# Scenario 500: Design of Reflective Diffuser

**This application scenario demonstrates the design and analysis of a micro structured mirror for the generation of a diffuse angular light distribution.**

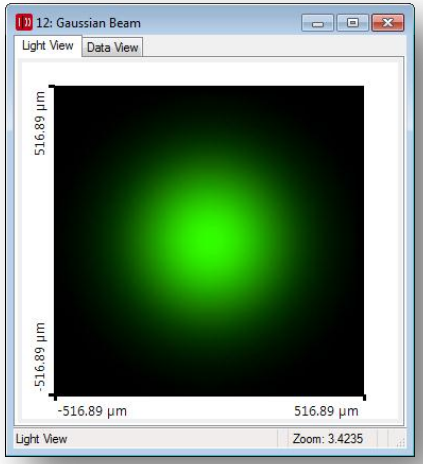
Keywords: diffuser, mirror, micro structured mirror, DOE, optimization, IFTA, CGH, kinoform

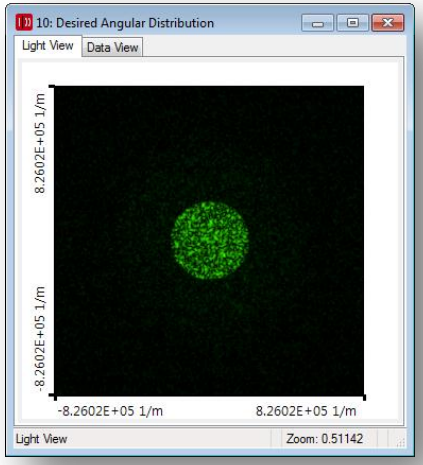
Required Toolboxes: Starter Toolbox, Diffractive Optics Toolbox

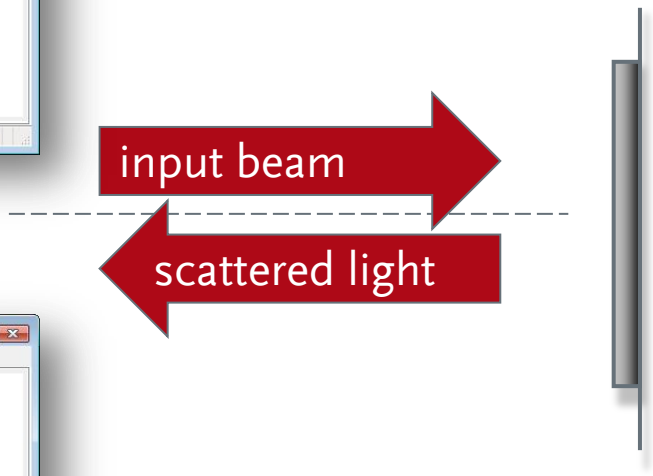
Related Application Scenarios: DO.001, DO.002, DO.003, Scenario 385.01

