Abstract:

This project consists of three parts. First part, we simulate how rectangular-shaped and cross-shaped plasmonic structures help Terahertz EM wave transmit through slits whose width is less than the diffraction limit. We observe electric fields enhanced at the corners of those plasmonic gratings using Comsol Multiphysics. Second part, we simulate the performance of a log-spiral antenna operating with input in different frequency using Comsol Multiphysics. We also observe the difference between the spiral metal structure and spiral slot structure. Third part, we simulate how a phased antenna array works using Matlab.

Part I

Project discussion and results:

The simulation setup is in Fig. 1. The left and right boundary are set as periodic conditions. We can notice that electric fields are enhanced around the corner of Au, indicating great amount of electrons excited. Fig. 2 shows that the transmission rate of this structure has a strong dependency with the input optical frequency. This is because the plasma frequency is the function of the distance between each metallic gratings.

Fig. 3 shows the 3D simulation of cross-shaped plasmonic structure. The electric field enhancement can also be observed. Fig. 4 also shows that the transmission rate of this structure has a strong dependency with the input optical frequency.

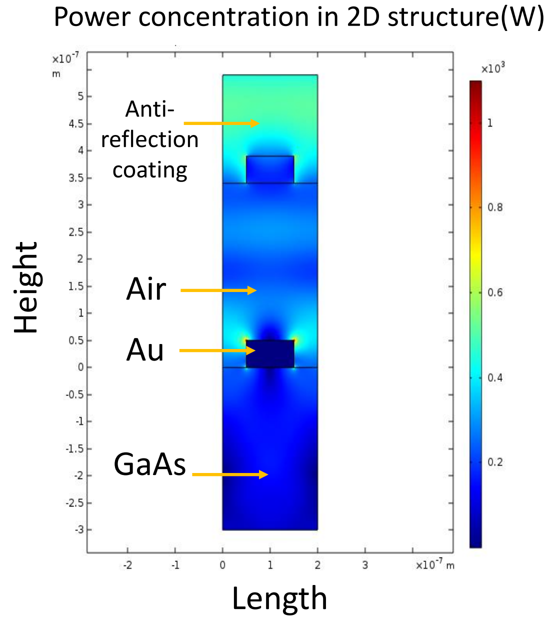

Fig. 1

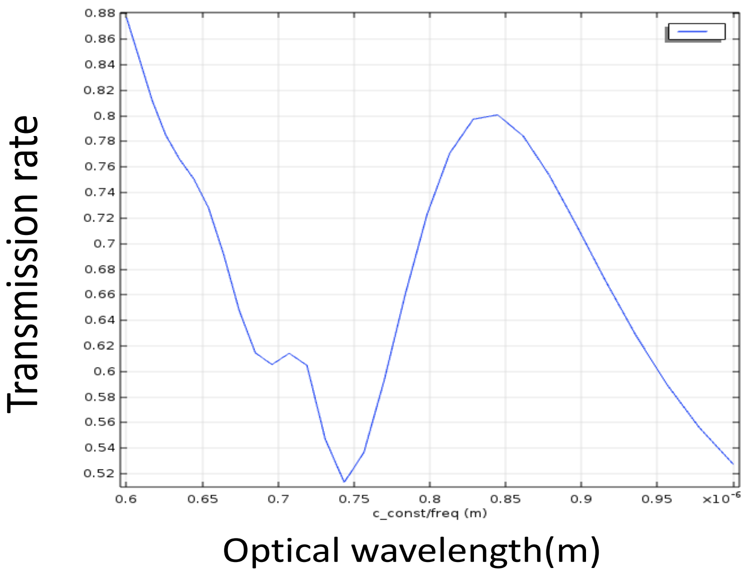

Fig. 2

Power Concentration in cross-shaped structure

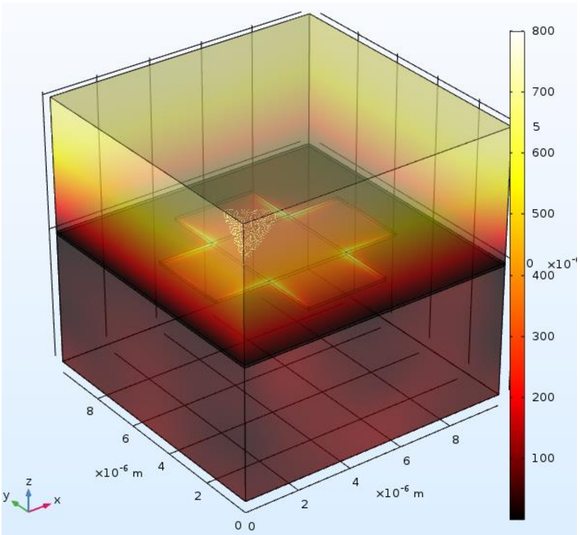

Fig. 3

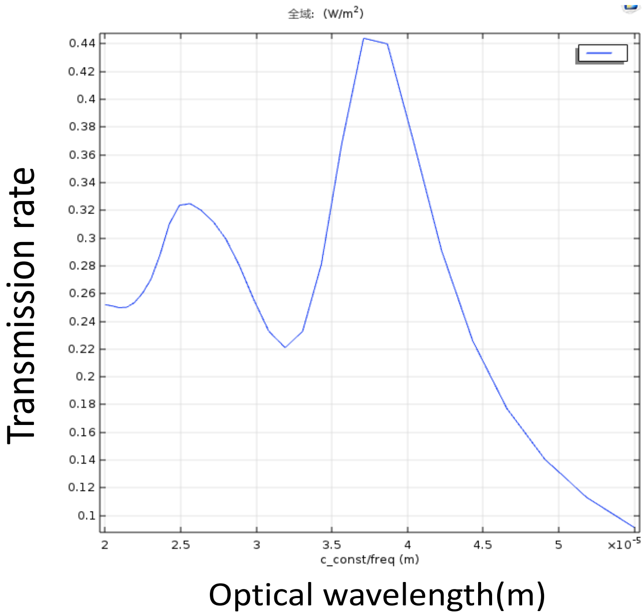

Fig. 4

Part 2

Project discussion and results:

The log-spiral antenna structure is shown in Fig. 5. The electric field is the stronger in the central of the spiral. The growing rate is 0.314. The spiral structure is metallic in fig. 6. The spiral structure is dielectric in fig. 6. From the far-field plots in Fig. 6-7, one can notice that this antenna is suitable for operation at low-frequency part of THz region. Moreover, directivity of the metallic spiral is better, Fig. 6, than the dielectric one in Fig. 7.

