Numerical Simulation of Bull's Eye Grating Using 2D Axisymmetric Model

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Introduction

•Plasmonic bull's eye gratings localize light in sub wavelength dimensions.
•Gratings fabricated on Ge-on-Si photodetectors can scale down the active area of the diodes.
•Thus high speed photodetectors are possible without compromising on responsivity.
•A frequency study of bull's eye grating using COMSOL Multiphysics shows presence of surface plasmons at selected frequencies.

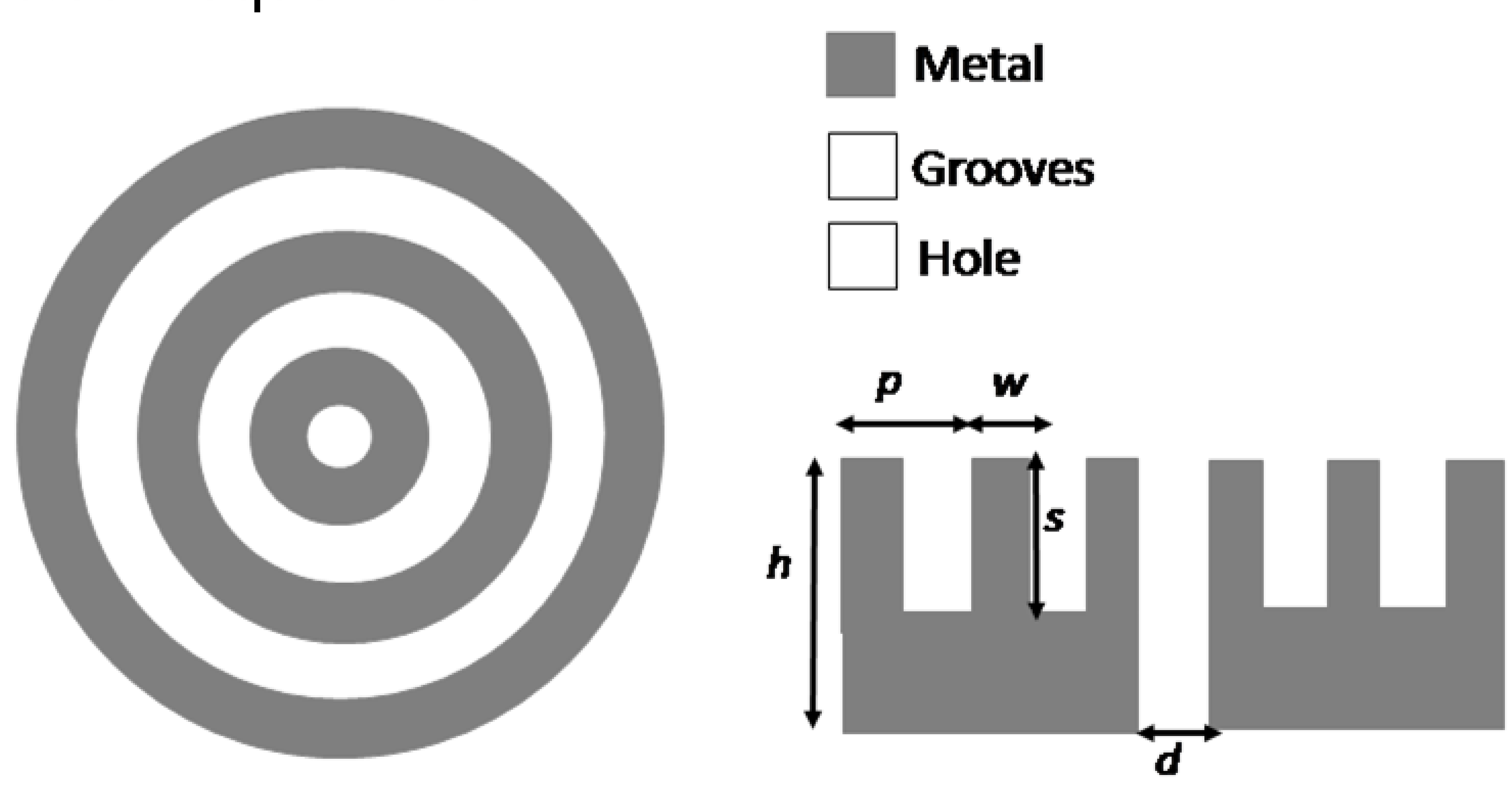

Figure 1. Top and cross sectional view of the bull's eye grating

Computational Methods

•To account for the circular geometry we have used 2D axisymmetric model shown in Fig. 2.
•The geometry has been modeled using frequency domain study under radio frequency module.
•Drude model has been used to define the frequency dependence of the relative permittivity.
•The parameters of the grating are optimized for resonance at λ =1550 nm. The relevant equations are

$$\nabla^2\mathbf{E} = \frac{-\omega^2\varepsilon(r,\omega)}{c^2}\mathbf{E} \qquad \mathbf{E} = \exp(-ik_z z)\hat{z}$$