LightTrans

# Modeling Task 1 of 4

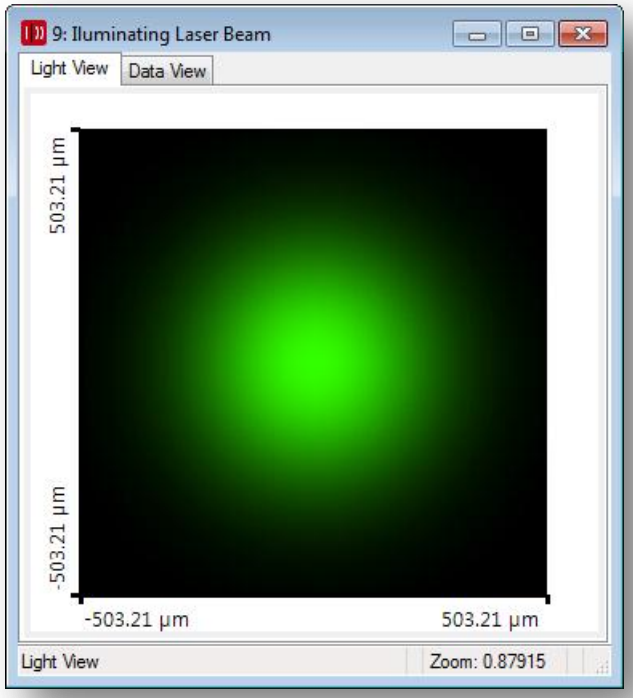


# Modeling Task 2 of 4

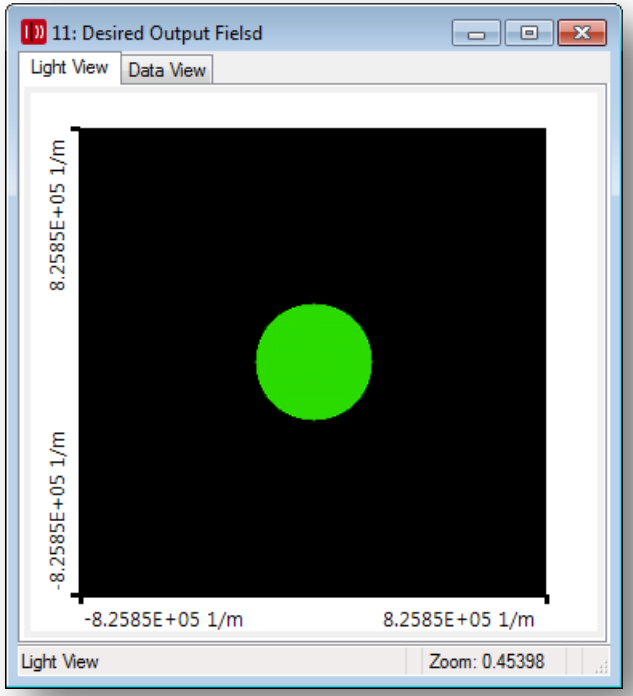
## Illuminating Beam Parameters




- Wavelength: 532 nm
- Laser beam diameter ($1/e^2$): 500 µm

# Modeling Task 3 of 4

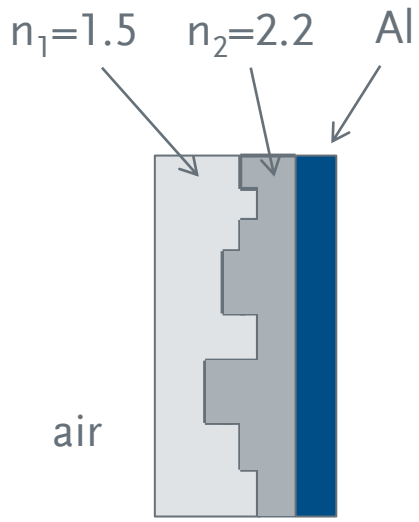
## Desired Output Field Parameters




- Angular distribution
- Circular Top Hat
- Diameter: 2°
- Resolution: 0.025°
- Efficiency: ≥85 %
- Stray light: ≤15 %

# Modeling Task 4 of 4

## Mirror Parameters




- Minimum pixel size: 1µm
- Height levels: 8
- Refractive index Al: from VirtualLab material catalog
- Definition area (DOE Aperture diameter): 1mm

# Design Steps

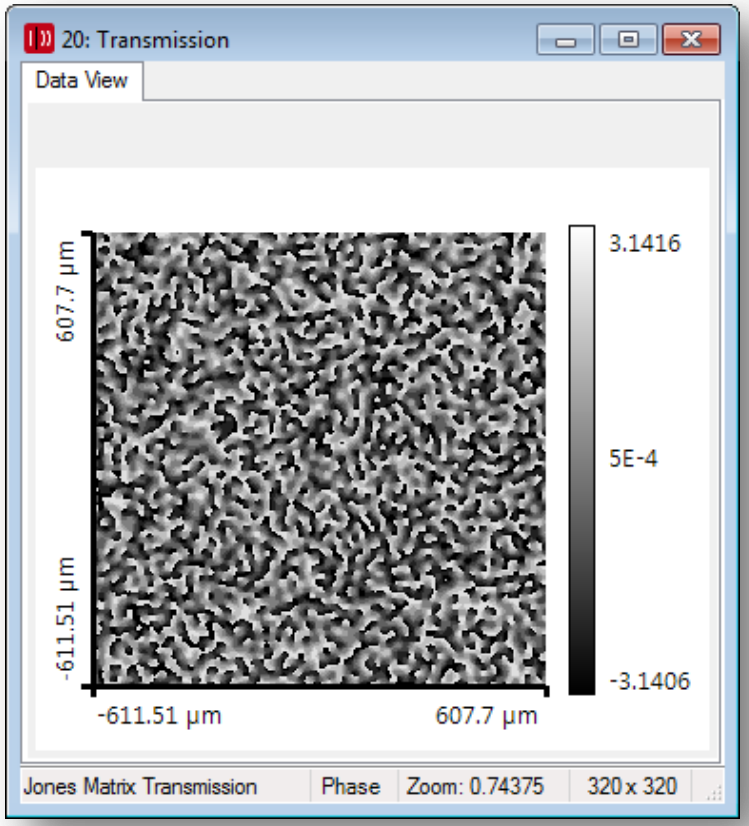
- Desing of reflection function:
  Optimization of reflection function by session editor and IFTA optimization document of VirtualLab

