TIME AND FREQUENCY DOMAIN MODELING OF THERMO-PLASMONIC EFFECTS

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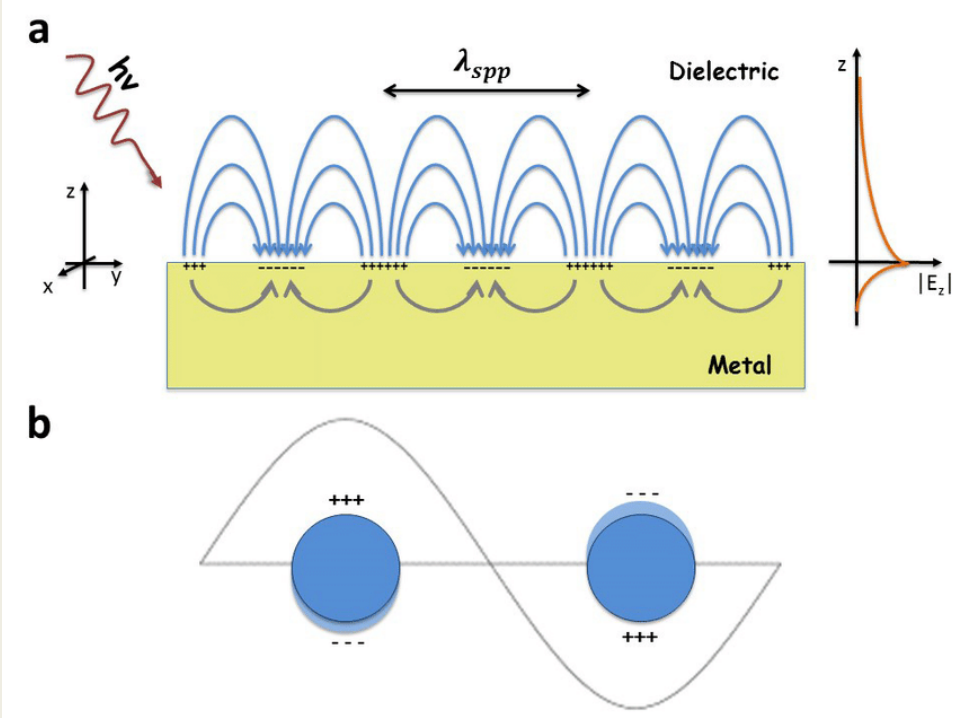
Plasmonic Materials:

- Metals, like silver and gold, have free conduction electrons
- Conduction electrons cause the electrical and optical properties of the metallic material
- When light is shined on a large piece of metal, these electrons reflect light back

Plasmonic Materials:

- In some special conditions, when light is shined on a metallic nanostructure, the light interacts with the free electrons on the surface of the material
- At certain “resonance” frequencies, the electrons oscillate and create a wave on the surface on the material
- This wave is known as a surface plasmon polaration (SPP)



https://www.researchgate.net/figure/Schematic-diagrams-illustrating-a-a-surface-plasmon-polariton-or-propagating-plasmon_fig3_311602957
https://www.scientificamerican.com/article/plasmonic-materials/

Thermo-Plasmonic Effects and the Two Temperature Model:

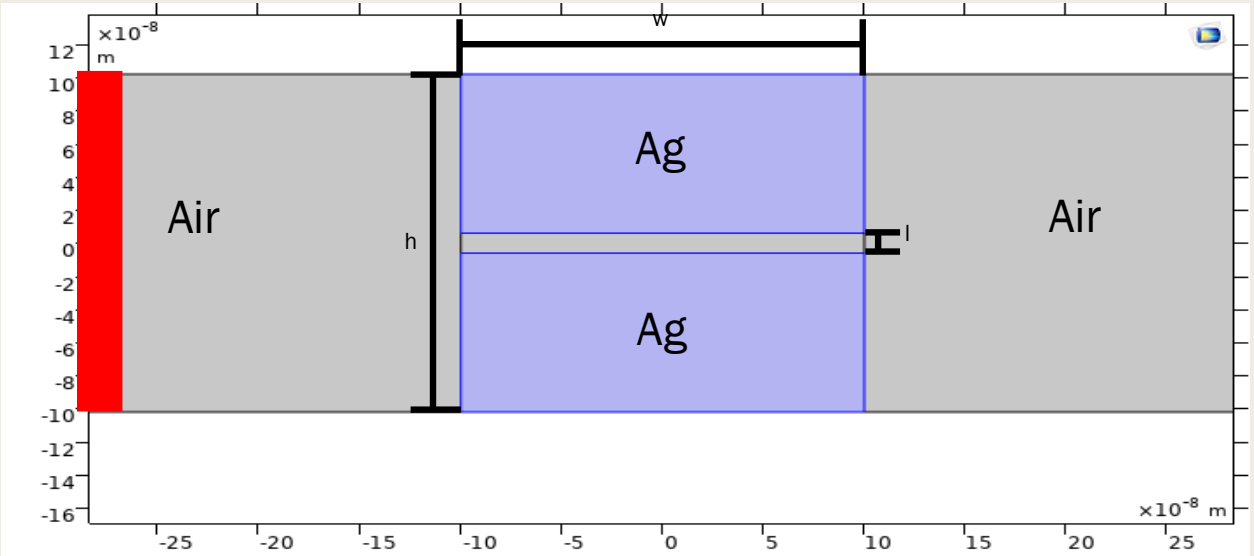
- At resonance frequencies, there is an increased absorbance of the photon energy by the electrons
- This causes the electrons to see a major increase in energy, and therefore a large increase in temperature
- The electrons then transfer energy to the lattice of the material
- Modeling the electron temperature and lattice temperature as they change over time is what is known as the Two Temperature Model (TTM)

Frequency vs Time Domain Modeling:

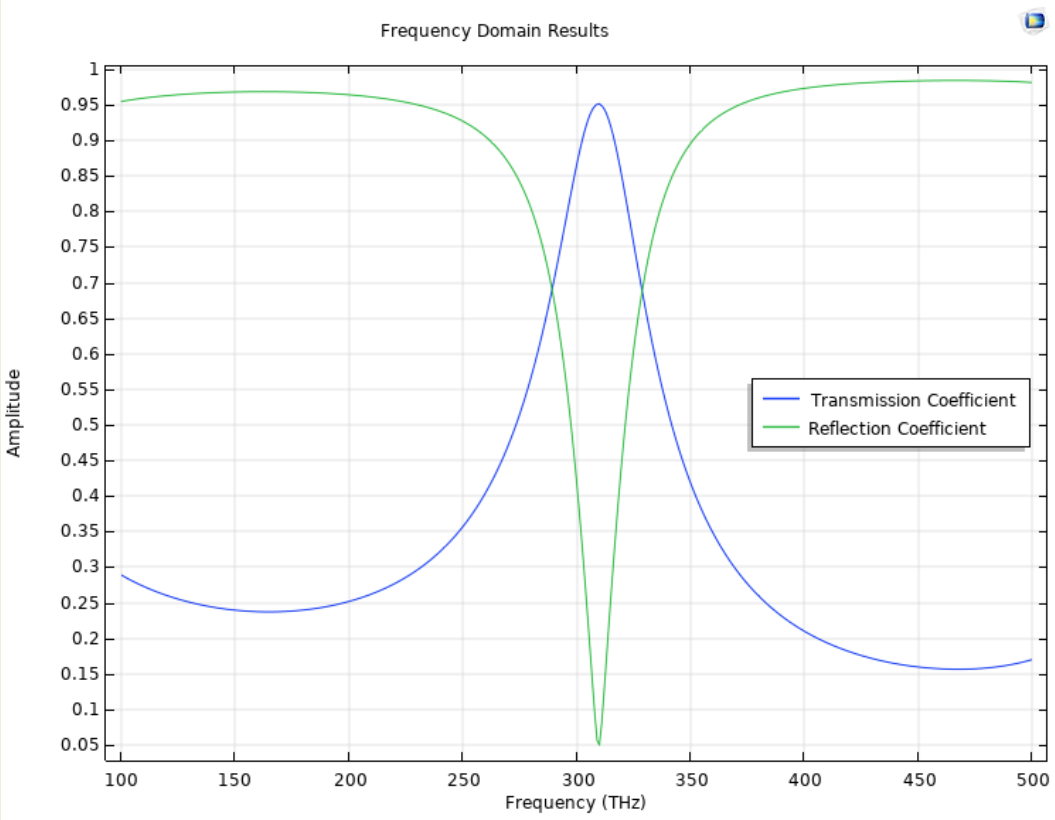
- Frequency Domain
  - *Uses Finite Element Method*
  - *Send one frequency of light at a time*
- Time Domain
  - *Uses Finite Difference Time Domain Method*
  - *Sends a pulse of light made of a band of frequencies*

