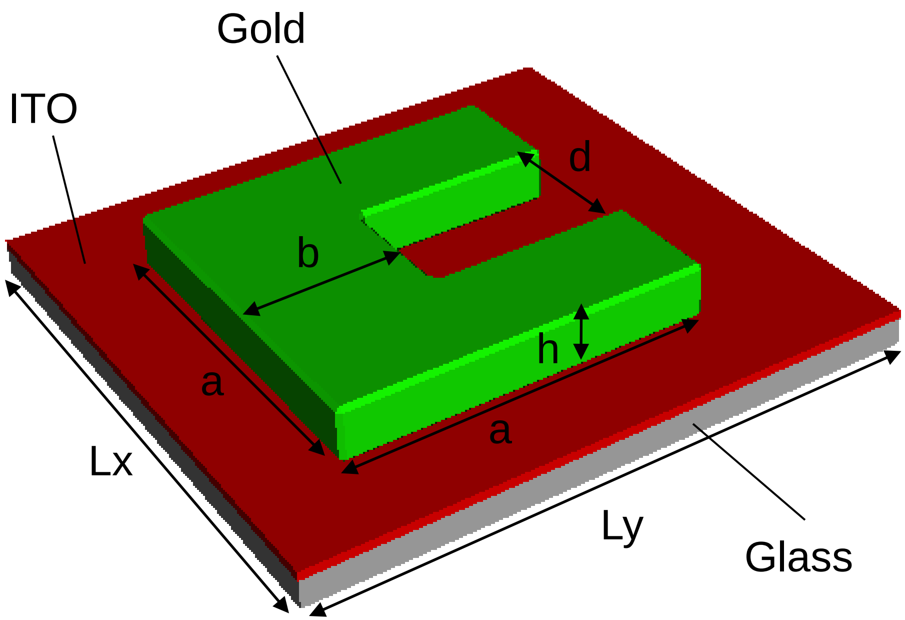
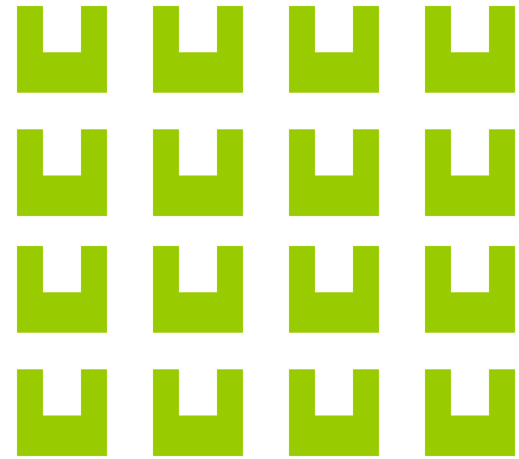
Simulation of Split Ring Resonator (SRR) at Optical Frequencies

Split Ring Resonator (SRR)

Glass substrate: 15nm, ε=2.25
ITO film: 5nm, ε=3.8
Gold: Drude model:

ω_p=1.367e16 (rad/sec)
ω_c=6.478e13 (rad/sec)





Lx = 315nm
Ly = 330nm
a = 200nm
b = 80nm, 90nm
d = 70nm
h = 30nm

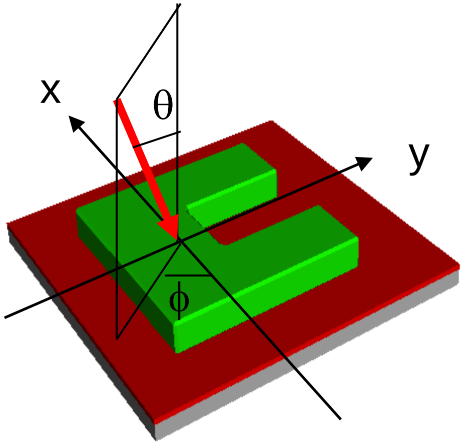
The parameters are based on the work of Enkrich et al [1] and Burger et al [2]

Simulation Setup

- Drude model used (via "drude" command, version 4.6) to calculate the complex permittivity of gold

