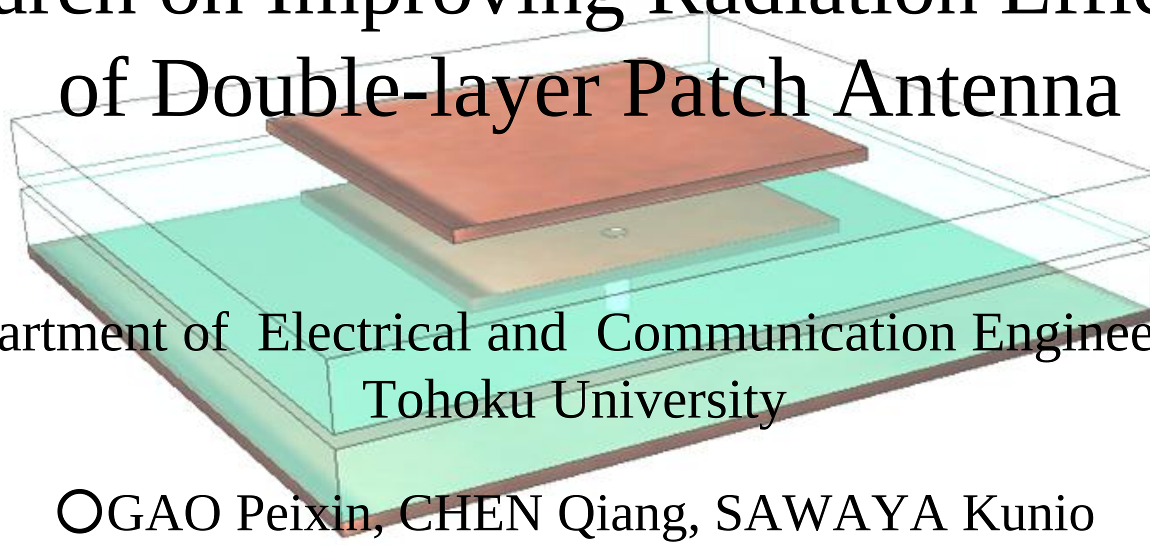
Student session 3 1A16

Research on Improving Radiation Efficiency of Double-layer Patch Antenna



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BACKGROUND

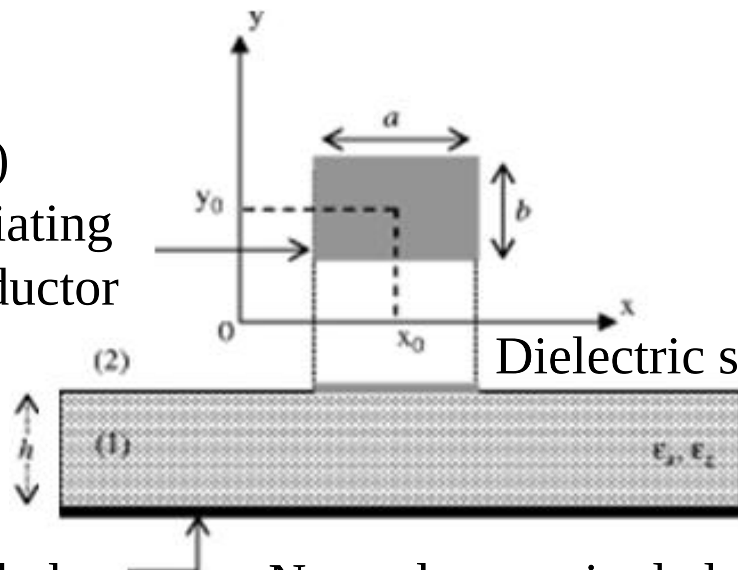
We are stepping into a world of communication.

As one of the core components in a communication system, antennas are widely used in our daily life

Patch antenna: Antenna with metal patch suspended over a ground plane

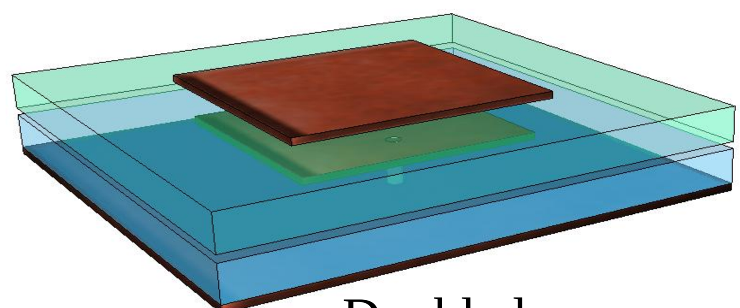
Generally lightweight
Low profile
Easily made
Productive at a low cost

Inherently narrow bandwidth



Normal case: single layer

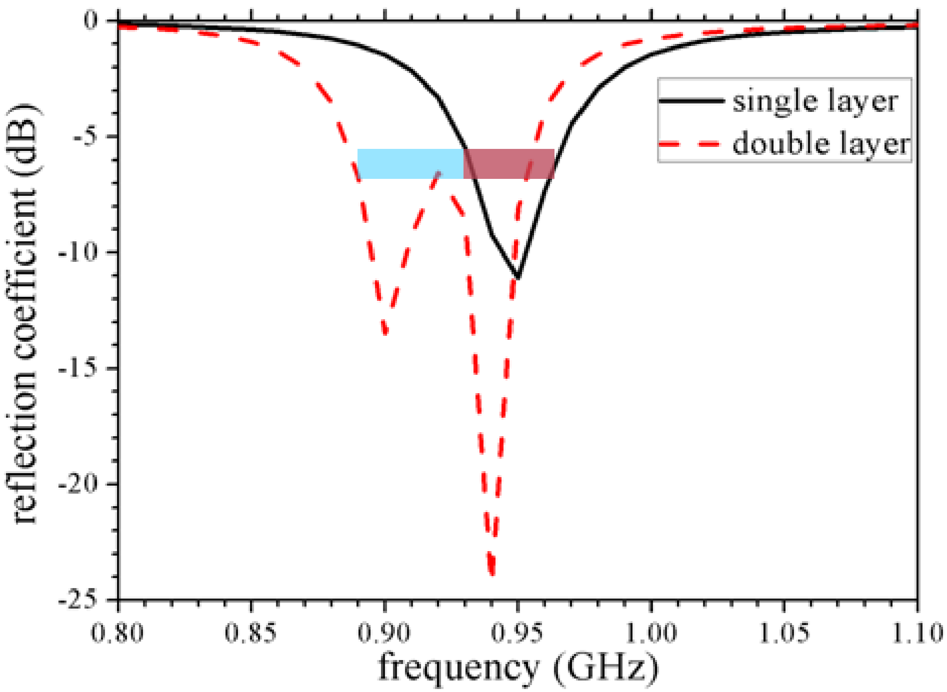
known improving method :
using double-layer structure