- Structure design:
  Calculation of micro structured mirror surface profile

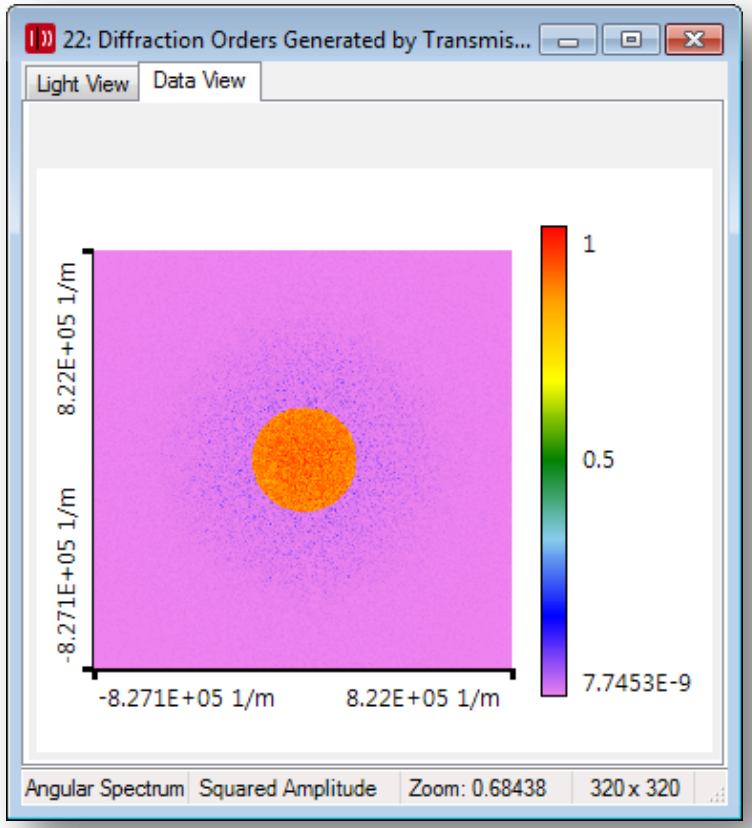
# Reflection Function Design

- Optimization of reflection function can be done by regular shape diffuser session editor (Design→ Diffuser Design→ Regular Shape Diffuser).
- The session editor generates the IFTA optimization document for the optimization of the reflection function.
- The session editor sample file ‘Scenario_500_ Design_Reflective_Diffuser_01.seditor’
- IFTA Optimization Document in sample file ‘Scenario_500_Design_Reflective_Diffuser_02.dp’