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

- PML2 command ("pml2", version 4.6) used to terminate the absorbing boundaries in z direction
    - Enhancements to standard PML command: (1) automatically optimize PML parameters, (2) run faster in FDTD iterations
    - Allowing boundaries to be placed closer to scattering objects to reduce simulation domain size and, therefore, save memory and run time
- Yee cell size = 5nm
- The following effects are simulated
    - Angle of incidence (theta, phi)
    - S-polarization
    - Dimension b (80nm, 90nm)



Transmission Calculation

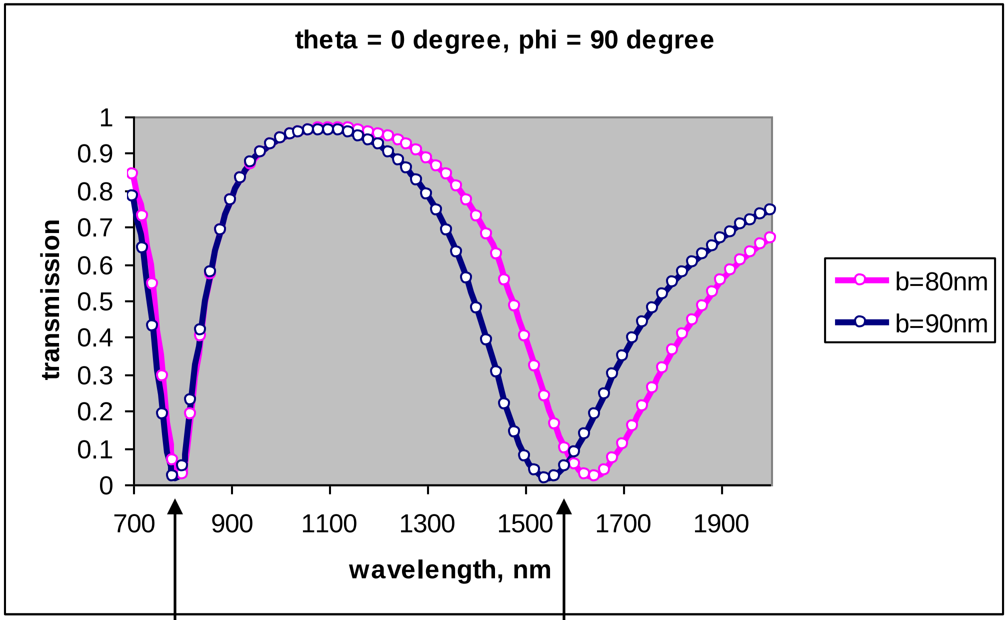
- The transmission through SRR is calculated as follows

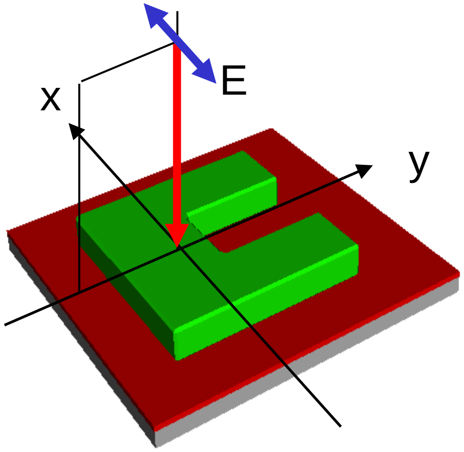
$$T = \frac{I_{SRR}}{I_{NoSRR}}$$

I_{NoSRR} is the e-field intensity of 0-order transmitted planewave w/o gold SRR.
I_{SRR} is the e-field intensity of 0-order transmitted planewave w/ gold SRR.

- The “scat_func” command with “ft=true” option is used to compute diffraction orders of the transmitted field

