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.

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

\[ \nabla^2 E = -\frac{\omega^2 \varepsilon(r, \omega)}{c^2} E \]

\[ E = \exp(-i k_z z) \]

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

Result
• 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 \( \omega_p \) shown by peaks of narrow line width.
• Presence of propagating plasmons above \( \omega_p \) shown by low frequency selectivity.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Units</th>
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<tbody>
<tr>
<td>( \omega_p )</td>
<td>2.24 \times 10^{16}</td>
<td>rad/s</td>
</tr>
<tr>
<td>( \gamma )</td>
<td>1.22 \times 10^{14}</td>
<td>rad/s</td>
</tr>
<tr>
<td>Max element size</td>
<td>2nf₀/5</td>
<td>rad/s</td>
</tr>
</tbody>
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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.

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References