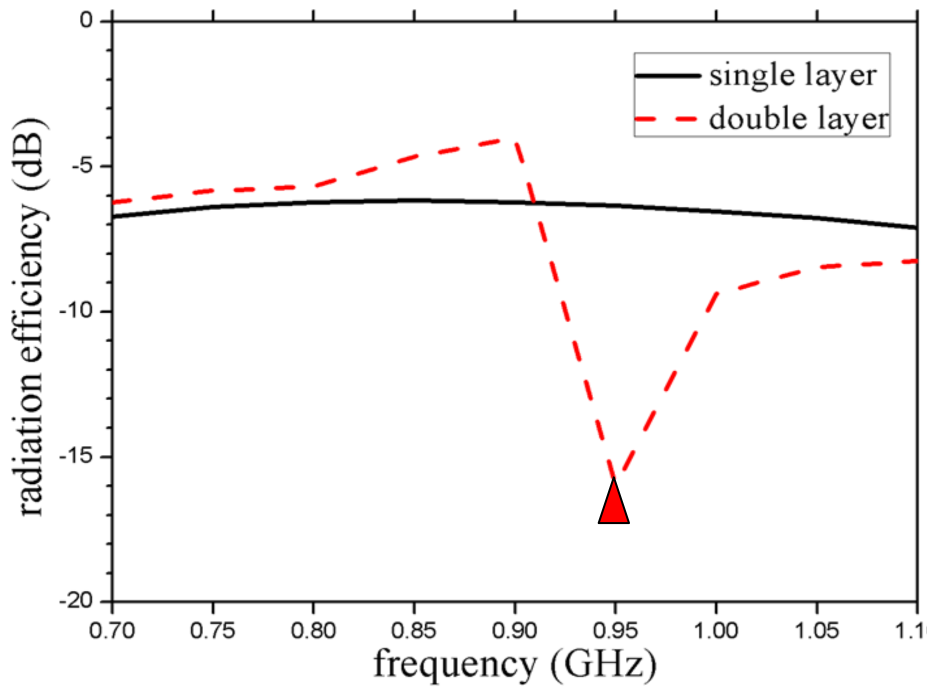


Double layer case

Antenna efficiency = Radiation efficiency × [1-(reflection coefficient)^2]

$$\eta_{ant} = \eta_{rad}\,(1-|\Gamma|^2)$$





For double layer case:

○ wider bandwidth

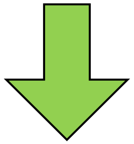
× steep falling down in radiation efficiency η_{rad}

INTRODUCTION

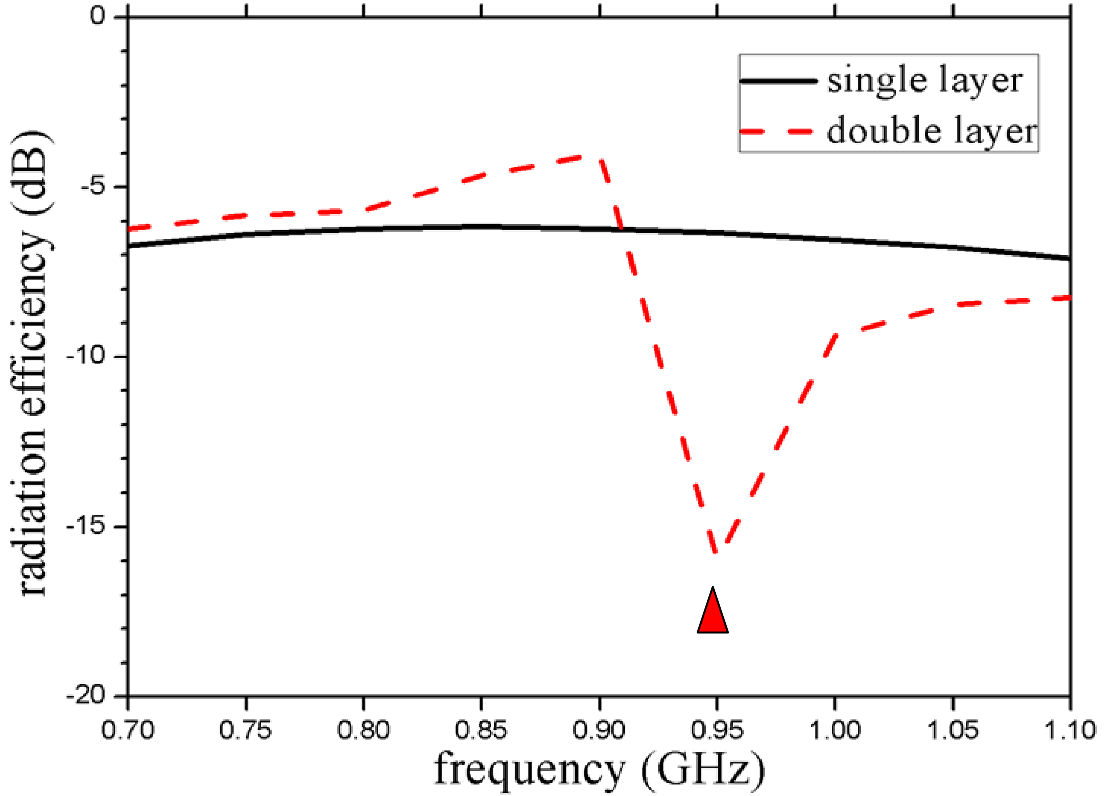
Generally, in order to get better antenna efficiency η_{ant} ,
we shall focus on two factors:

Radiation efficiency η_{rad}

& reflection coefficient Γ



For double layer patch antenna
radiation efficiency



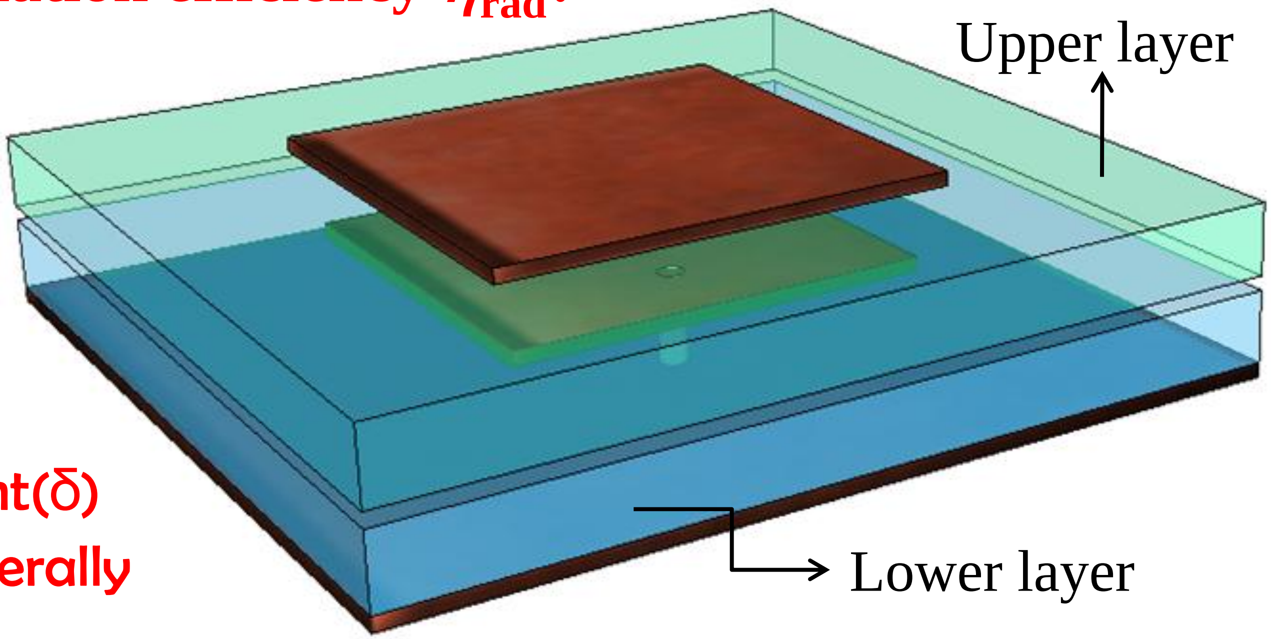
Worse performance on radiation efficiency

PROBLEM

How to optimize radiation efficiency η_{rad}?

Dielectric substrate parameters:

- Permittivity (ε)
- Dielectric loss tangent(δ)
- Permeability (μ, generally fixed as μ_0)
- …

