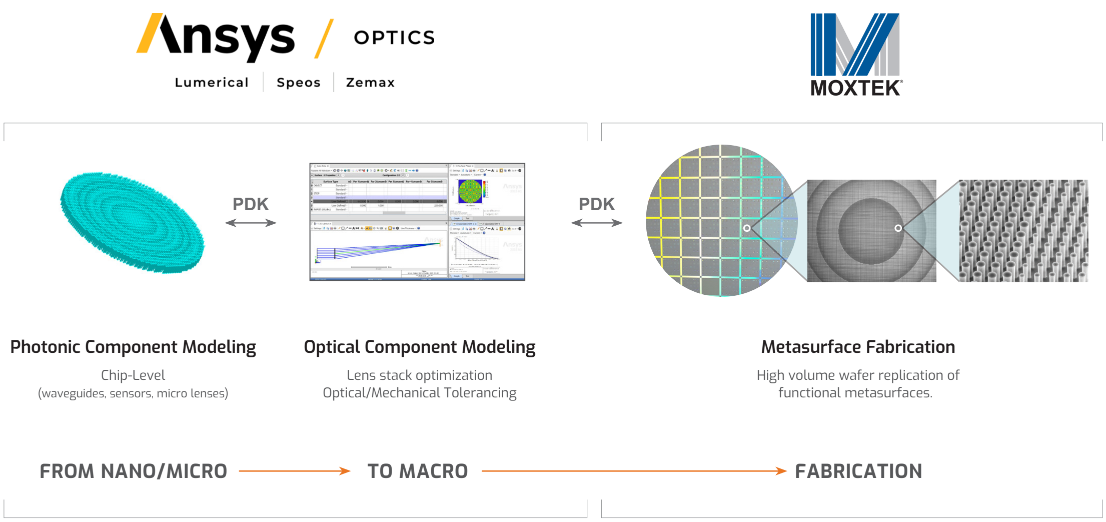
Moxtek/Ansys Meta-optic PDK

Workflow Technical Note

How to Use Ansys Lumerical FDTD™ and Ansys Zemax OpticStudio® Software to Design and Fabricate Metasurfaces

Ansys and Moxtek® have partnered to develop and promote a Process Design Kit (PDK) that integrates FDTD and OpticStudio software with Moxtek's nano-fabrication capabilities.This PDK includes visible wavelength meta-atom libraries and will serve as a standardized toolset enabling designers to efficiently model, simulate, and fabricate advanced metasurfaces within the Moxtek nano-foundry.



Purpose:

- **Accelerate Innovation:** Streamline the design-to-fabrication workflow for metasurface-based optical components by combining Ansys' industry-leading optics and photonics simulation tools with Moxtek's nano-fabrication expertise.
- **Metalens Prototyping:** Allow researchers and engineers to design metasurfaces using FDTD and OpticStudio, with validated parameters and process rules from Moxtek, increasing first-pass success in physical fabrication.
- **Advance Photonics Technologies:** Support the development of next-generation optical devices such as flat metalenses and other metasurfaces by leveraging Ansys optical modeling software with Moxtek's nanoimprint and etch technology.
- **Industry and Academic Collaboration:** Provide a foundation for R&D partners to explore metasurface applications with reduced barriers to entry.
- **Volume Manufacturing:** Access to an existing high-volume fab, capable of millions of parts per year.

This collaboration ultimately bridges the gap between simulation and real-world fabrication, empowering innovation in photonics and nanotechnology.

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Instructions for Design of Metalens with Moxtek Meta-atom Library PDK

1. Download the **[ADD LINK]** from Moxtek. Copy the meta-atom library files to your Zemax project folder.

2. In OpticStudio, add a surface to represent the metalens. The surface can be either type "Binary 2", or "User defined" with the dll file set as "us_binary_mix12_231020.dll". The Binary 2 element can only create radially symmetric lenses, but the user defined surface can create non-symmetric lenses that incorporate cartesian terms (X^n Y^m). For either surface, optimize the coefficients to fit your needs.
   - For the "Binary 2" surface, leave the radius terms at zero and adjust only the terms starting with "Maximum Term #". Leave "Diffract order" equal to 1.
   - For the "User defined" surface, leave the parameters "Par Pow Mode" and "Custom Pow" equal to zero because they are not relevant for optimizing the phase profile of the metalens.
   - The metalens surface should be on a flat piece of glass. The material to use is "Eagle-XG.dat" (found in the zip folder) which describes Eagle XG display grade glass from Corning.
   - 0.5 mm and 0.7 mm Eagle XG thicknesses are currently standard in the Moxtek foundry. Other substrate options are available. Contact Moxtek for more information.