$$\varepsilon(\omega) = 1 - \frac{\omega_p^2}{\omega^2 + i\gamma\omega}$$

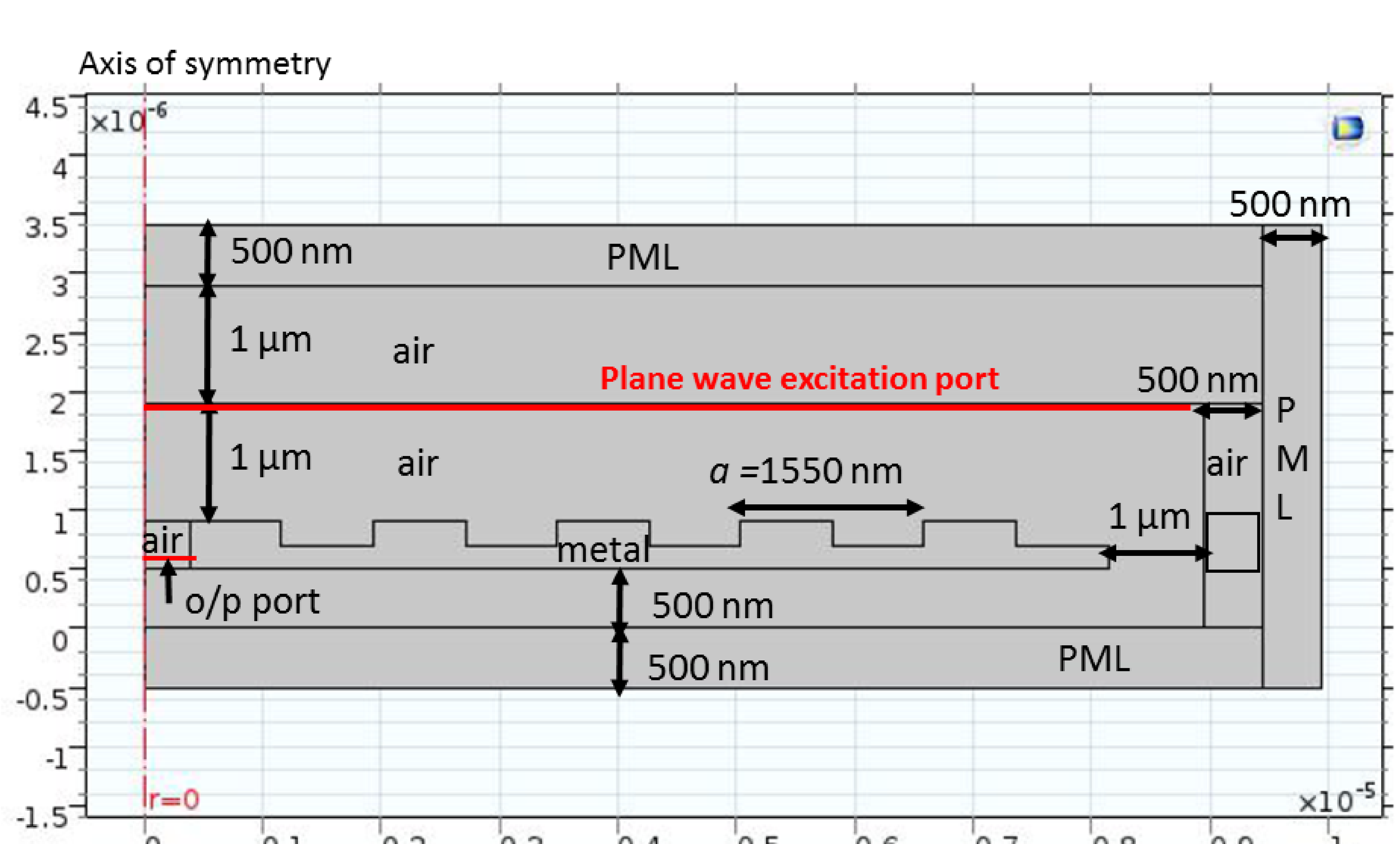

Figure 2. Geometry of the model used in COMSOL

Results

•A frequency analysis has been carried out by a parametric sweep of f_0 for $0.8 \leq 2f_0 \pi/\omega_p \leq 1.2$.
•The plot shown in Fig. 3 shows frequency selectivity.
•Presence of localized surface plasmons below ω_p shown by peaks of narrow line width.
• Presence of propagating plasmons above ω_p shown by low frequency selectivity.

