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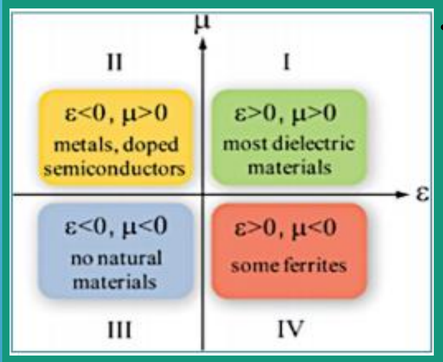
Introduction to Metamaterials

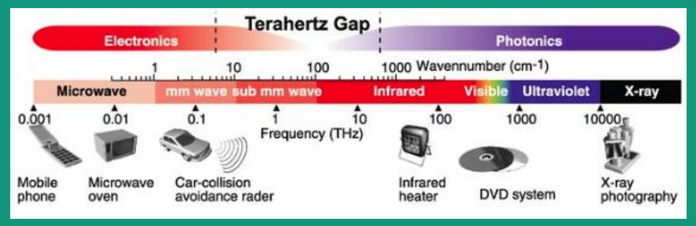
- Periodic Structures
- Exhibit Low Material Loss
- Man made, with configurable features



- *Metamaterials exist in quadrant III where Permittivity(e) and Permeability(u) are both negative resulting in a negative refractive index*

Terahertz Radiation

- Wavelengths range from 1mm to 10um
- Non-Ionizing
- Current detection methods are ineffective due to "Terahertz Gap"



Applications of Metamaterials

- Medical Imaging
- Security and Safety Detection
- Communications and Data Transmission

Objectives

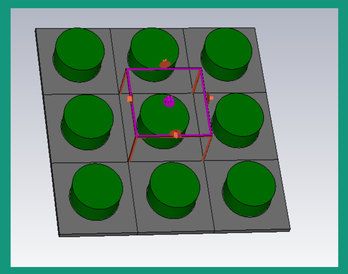
- Create metamaterial that exhibits low material low using Titanium Dioxide(TiO2)
- Identify useful geometries
- Identify smallest size of useful geometries to appeal to fabrication processes.

References

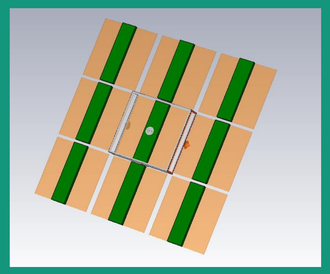
- Fukunaga, Kaori & Marcello, Picollo. (2010). Terahertz spectroscopy applied to the analysis of artists' materials. Applied Physics A. 100. 591-597. 10.1007/s00339-010-5643-y.

Methods

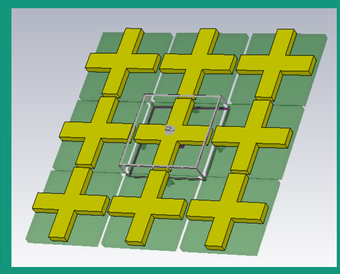
- Structure designed and simulated using CST studio
- Simulated Disk, Cross, and Wire geometries to investigate various results
- Performed multiple parameter sweeps of various dimensions values including: Length, Width, Radius, Periodicity, and Thickness