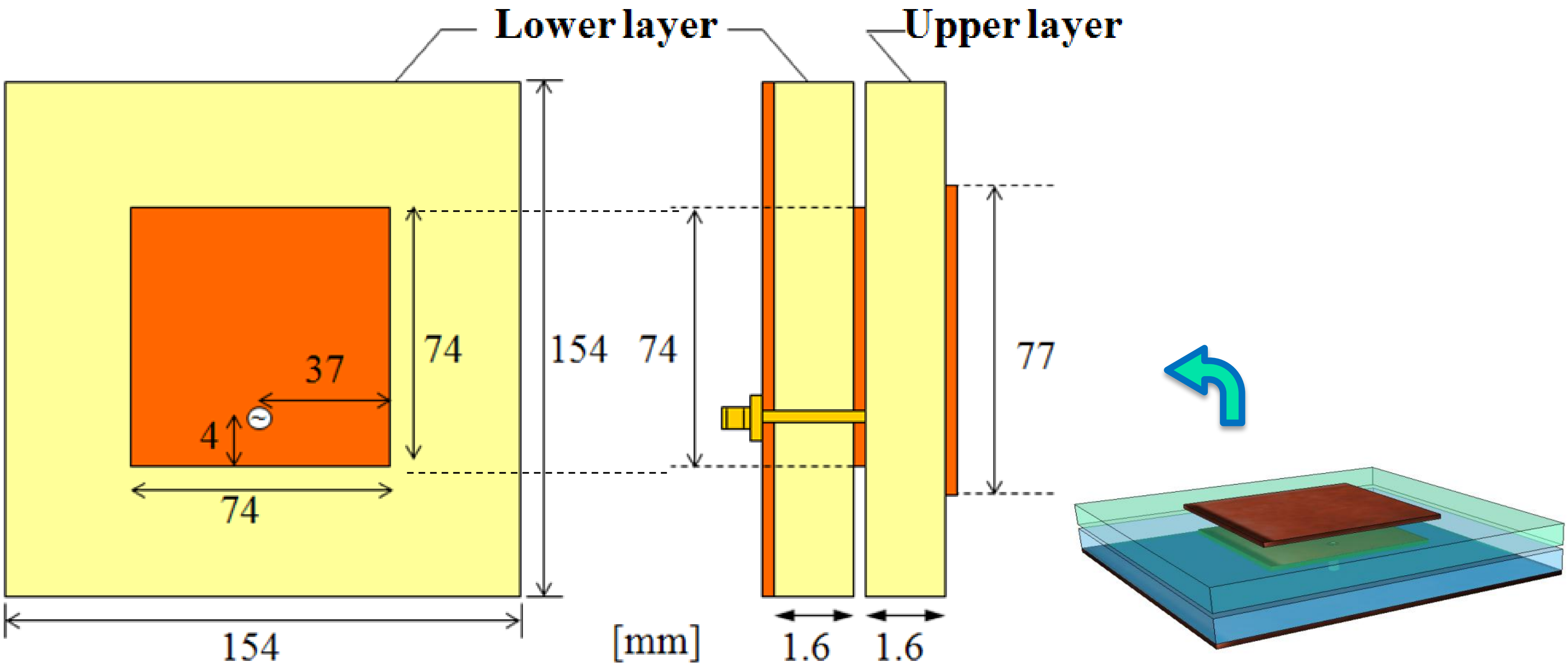


So …

- What will happen when using different loss tangent (tanδ) of the substrates?
- What about changing ε of the substrates?

Simulation model

- Double-layer patch antenna with center frequency around 1 GHz*.



Size of the simulation models

* Feeding based on FR4-epoxy as both upper and lower layer substrates

NUMERICAL SIMULATION MODEL

Two materials as substrates:

- **FR4-epoxy** :

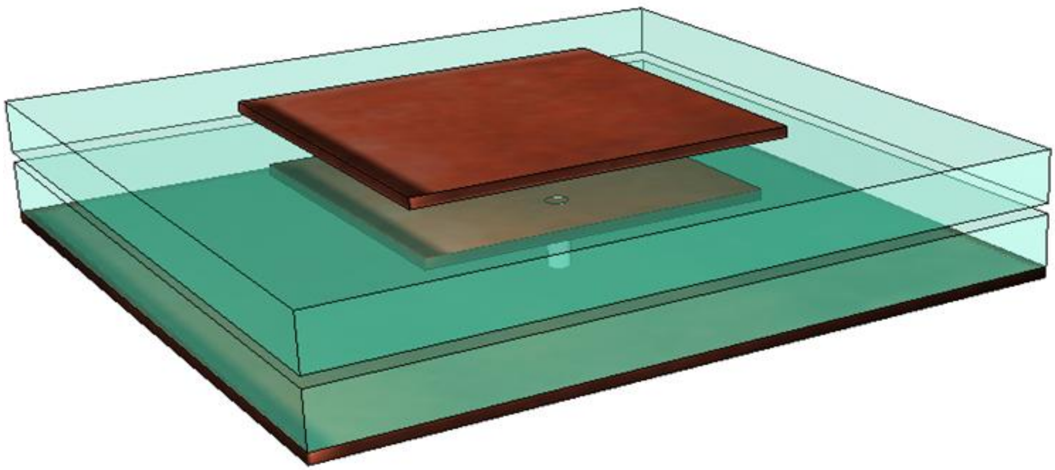
Relative permittivity ε_r =4.4

loss tan δ =0.02

- **Teflon** :

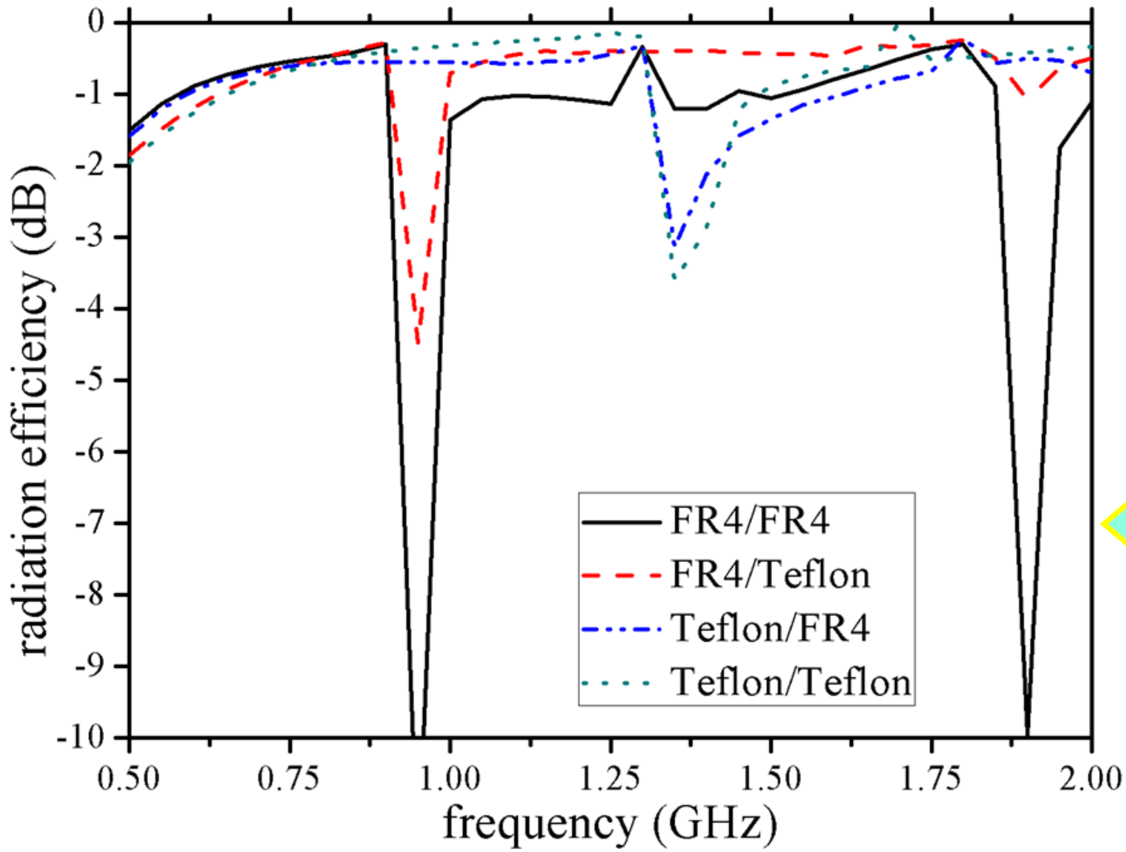
Relative permittivity ε_r =2

loss tan δ =0.001



	Upper layer	Lower layer	δ ranging
Case 1	FR4-epoxy	FR4-epoxy	e-1~e-5
Case 2	FR4-epoxy	Teflon	e-1~e-5
Case 3	Teflon	FR4-epoxy	e-1~e-5
Case 4	Teflon	Teflon	e-1~e-5