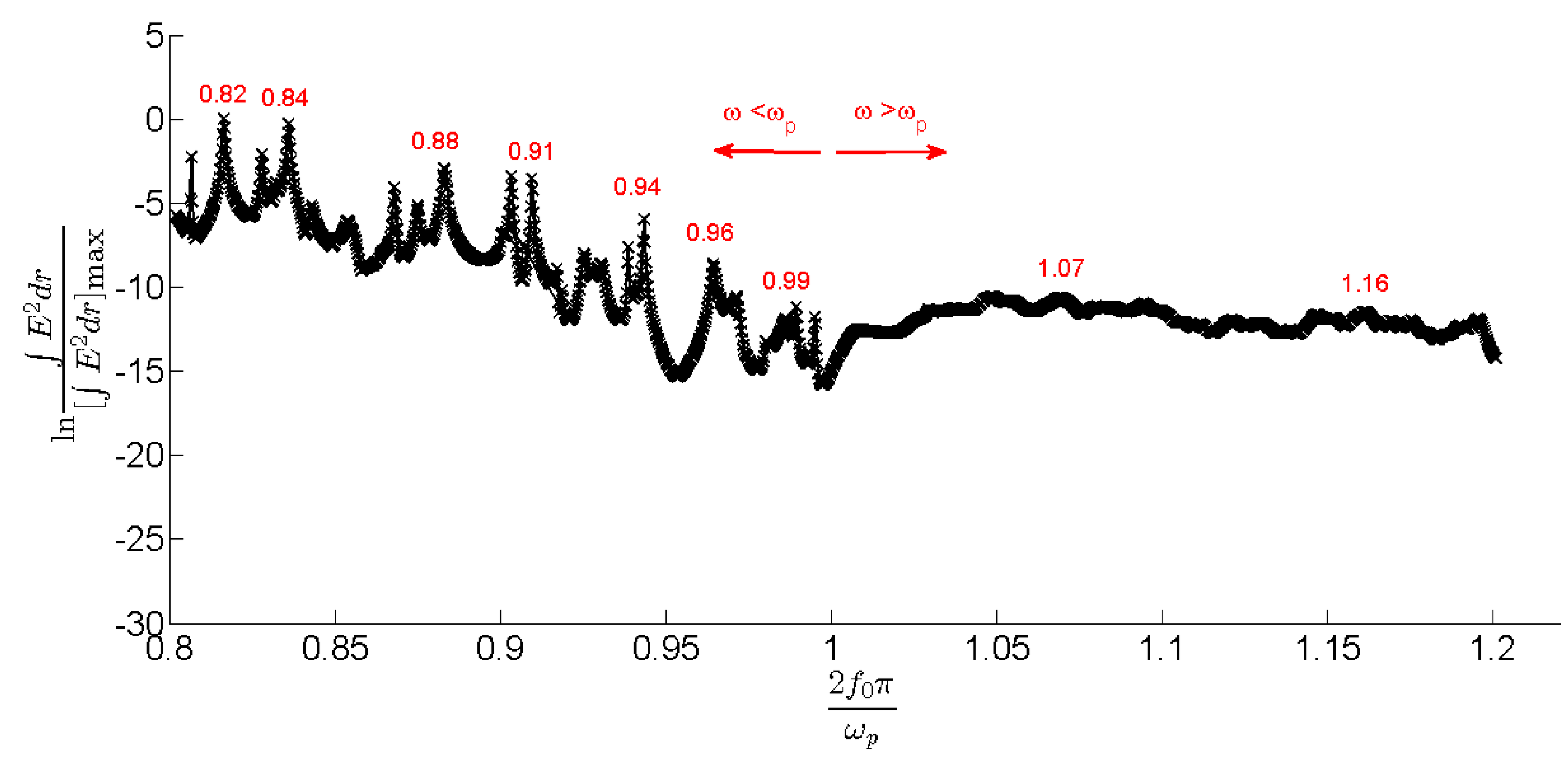

Figure 3. E field sweep for $0.8 \leq 2f_0 \pi/\omega_p \leq 1.2$

Variable	Value	Units
ω_p	2.24×10^{16}	rad/s
γ	1.22×10^{14}	rad/s
Max element size	$2\pi f_0/5$	rad/s

Table 1. Parameters

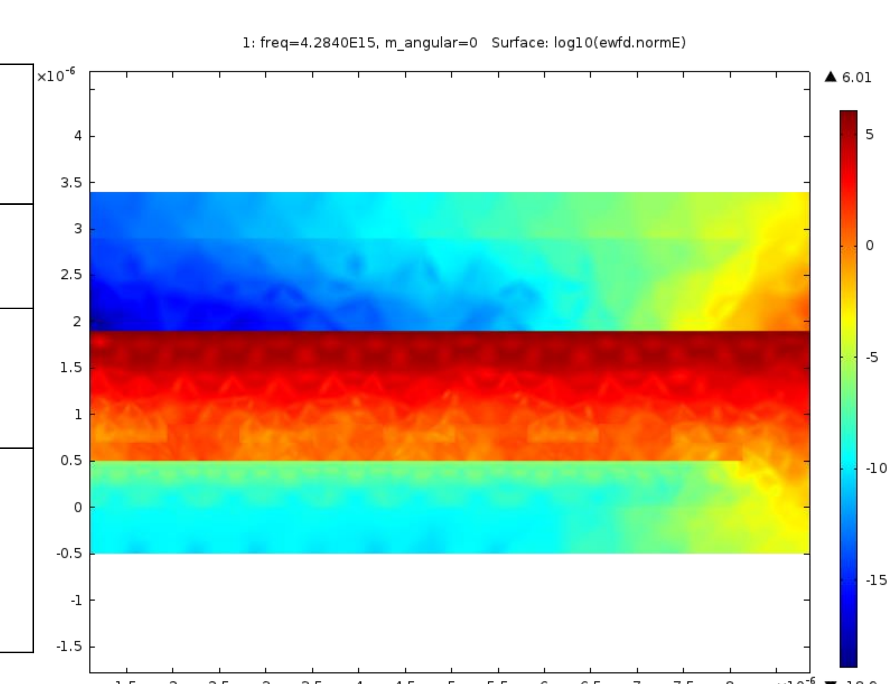

Figure 5. E field at $\omega/\omega_p = 1.2$

Conclusions

•The enhancement in E fields due to surface plasmon can be seen from the frequency analysis.
•Such gratings integrated with photodiodes paves way for ultra small active area and high sensitivity.

Acknowledgements

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References

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