# Reflection Function Design Result



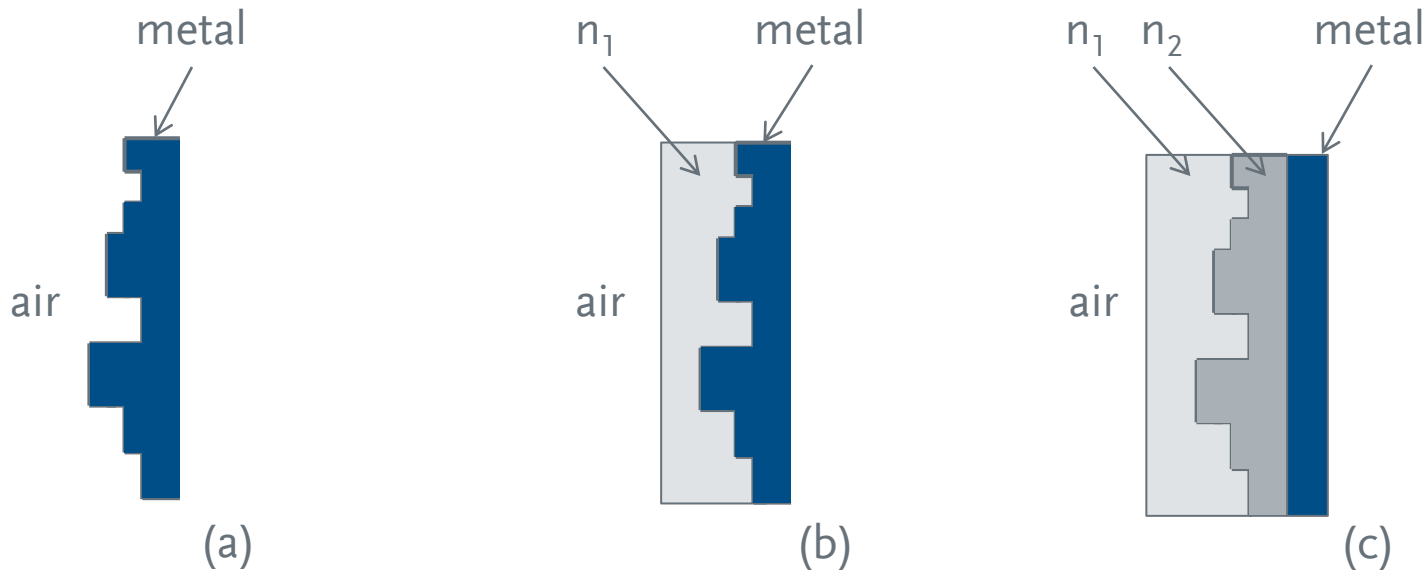

Phase of optimized reflection function




Intensity of diffraction orders generated by reflection function

# Structure Design

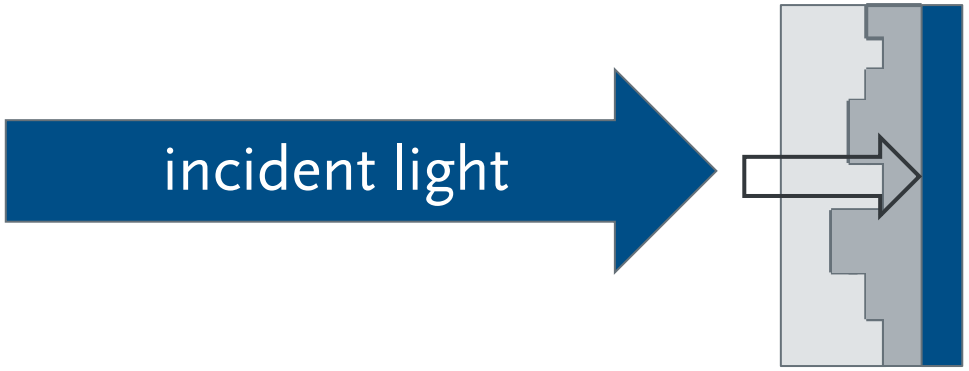
**Types of Micro Structured Mirrors**




- Case (a): Included in structure design feature of VirtualLab
- Case (b): Only a modification of case (a) and can be constructed quite easily by modifying the output of the structure design.
- Case (c): Not included in the structure design feature of VirtualLab. Design will be demonstrated in this scenario.