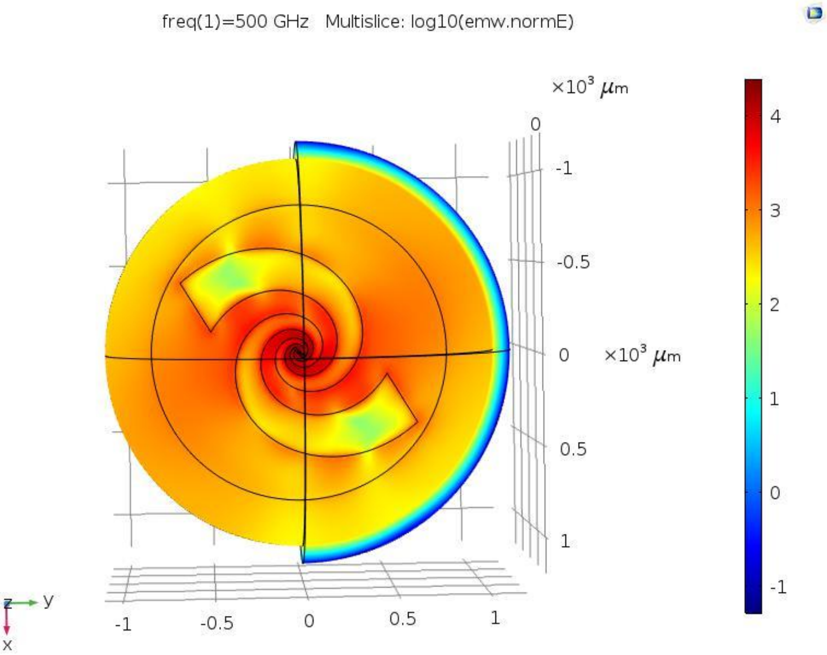

Fig. 5

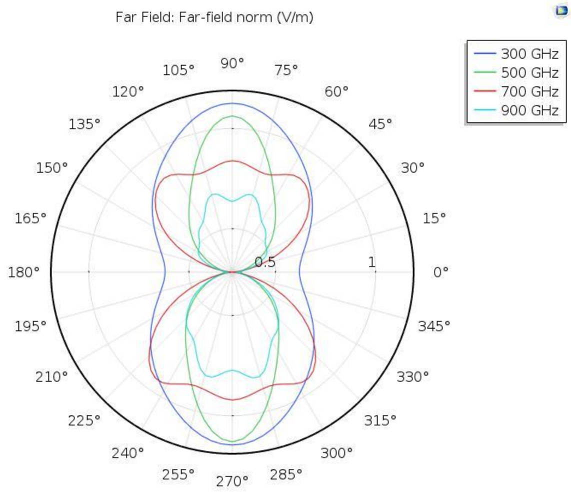

Fig. 6

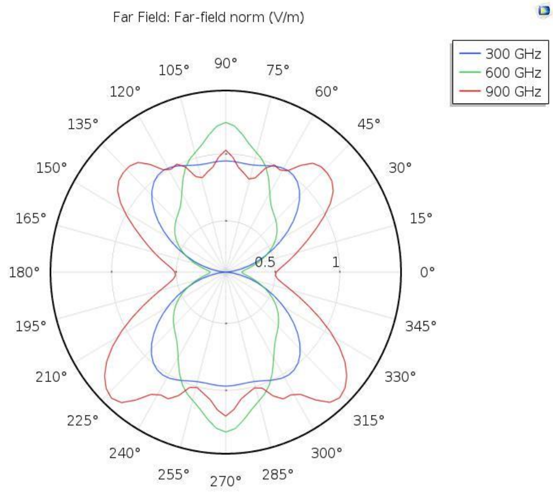

Fig. 7

Part 3

Project discussion and results:

We build up antenna array simulations using Matlab. There are N1×N2 antennas. In our codes, phase and amplitude of each antenna can be adjusted. Different types of antenna can be modeled into array once the characteristics of a single antenna is obtained.

In this project, we use dipole antenna as the basic antenna element. The power plot of the antenna is shown in Fig. 8. The two horizontal axes represent the angles that construct a sphere. The vertical axis is the amplitude of the power of EM wave in a specific angle. The half power band width (HPBW) is 78 degrees.

In Fig. 9, there are 3×3 dipole antennas. d is the distance between antennas. We can observe that HPBW is better with antenna arrays than that of a single antenna. Moreover, when d is too large, the amplitude of side lobes may be close to the main lobe.

Fig. 10 shows that when the number of antennas increases, directivity enhances. Directivity is almost linear with the number of antennas in one dimension.

Fig. 11. shows that there is always a combination of phases for an antenna array to steer its beam to the full extent (0 and 180 degree) when there are at least 2×2 antennas.

Fig 12 shows that when 1×1 antenna expands to 6×6 antennas, HPBW improves from 78 to 15.9 degree/axis. It is the tradeoff between performance of HPBW and the cost of areas.