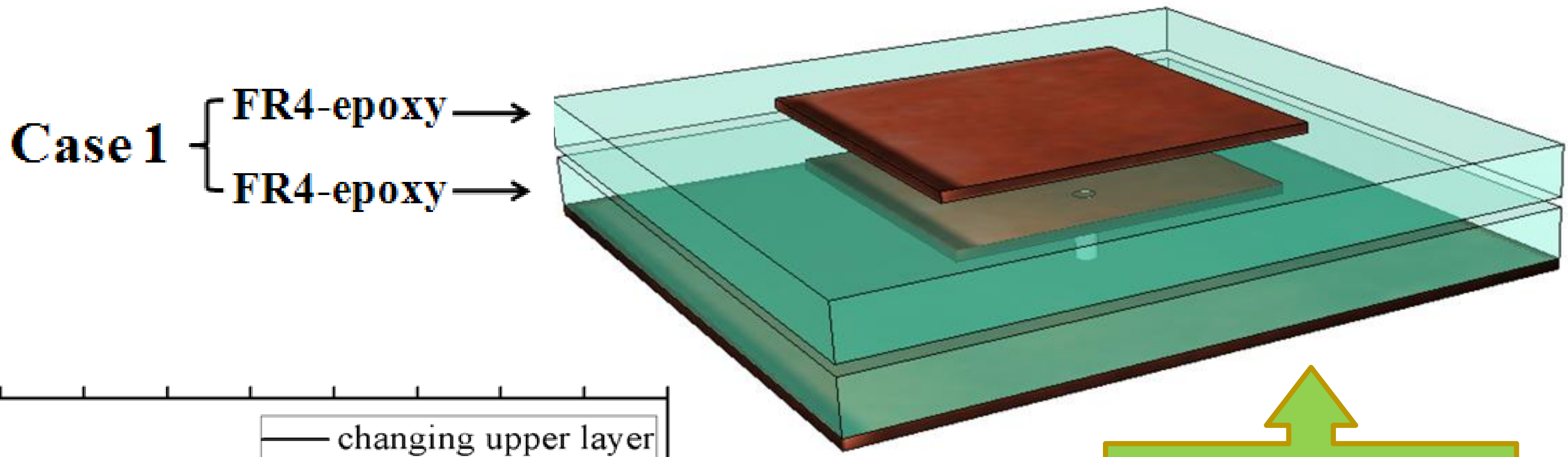
OBSERVATION AND CONCLUSIONS

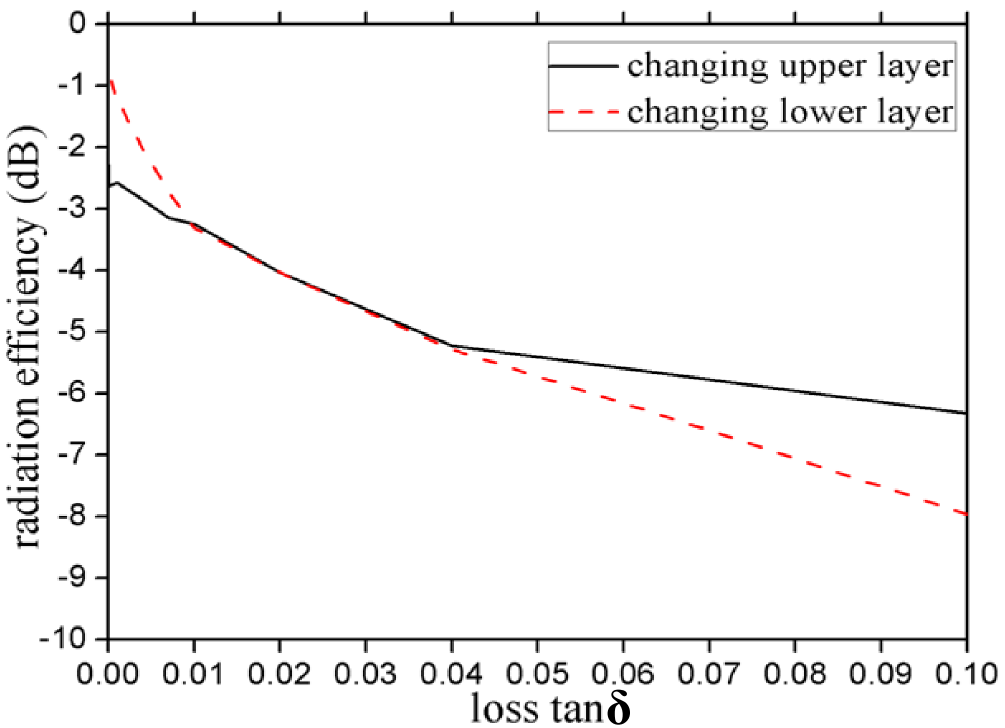


Radiation efficiency of four cases with unified loss tan δ at 0.001

- Radiation efficiency η_{rad} of four cases look similar

Comparison between changing tanδ of upper and lower layer





