Numerical Optimization Technique for the Optimal Design of the Surface Plasmon Grating Coupler

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Abstract

The optimal design of the grating coupler for surface plasmon generation is revisited for its interdisciplinary importance in the efficient use of energy, and the strong dependence of the energy convergence rate of the system on the design. This work contributes a comprehensive gradient based numerical optimization technique to optimize both geometry of the grating and parameters of the Gaussian beam simultaneously. We conduct gradient based optimization in COMSOL Multiphysics to obtain a numerical gradient and update the design. The method modifies all geometrical boundaries of each groove independently. The efficiency of energy conversion between the Gaussian beam and the plasmon is maximized. The gradient of the objective function is calculated from post processing COMSOL Multiphysics' Sensitivity Analysis information, and then used to update the geometry of each groove in a fixed mesh. Gaussian beam parameters are also optimized simultaneously in the final design. An optimal design shows different groove width, depth, and distance between adjacent grooves as illustrated in Figure 1. The conversion rate of the optimal design is significantly greater than the initial uniform groove grating design. A geometric parameter optimization step is illustrated in Figure 2. An significant increase in the magnetic field amplitude produced by the new design is observed in Figure 3. Results obtained show the practical value of these tools to be used on a n-grooves grating. This methodology is applicable to other optimization with partial differential equations problems that use the Finite Element Method discretization linear system.

Figures used in the abstract

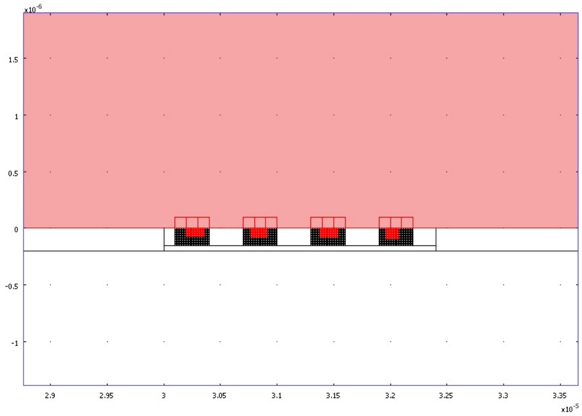

Figure 1

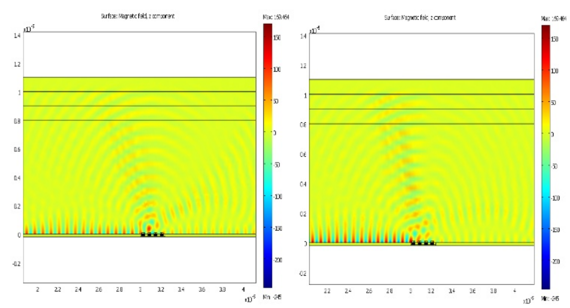

Figure 2

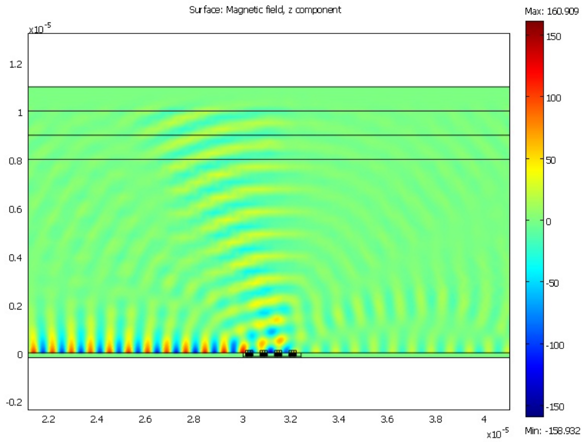
Surface: Magnetic field, z component
x10^-5
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
3.8
4
x10^-5
Max: 160.909
150
100
50
0
-50
-100
-150
Min: -158.932

Figure 3