Effects of b

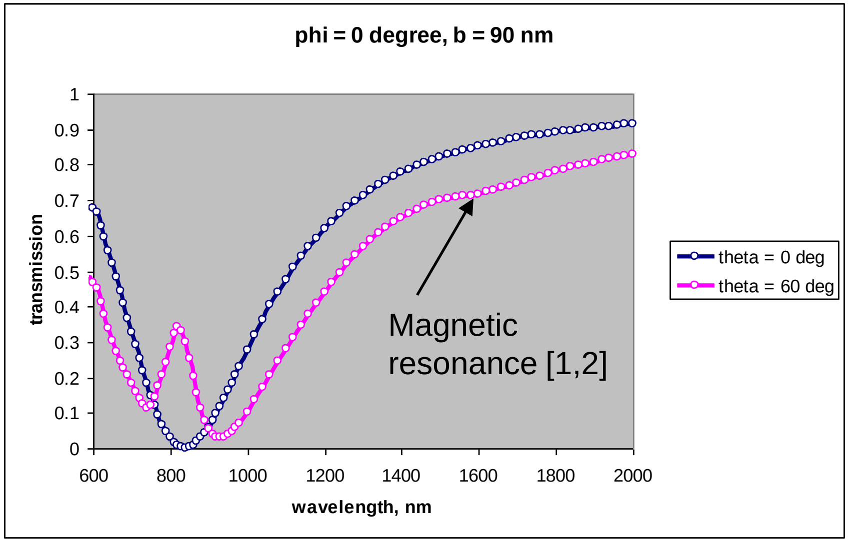


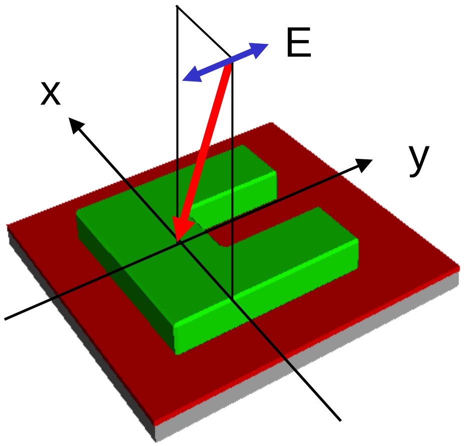


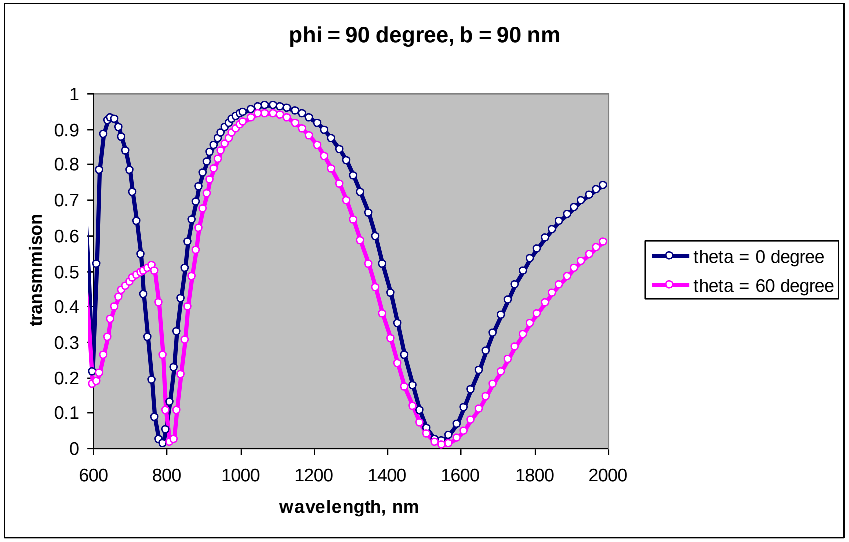
Mie resonance [1,2]

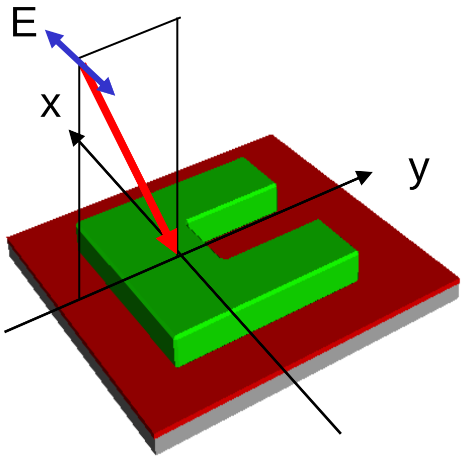
Magnetic resonance [1,2]

Effects of Incident Angles









References

[1] Enkrich et al, "Magnetic Metamaterials at Telecommunication and Visible Frequencies," Physical Review Letters, PRL 95, 203901, 11 Nov. 2005

[2] Burger et al, "Numerical Investigation of Light Scattering off Split-Ring Resonators," Metamaterials, Proc. of SPIE Vol. 5955, 595503, 2005