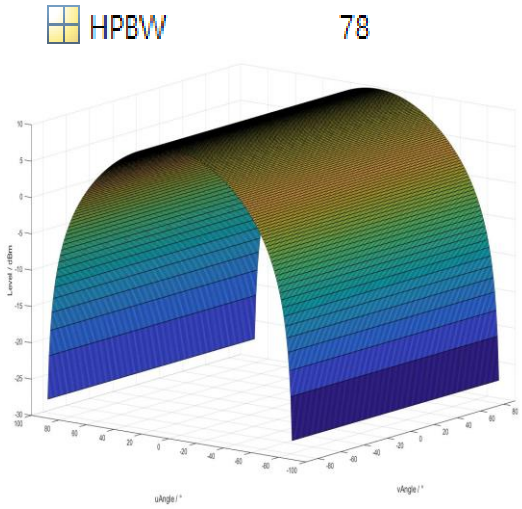

Fig. 8

3×3 of dipole antennas

1 THz, d=λ/2 1 THz, d=λ

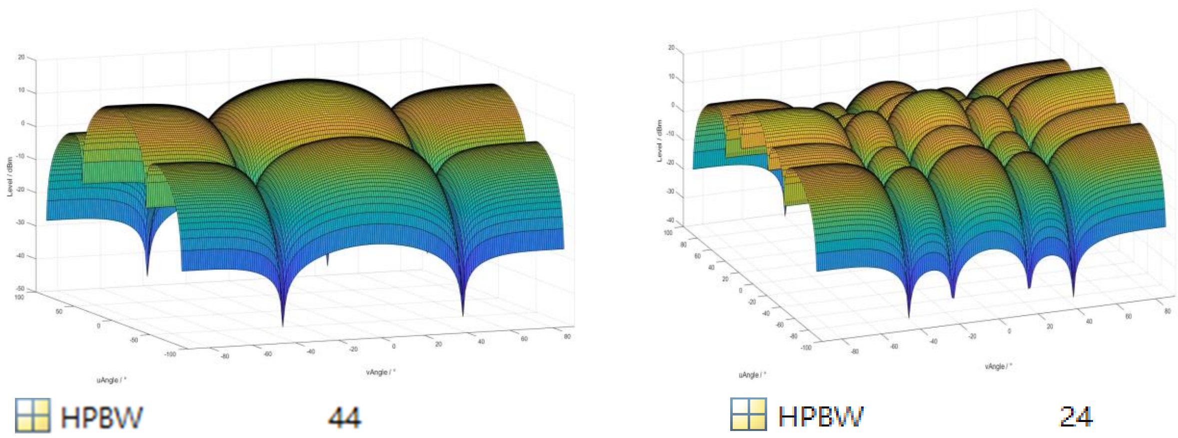

Fig. 9

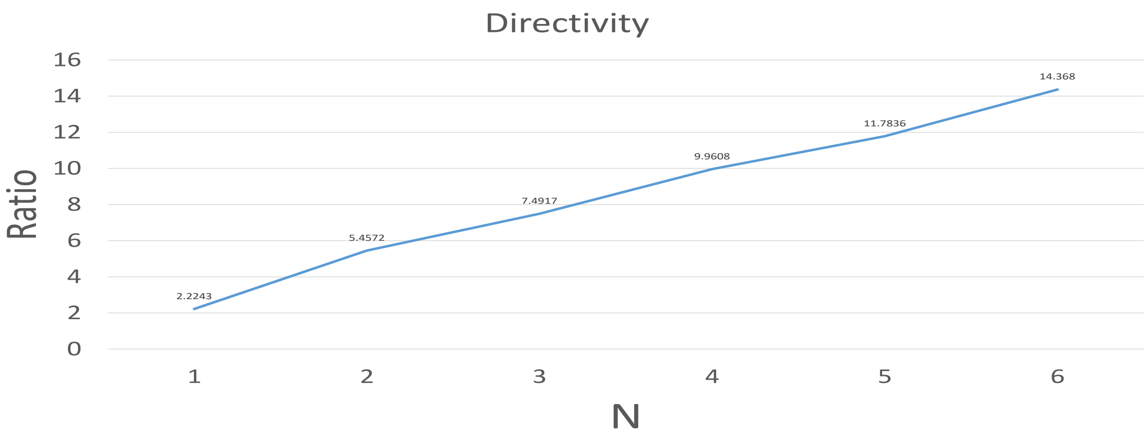

Fig. 10

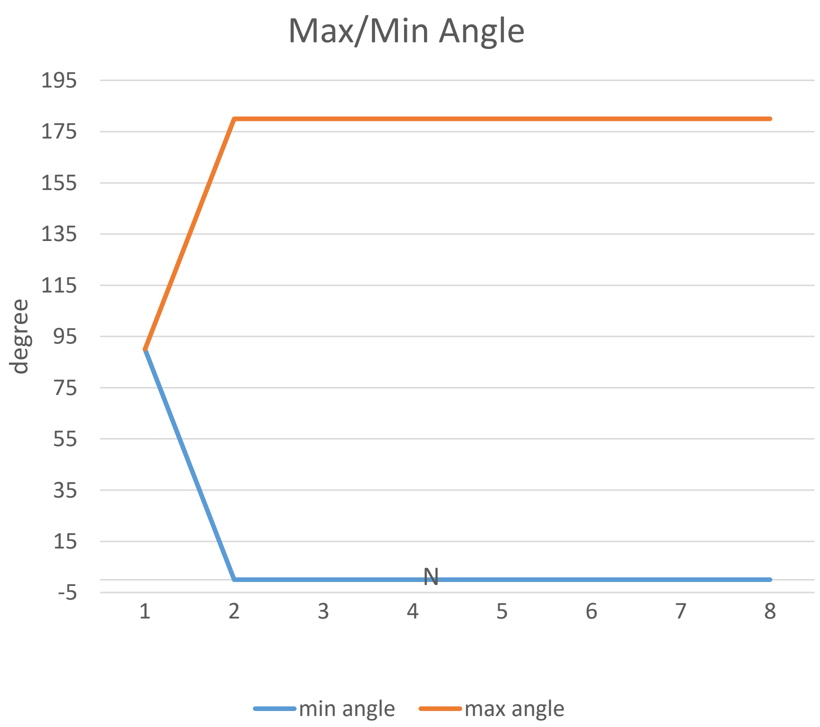
Max/Min Angle
195
175
155
135
115
95
75
55
35
15
-5
degree
N
1
2
3
4
5
6
7
8
min angle
max angle