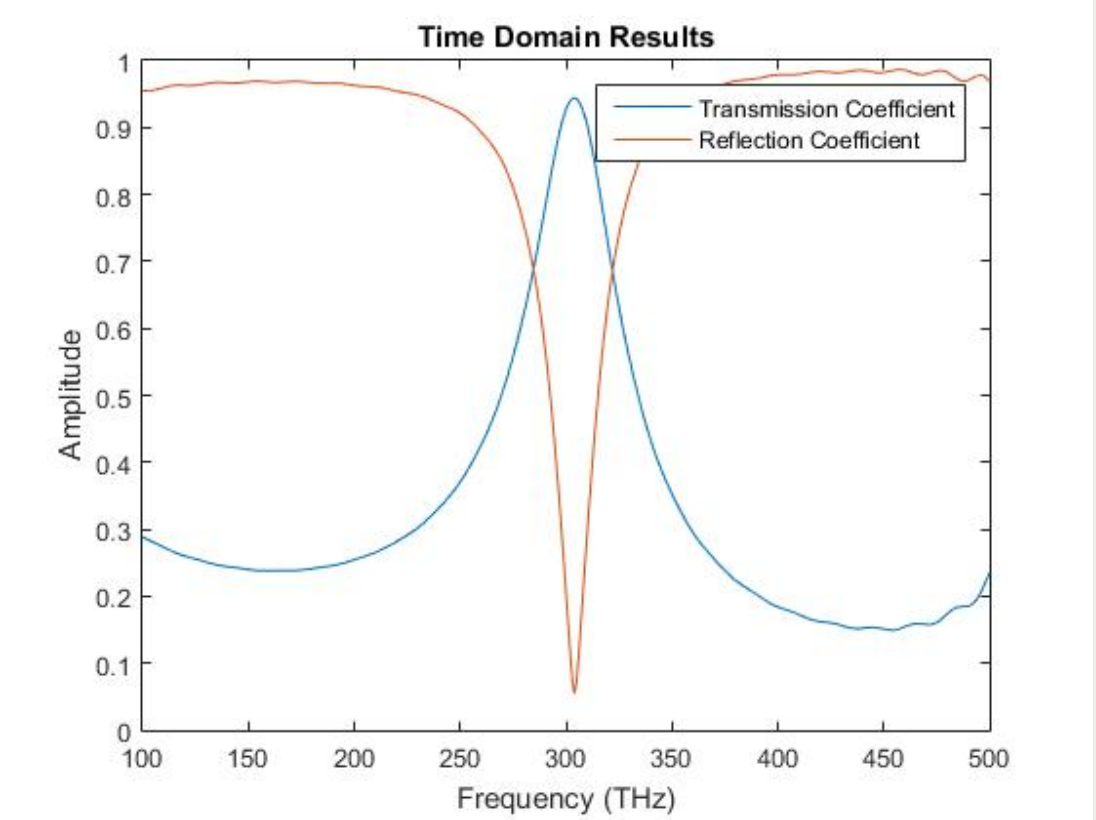
The Plasmonic Structure under Study:

- Width (w): 200 nm
- Height (h): 204 nm
- Slit (l): 12 nm
- Wavelength (λ): 1 um

