Stretchable Plasmonic Metasurfaces, PSED Cluster 2016-2017

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MECHANICAL ENGINEERING
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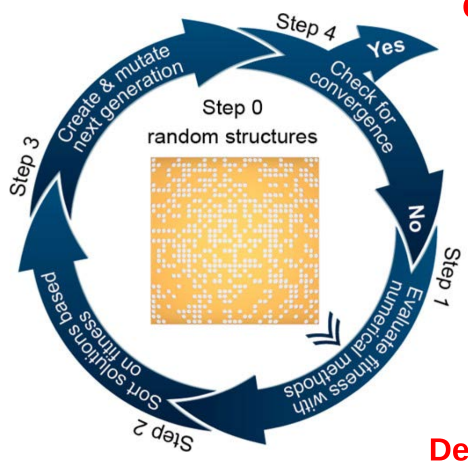
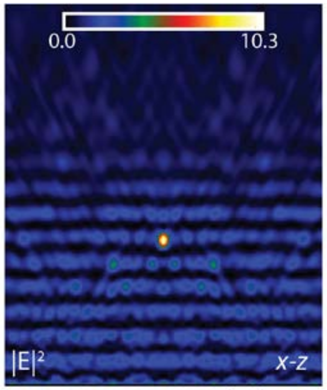
RESEARCH OBJECTIVE

Traditional lenses give a constant optical response throughout their lifetime and therefore cannot be modulated on-the-fly to correct for damage or any sort of aberration. We propose stretchable plasmonic metasurfaces, which are multifunctional, mechanically flexible and durable, and more compact than classical dielectric lenses. Our objective is to incorporate a novel fabrication method with a computational optimization approach while accounting for the manufacturing constraints of stretchable metasurfaces, effectively allowing a single physical surface to achieve multiple lattice spacing dependent desired responses. Currently, the design of the metasurfaces relies on a heuristic optimization algorithm which determines the location of the nanofeatures on a square array to achieve a desired light profile. This method results in extremely complex layouts that are difficult to manufacture and limit scalability.

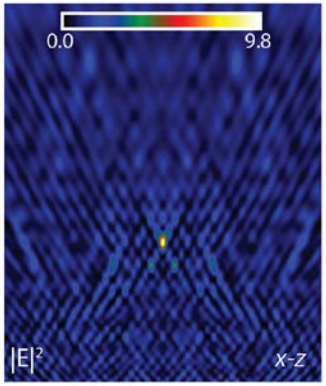


Genetic Algorithm Verification & Modification

- Genetic algorithm (GA) was used to generate metasurfaces with desired focal points
- Concurrent optimization of a single lattice for two different responses at two different lattice spacings
- Fields calculated by superposition of units on lattice assumed to be in infinite periodic array
- Verified the accuracy of this assumption and used this superposition of fields to limit the use of computationally expensive full FDTD simulations

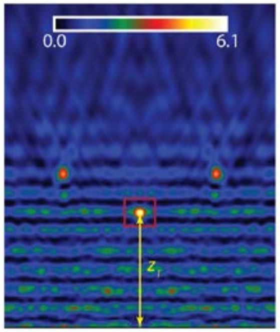


GA Superposition Calculation

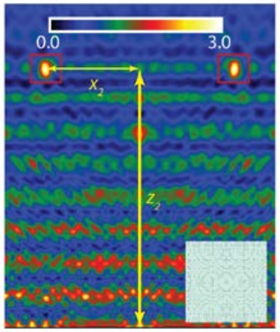


Full FDTD Simulation

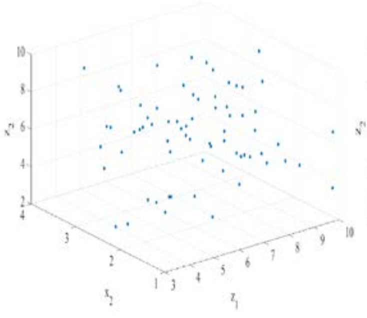
Design of Experiments to Determine Compatibility Rules



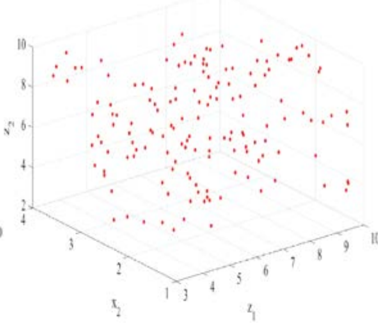
$a = 400$ nm



$a = 500$ nm



Compatible Responses



Incompatible Responses

- DoE of over 200 sets of a single focal point at initial lattice spacing to two focal points at a stretched lattice spacing
- Predictive models were only able to correctly predict compatibility ~ 50% of the time
- Yielded many lattices with unusual optical properties – ability to switch most intense focal point by biaxial strain
- Ongoing work: experimentally fabricate & measure metasurfaces

IDEAL Integrated DEsign Automation Laboratory

THE ODOM GROUP

NORTHWESTERN UNIVERSITY