# Analysis of Mirror

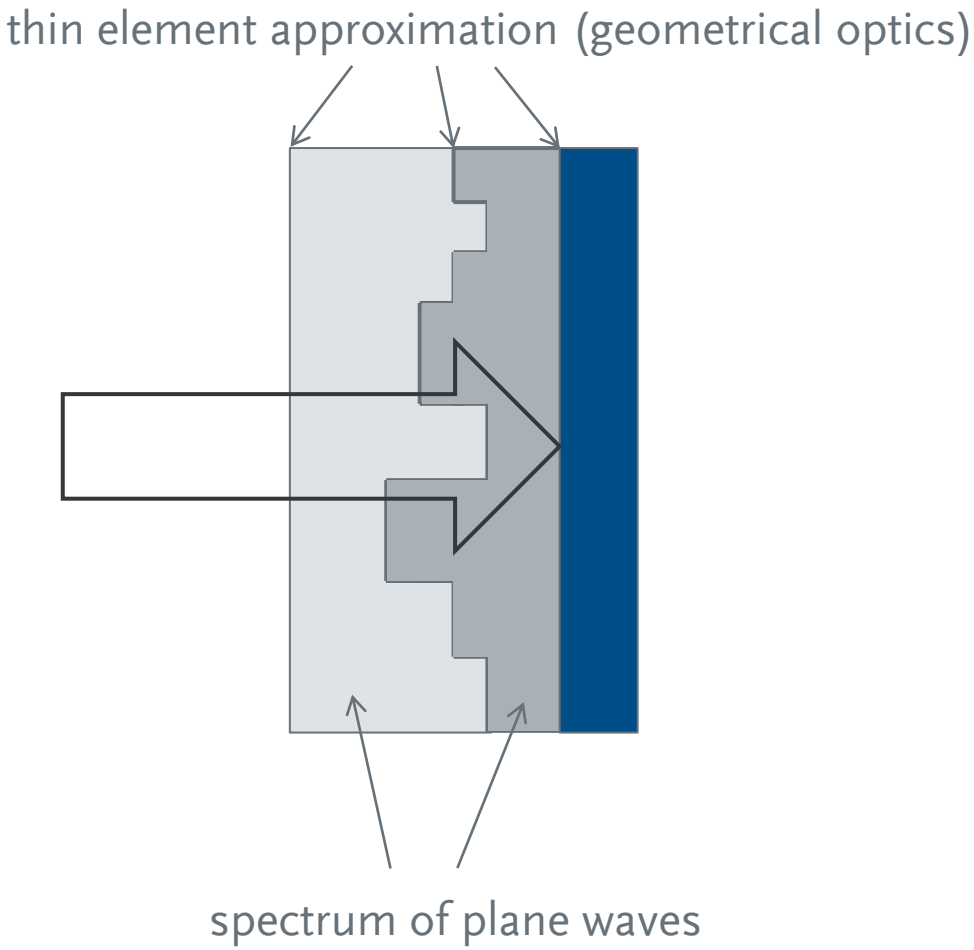
Step 1:



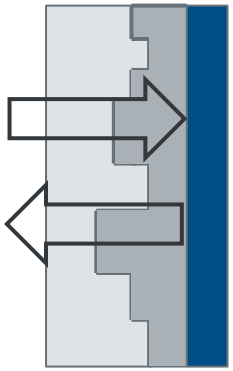

Step 2:


- Sequential field tracing analysis of micro structured mirror.
- Multiple reflections will be neglected in this example.
- Light Path Diagram used for analysis.

