Metalens Design and Simulation with RSoft and CODE V

0. Abstract

An effective simulation approach for metalens design is demonstrated by combining multiple simulation algorithms. Finite-Difference Time-Domain (FDTD) or Rigorous Coupled Wave Analysis (RCWA) is used to calculate the phase delay of various individual nano-cells, and then efficient beam propagation methods are used to trace the beam through the metalens or its equivalent phase mask.
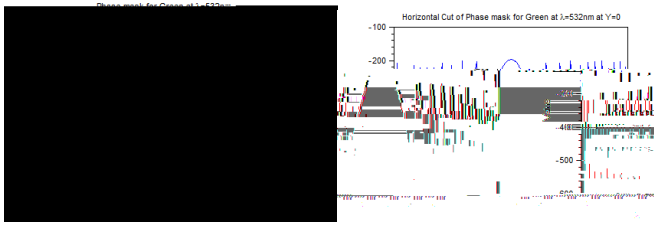
rigorous algorithm such as FDTD must be used. However, FDTD is computationally expensive, requiring substantial computer resources. The largest metalens that can be directly simulated in most labs through FDTD is only tens of micrometers in diameter, much smaller than what is needed [1].

In practice, however, direct FDTD simulation of the entire metalens is fortunately not required. In this paper, we demonstrate an approach that decomposes the metalens into simpler elements that can be solved individually. A rigorous algorithm such as FDTD, or alternatively RCWA, is used to calculate the phase shift of the individual unit nano-cells, from which a phase mask for the complete metalens is constructed. More efficient algorithms, such as Beam Propagation Method (BPM) or Beam Synthesis Propagation (BSP), are then used to simulate the propagation through the metalens. For the propagation,

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Figure 3: Phase mask of the metalens

2.3. Validation of BPM algorithm on a small structure

BPM is an efficient method to simulate forward propagation without accounting for backward reflections. We first validate BPM against the bidirectional FDTD algorithm on a small metalens 20µm in diameter and NA=0.25. The theoretical focal length is F=17.3µm. Shown in Figure 4 on the left is the BPM simulation result with F=16.96µm, and on the right is the FDTD result with F=17.14µm. This comparison shows that BPM agrees very well with FDTD for this application.
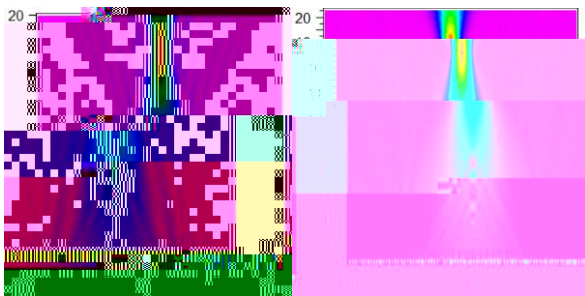

Figure 4: BPM result (left) and FDTD result (right)

For comparison the memory requirements for BPM were 0.19G and FDTD was 55G, and the respective simulation times