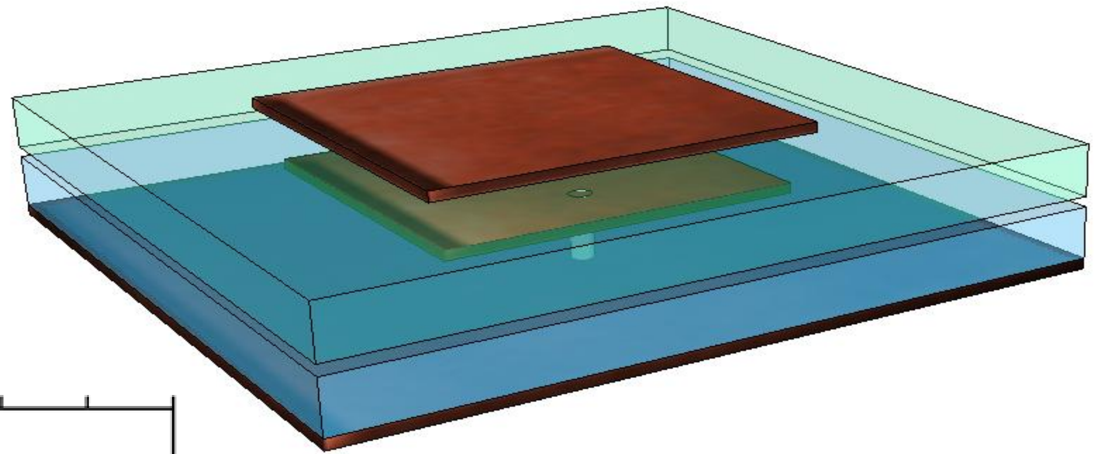
Combination of FR4/FR4

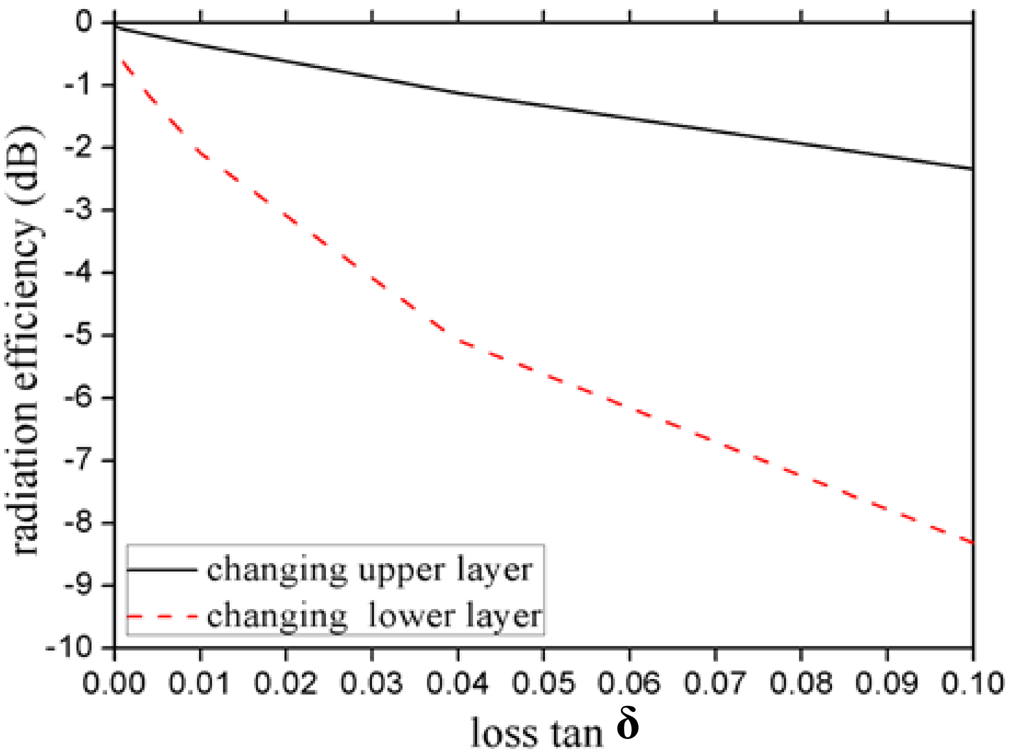
- Dielectric loss(tanδ) —main impact factor
- Relation
- More sensitive to lower layer substrate's dielectric loss.

OBSERVATION AND CONCLUSIONS

Similar observations also happen in other model teams.