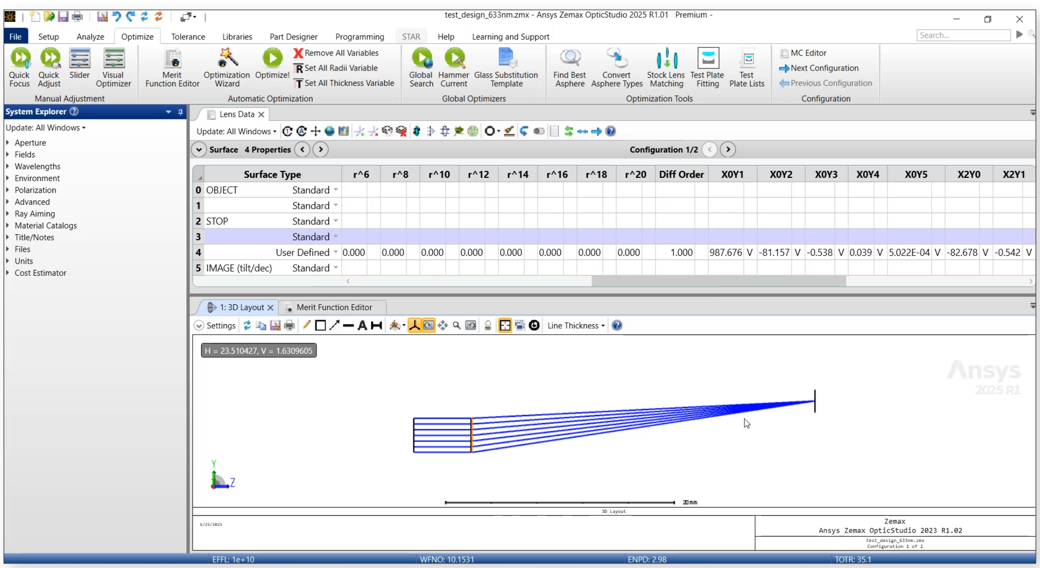

Figure 1: Optimization of metalens coefficients

3. Copy the coefficients of the surface element to a csv file, with the value on the second line.
   - For the "Binary 2" surface, the first value is "Max Term #". See the template "lens design coefficients -Binary 2.csv" included in the zip folder.
   - For the "User defined" surface, the first coefficient is Rnorm. Make sure that "Diffraction Order" is equal to 1. See the template "lens design coefficients -us_binary_mix12_231020.csv" included in the **[ADD LINK].**

4. In FDTD, open the script “Generate_metalens_with_Moxtek_library.lsf”. Change the entries in the section called User Settings to match your needs, but please leave the code after it unchanged to avoid errors.
    a. Comment/uncomment the value of surface_type according to the type of surface selected earlier.
    b. Update the metalens_coefficient_table variable to the name of the csv file with your lens coefficients.
    c. Update the lens_radius and comment/uncomment the meta-atom library file that you want to use.
    d. Comment/uncomment propagation_direction (select air-to-substrate if the light rays propagate from air through the metalens and into the substrate; select substrate-to-air if they proceed in the reverse direction).
    e. Run the script.

Generate_metalens_with_Moxtek_library.lsf

```
### User settings: ###

# If using type "Binary 2":
#surface_type = "Binary 2";
#metalens_coefficient_table = "lens design coefficients -Binary 2.csv";

# If using type "us_binary_mix12_231020":
surface_type = "us_binary_mix12_231020";
metalens_coefficient_table = "lens design coefficients -us_binary_mix12_231020.csv"

# Set the target extent of the metalens.
lens_radius_mm = 1.5; #Units: mm

# Select whether the light is entering the substrate or leaving the substrate as it
propagation_direction = "substrate-to-air";
#propagation_direction = "air-to-substrate";

# Select the library corresponding to your desired wavelength.
#metaAtom_library = "Moxtek_library_Wl532_v001";
metaAtom_library = "Moxtek_library_Wl633_v001";

# Select whether to export the GDS file.  1 to export.  0 to not export.  Exporting
export_GDS_layout = 0;

### End user settings ###
```

Figure 2: Lumerical script parameters

5. Copy the generated .h5 metalens file to your Zemax surfaces folder (typically located at C:\Users\username\Documents\Zemax\DLL\Surfaces\).