All-Dielectric Disk
Permittivity: 75

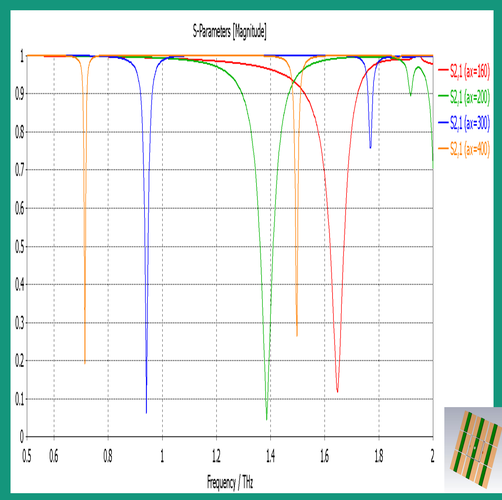


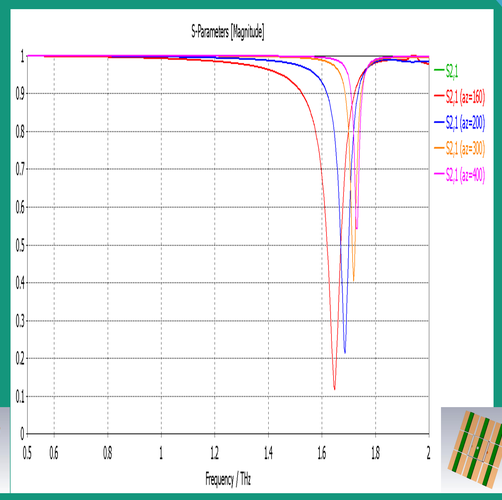
All-Dielectric Wire
Permittivity: 75



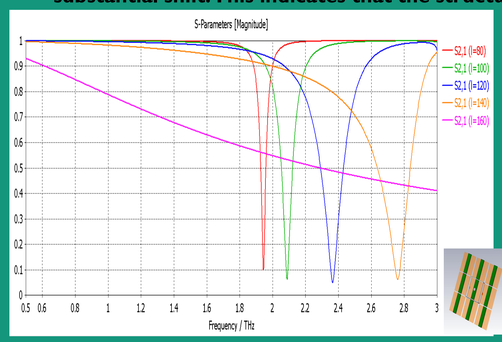
All-Dielectric Cross Wire
Permittivity: 75

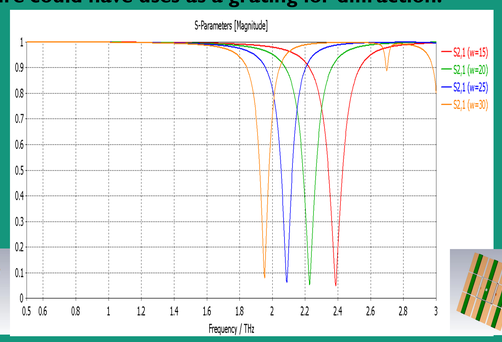
Results





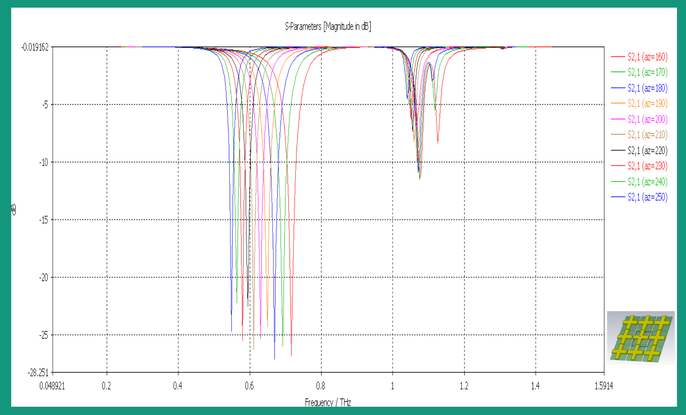
- A parameter sweep of the dimensions that dictates periodicity in the z-axis shows a minor shift in where the resonance frequency occurs., where in the x-axis direction this is a minor substantial shift. This indicates that the structure could have uses as a grating for diffraction.



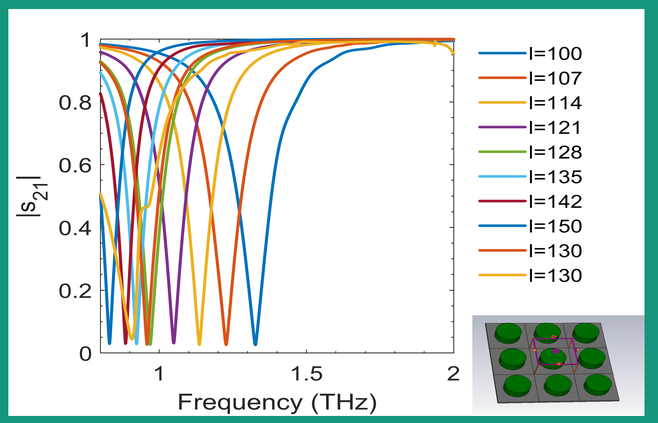


- A parameter sweep of the length and width dimensions showed that the resonance shifted toward higher frequencies. This showed that there is a dependence in length and width for the resonance.

Results Continued



- A parameter sweep of the dimension which dictates periodicity in the z-axis shows a shift in where the resonance frequency occurs. This shows that the cross structure is a two dimensional case of the wire structure.



- A parameter sweep of the length dimension causes a change in the disks radius, which on the disk structure Radius = Length/2, showing that the resonance shifts down in frequency and that there is a dependence on radius.

Summary

- Structures that exhibit resonance in the Terahertz frequency range.
- Various geometries that show unique results
- Structures that are practical to fabricate with current techniques
- Structures that can be used as grating for diffraction purposes.

Future Work

- Find specific dimensions for subwavelength structures as fabrication requires them to reside on a thin film.
- Simulate using a realistic and dynamic value of epsilon for the Ti02.
- Investigate further the resonance dependencies to observed dimensions.
- Extend simulations into experimentation.

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