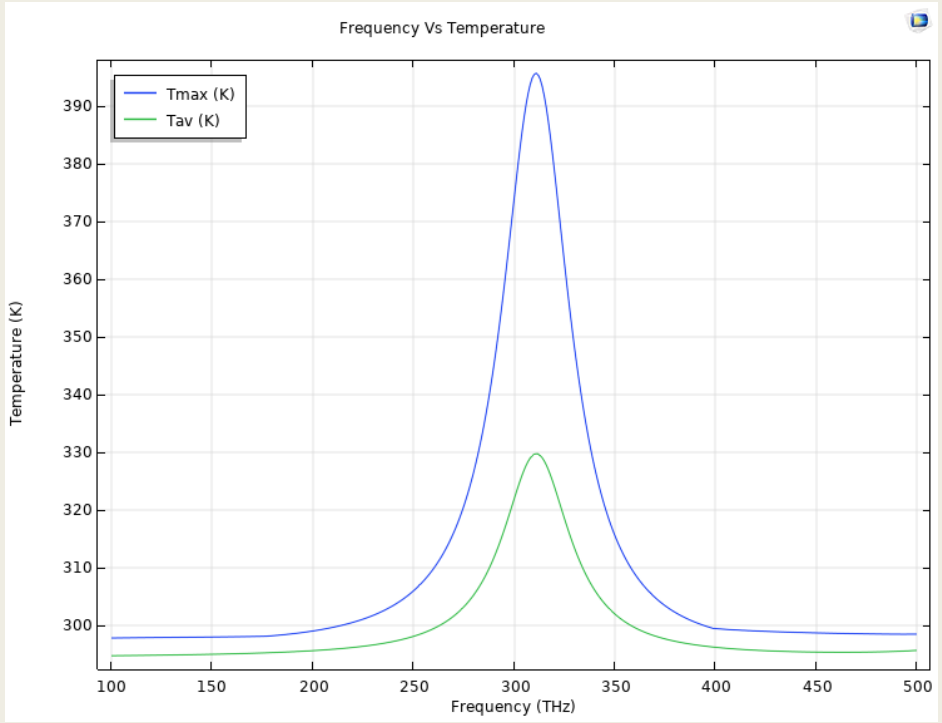


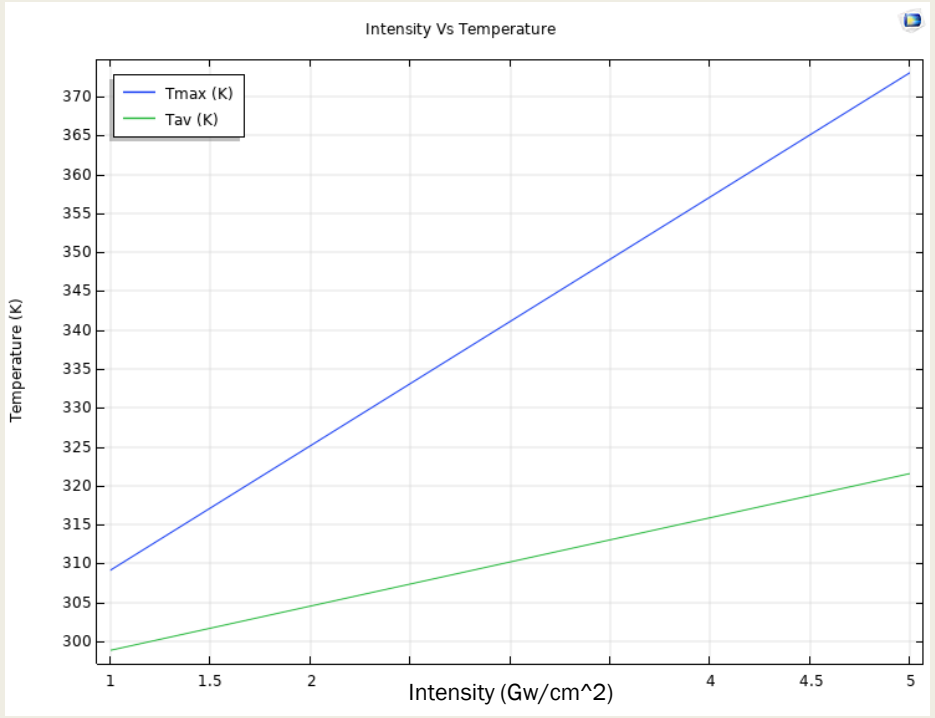
Time and Frequency Domain Comparison:





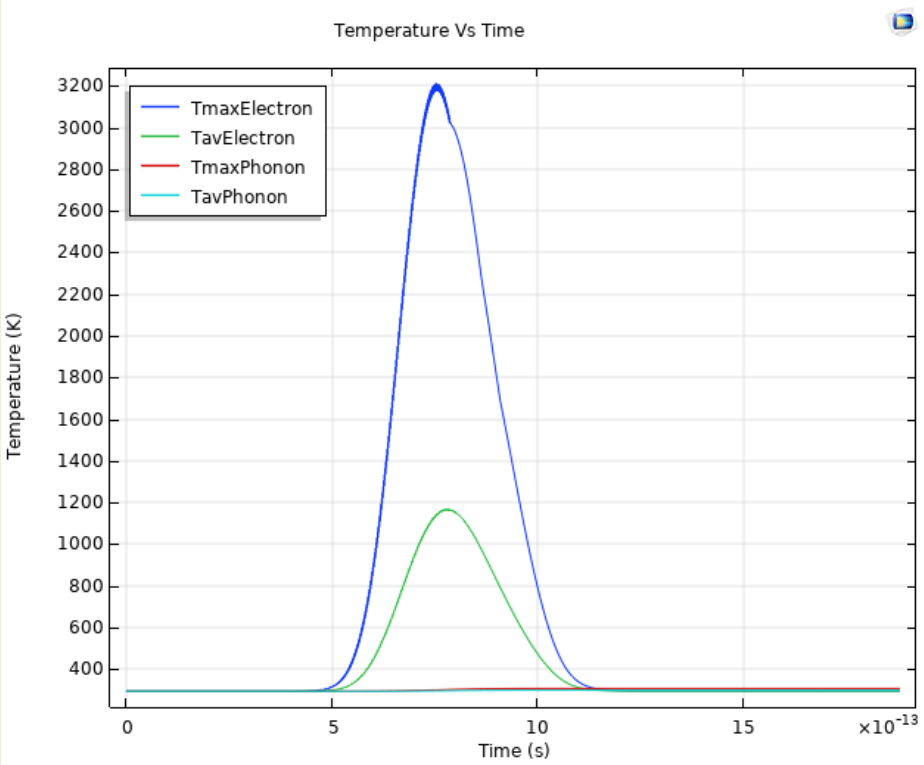
Frequency Domain Heating Simulations:

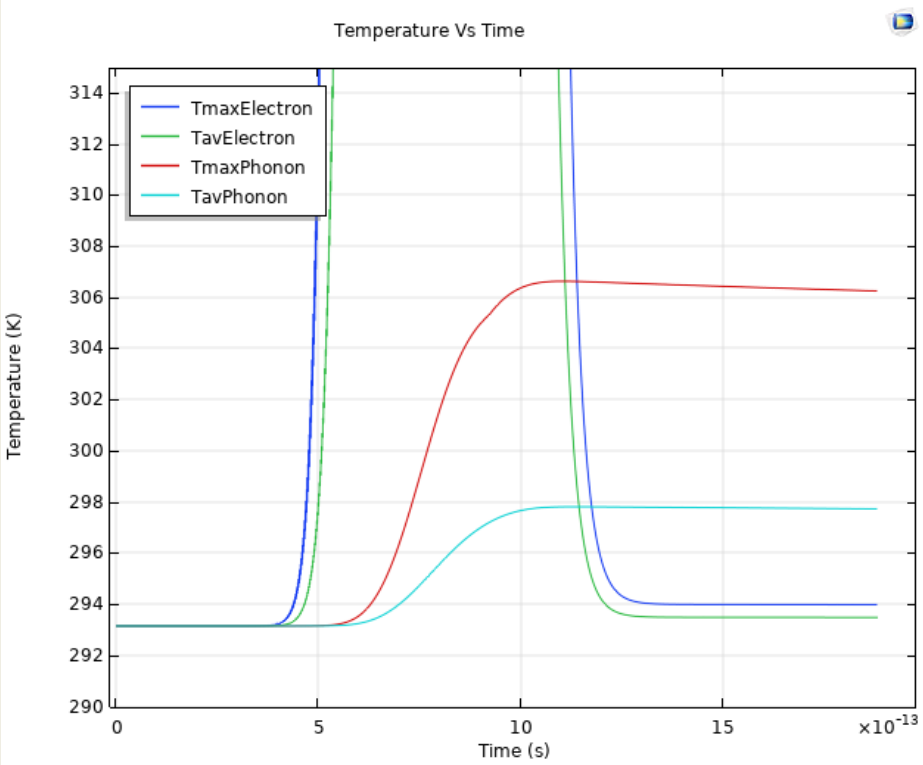




Intensity of 5 GW/cm^2

Time Domain Heating Results:

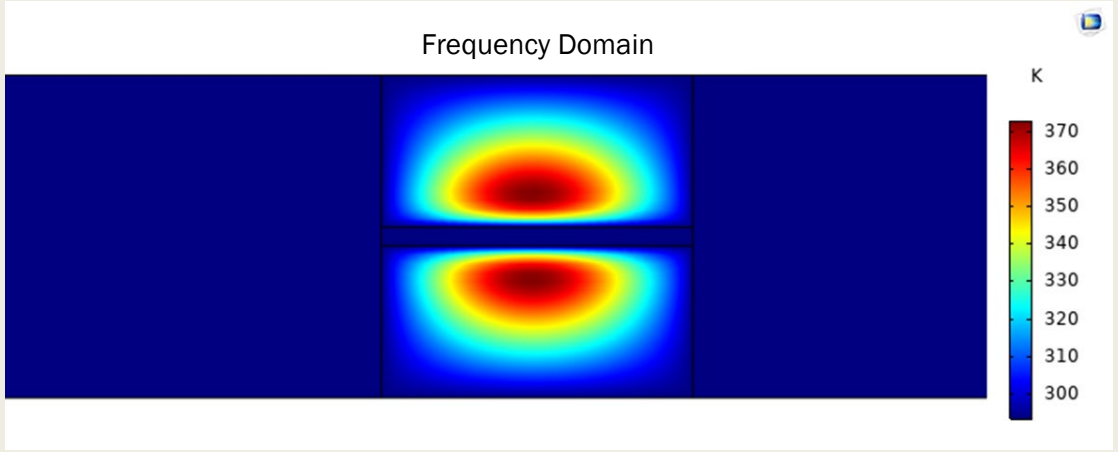


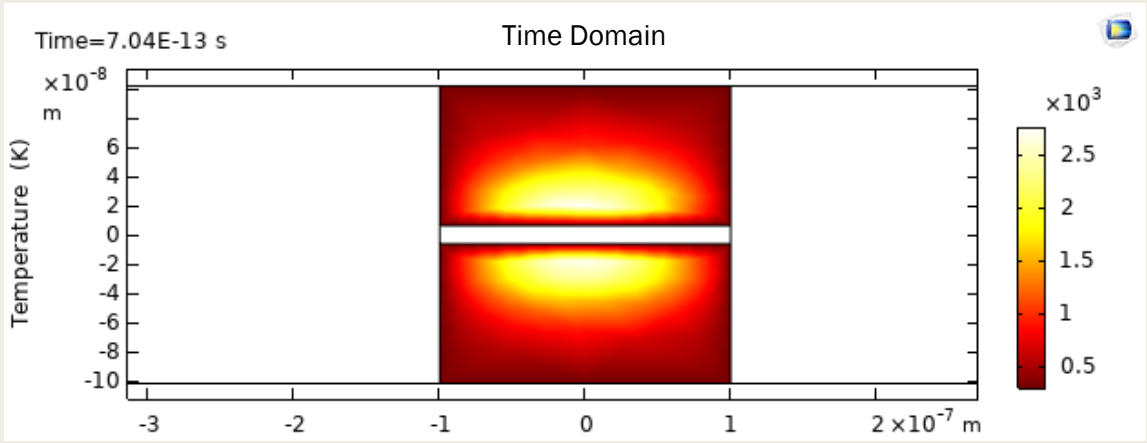


Pulse intensity = 100 GW/cm^2

Time and Frequency Domain Heat Map Comparison:

- Both domains exhibit heating from the center of the material
- This is due to the surface plasmons causing an increased absorbance in the center of the material





References:

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