# Analysis of Mirror



# Structure Design Theory and Assumptions

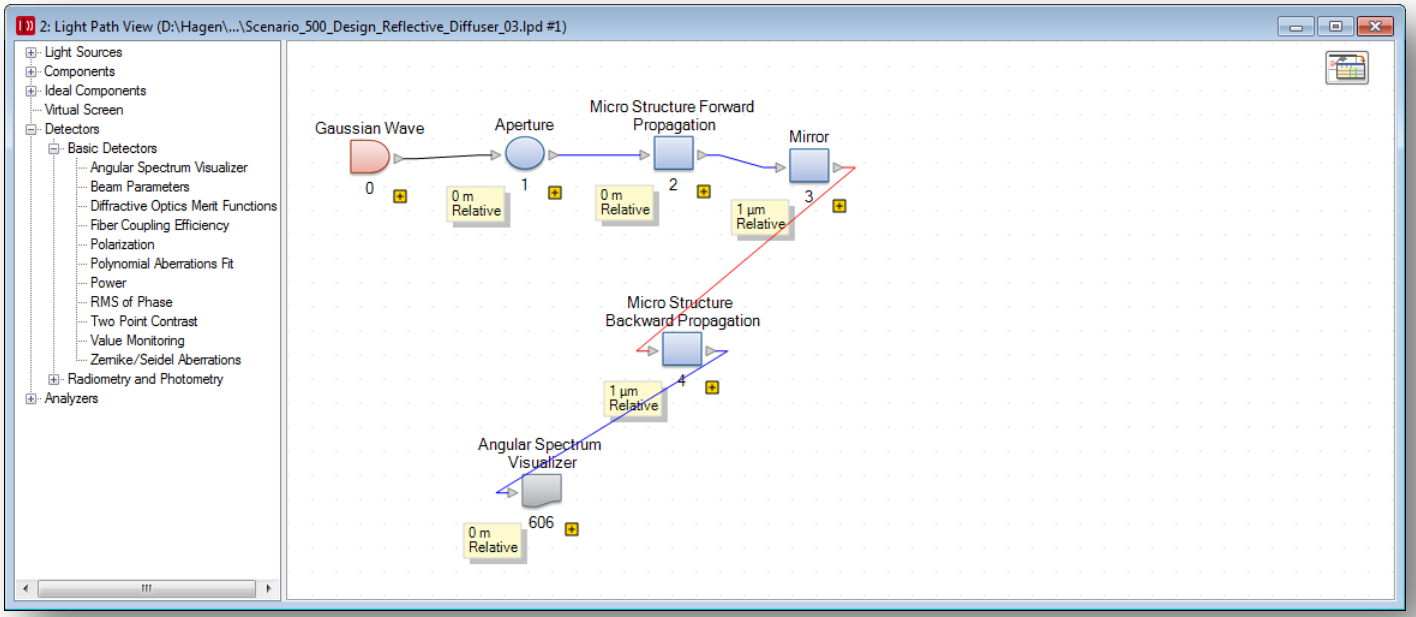


- Phase modulation of mirror can be approximately modeled by thin element approximation:

$$\Delta\varphi(x,y) = \frac{4\pi h(x,y)}{\lambda}\left(n_1 - n_2\right)$$

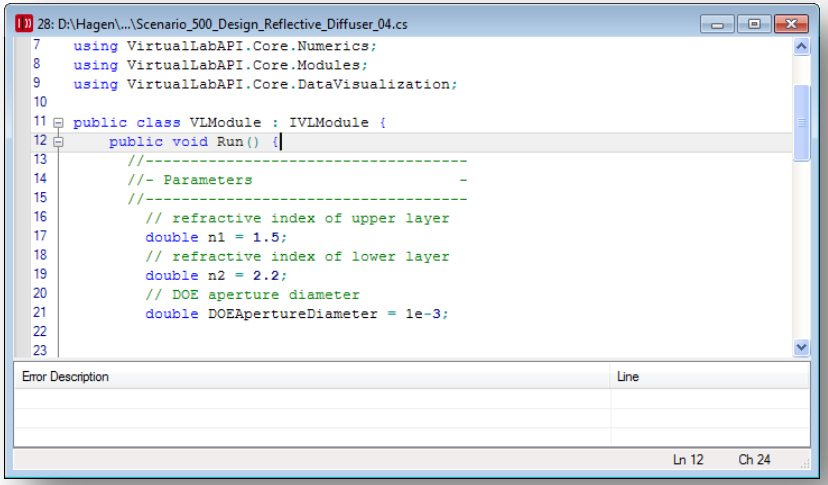
- Thin element approximation can be used to calculate the height profile from the phase of the reflection function.
- Approximations:
  - Features larger than five wavelengths
  - Thin layers and surface profiles (approximate one micron)
  - No interference, diffraction and refraction effects within the micro structured mirror