Fig. 11

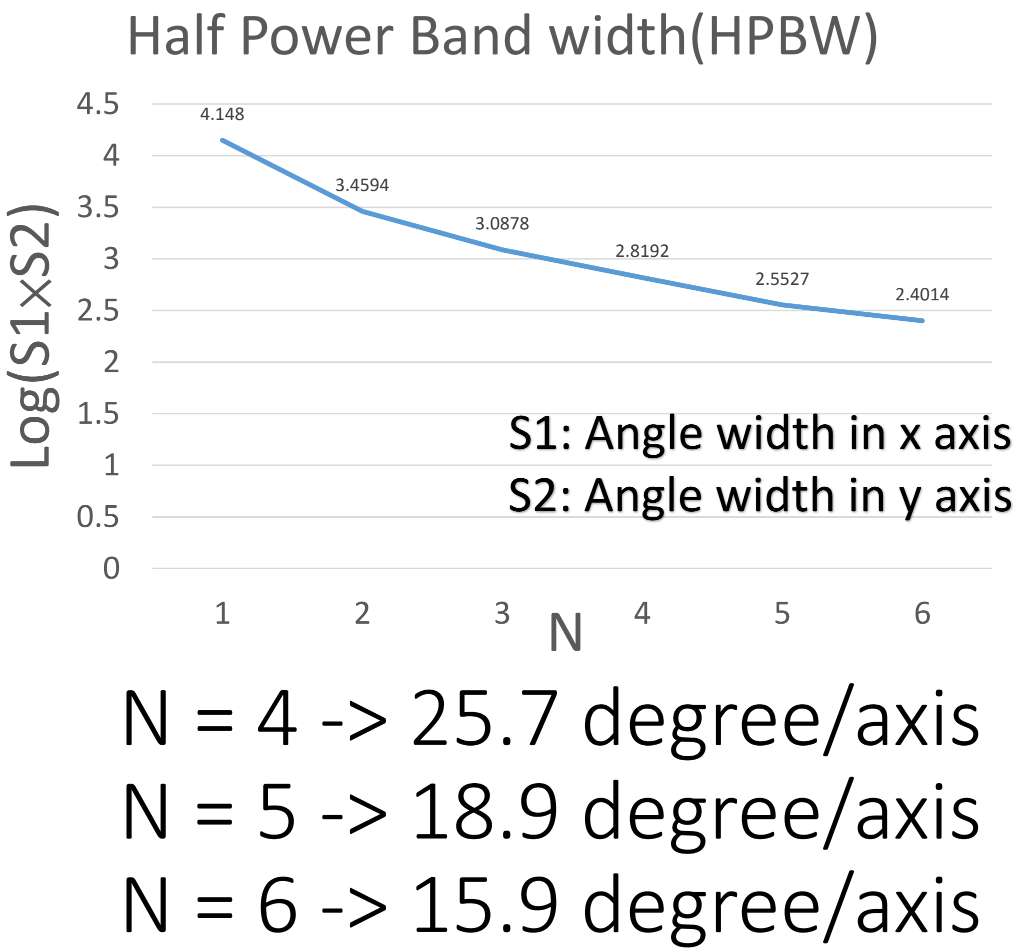
Half Power Band width(HPBW)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Log(S1×S2)
4.148
3.4594
3.0878
2.8192
2.5527
2.4014
S1: Angle width in x axis
S2: Angle width in y axis
1
2
3
4
5
6
N
N = 4 -> 25.7 degree/axis
N = 5 -> 18.9 degree/axis
N = 6 -> 15.9 degree/axis

Fig. 12