6. In OpticStudio, change the user-defined surface dll from “us_binary_mix12_231020.dll” to “lumerical-metalens-2025R1-2-20250120-307ab4f9d1.dll”.
    - Change the “Aperture->Maximum radius” surface property to the size of your lens in mm.
    - Change the comment to the name of the metalens file you copied in the last step (including the ‘.h5’ extension). Make sure that Set “Make Log” is to 99, “Method” to 1, “Window size” to 100, and “Order” to 0. For more information on these parameters, please see the tutorial here: https://optics.ansys.com/hc/en-us/articles/18254409091987-Large-Scale-Metalens-Ray-Propagation.

3. Reload all surfaces.

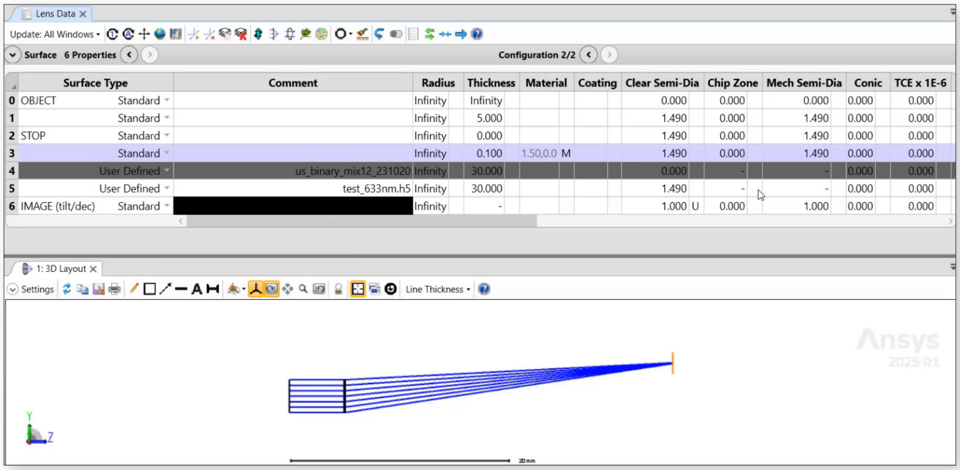

Figure 3: Generated metalens reloaded in Zemax

7. A simulation of a Moxtek metalens with your specifications should now be working in your optical system.

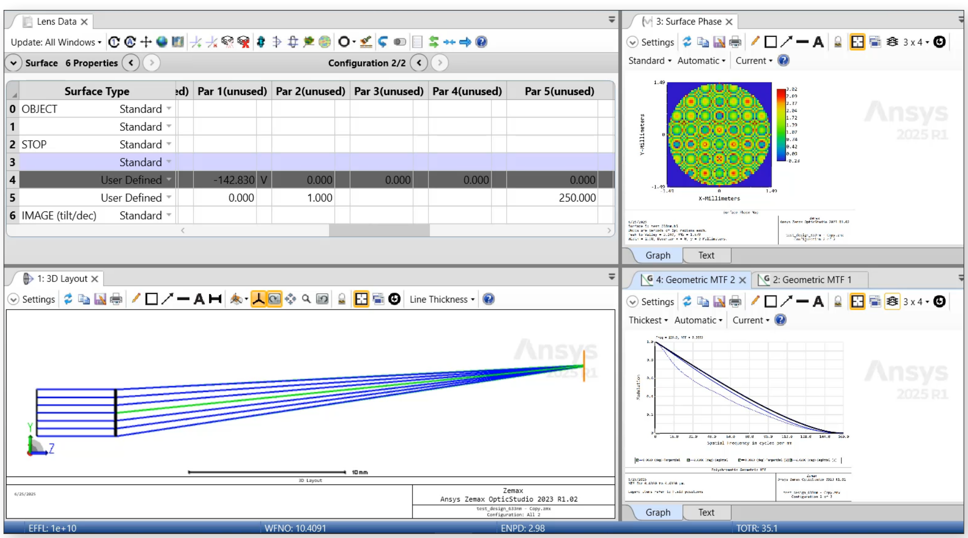

Figure 4: Simulated performance of metalens

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