Case 2 { **FR4-epoxy** →
Teflon →

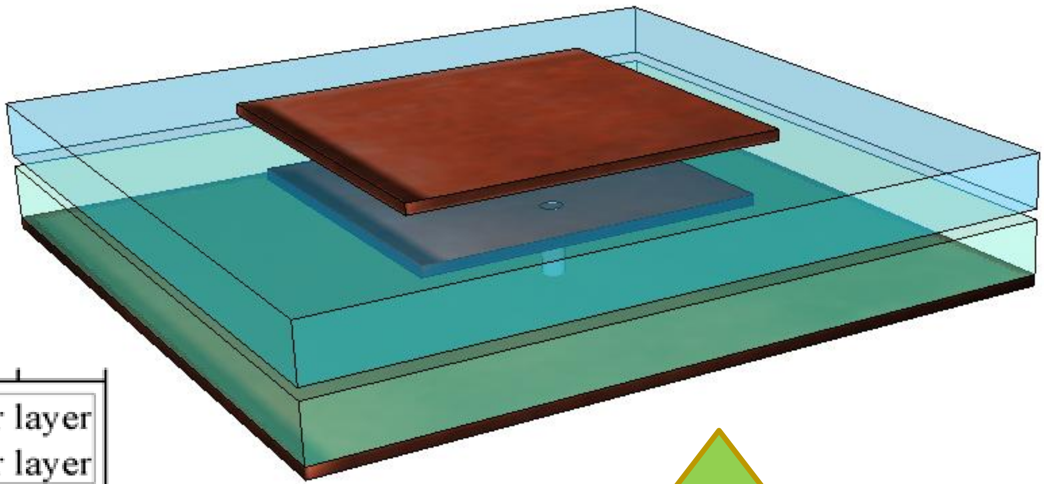




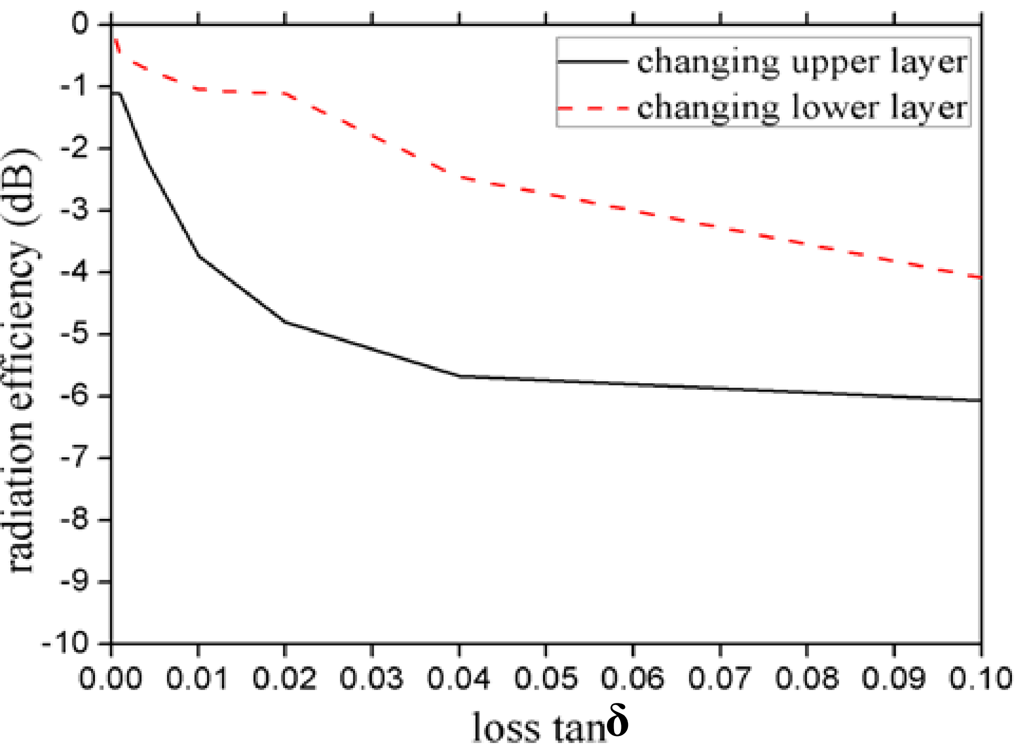
Combination of FR4-epoxy/Teflon

OBSERVATION AND CONCLUSIONS

Case 3 — Teflon, FR4-epoxy

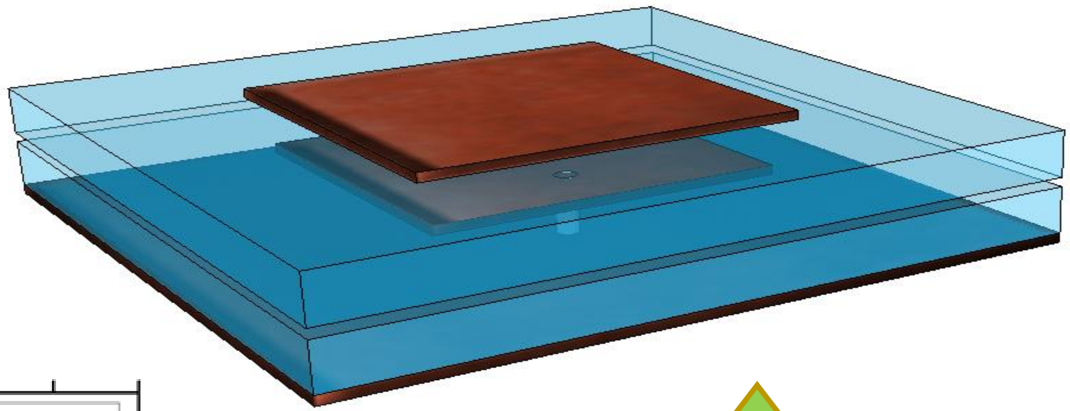


Combination of Teflon/FR4-epoxy

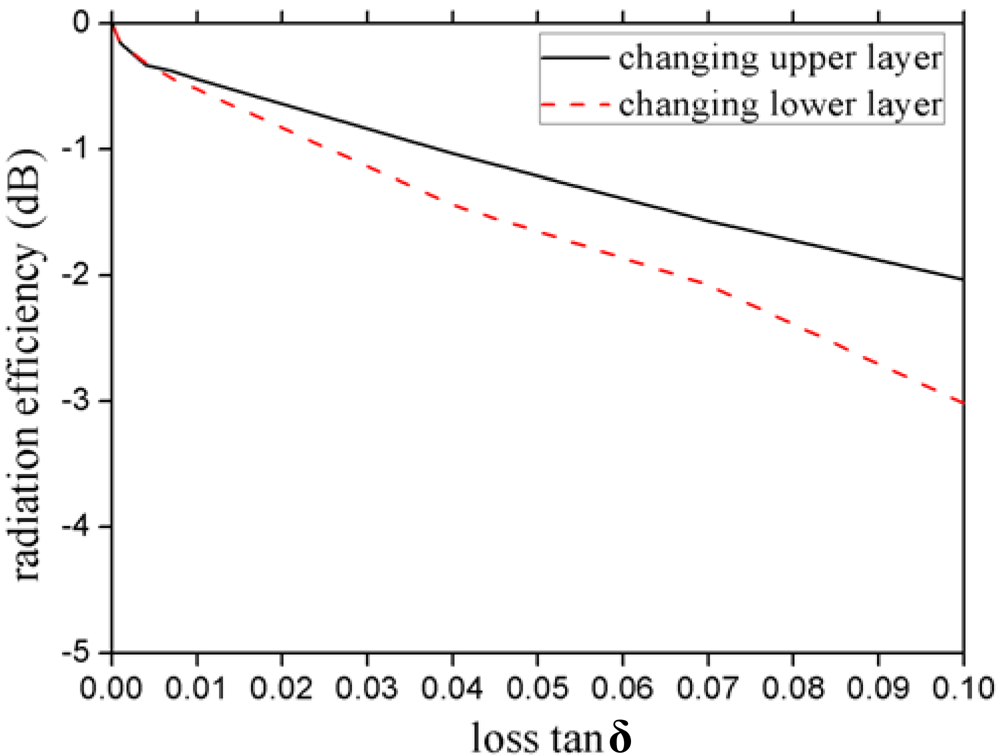


OBSERVATION AND CONCLUSIONS

Case 4 { **Teflon** → / **Teflon** →



Combination of Teflon/Teflon



- Based on observations and corresponding conclusions demonstrated , we get some hints on optimizing radiation efficiency of the antenna

CONCLUSIONS AND FUTURE WORK

- The relation between the loss tanδ and radiation efficiency η_{rad} is that when tanδ increases, η_{rad} decreases.
