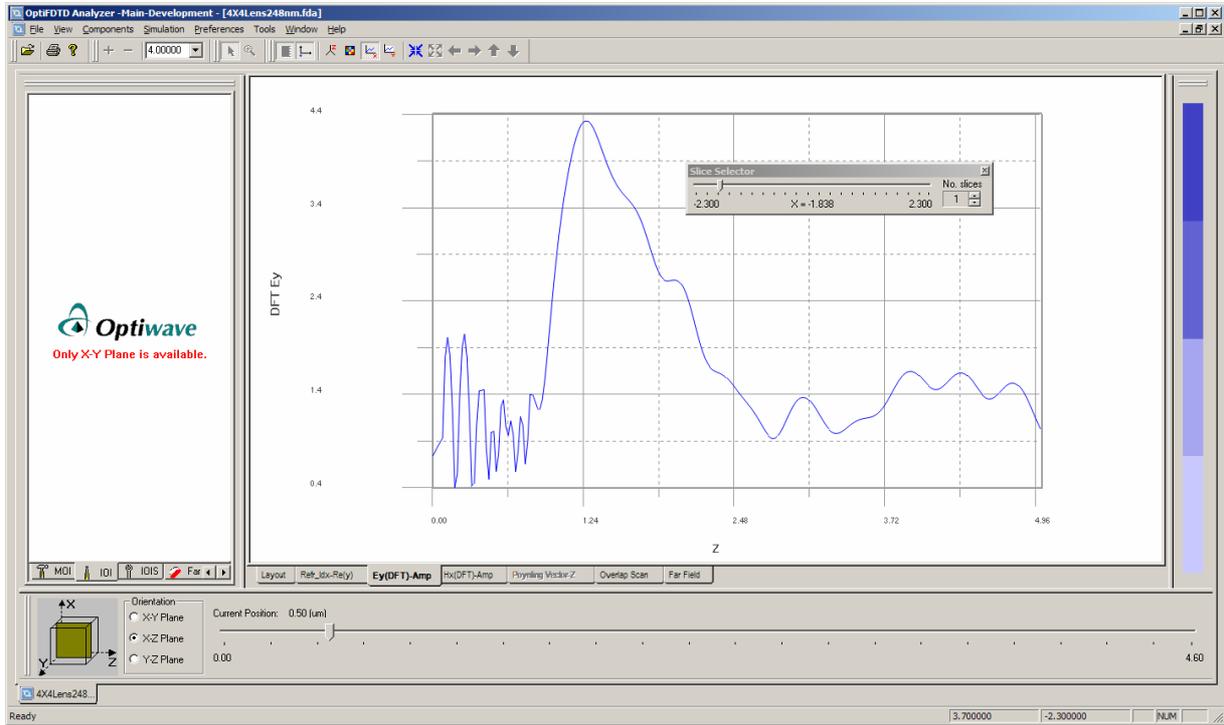


Figure 6, Field pattern in xz plane  
 It can be read that each lens focus at  $z=1.26$ , focus distance  $1.26-0.8=0.46\mu\text{m}$