# Structure Design



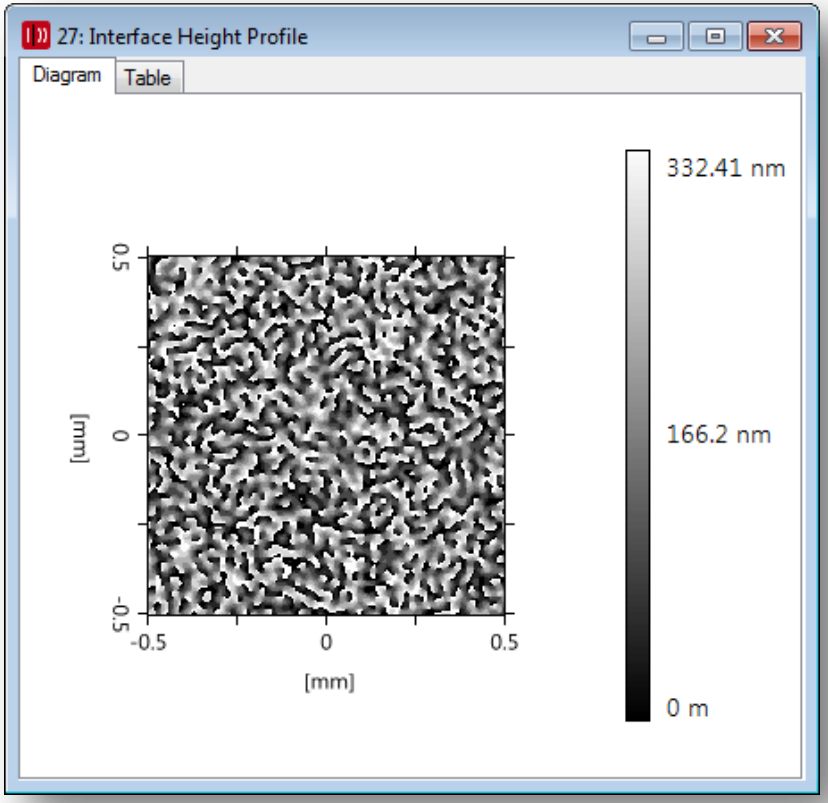

- Mirror modeled by two double interface components and a plane reflecting Al surface
- Light path diagram stored in sample file ‘Scenario_500_Design_Reflective_Diffuser_03.lpd’

# Structure Design



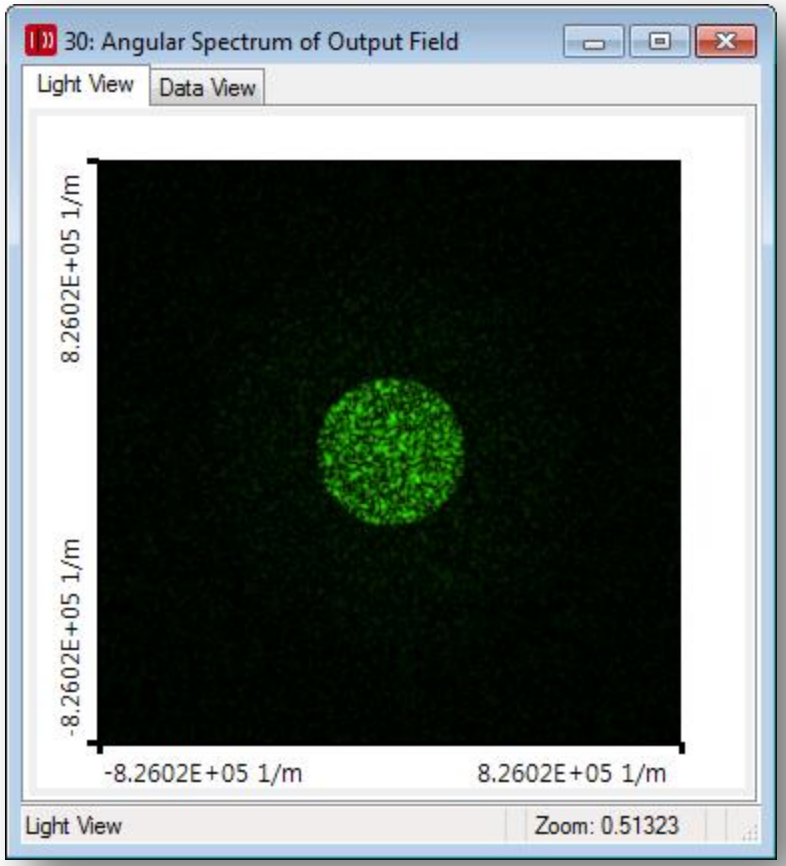

- Module ‘Scenario_500_Design_Reflective_Diffuser_04.cs’ can be used for the calculation of the surface profiles of both double interface components from the reflection function.
- The parameters section of the module allows to enter the refractive indices of the two layers and the DOE aperture diameter.
- Activate window with reflection function before running this module.

# Design Results




- Micro structured surface profile of mirror
- Modulation depth of 8 level surface 332nm

# Design Results




- Intensity of angular spectrum of output field
- Angular spectrum in wavenumber domain ($k_x$, $k_y$)

# Conclusion

- VirtualLab enables the design of micro structured light diffusing mirrors.
- Different micro structured mirrors can be simulated and optimized.
- Optimization of micro structured mirror is a two step process consisting of a reflection function design and the calculation of the surface profile.