- The rediation efficiency seems more sensitive towards the changing of lower layer substrate's loss tangent.
- when designing a double layer patch antenna, try to decrease the loss tan δ, especially of lower layer substrate, within price requirement.

Future work

- Reason of radiation efficiency falling down at some frequency ranges is not yet of certainty, which needs more research on it.
- Reducing reflection coefficient at frequency of high radiation efficiency.

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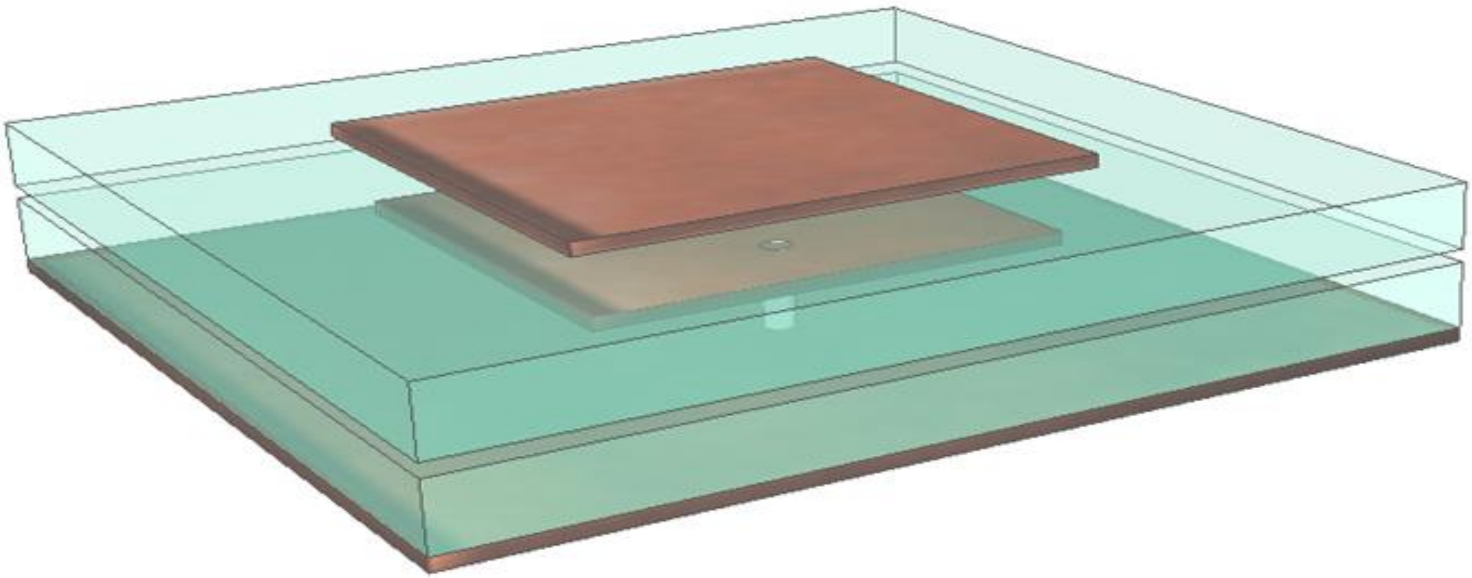
THANK YOU FOR LISTENING !



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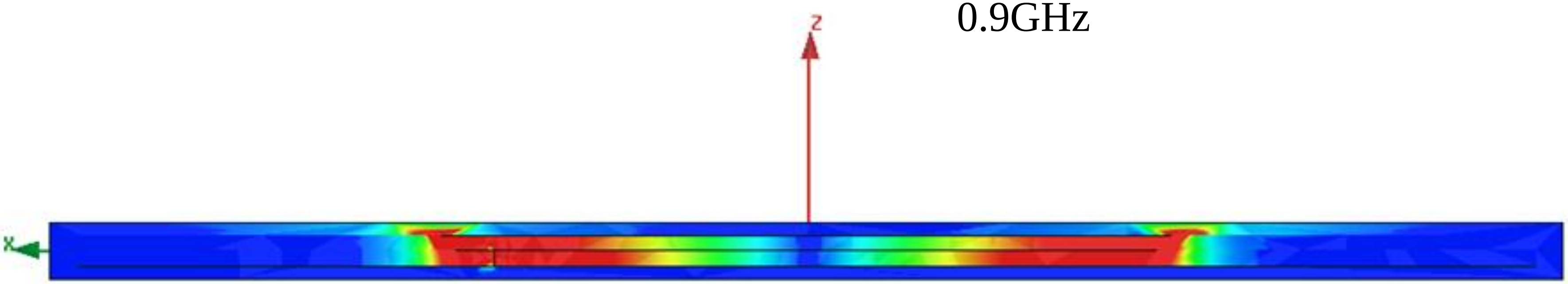
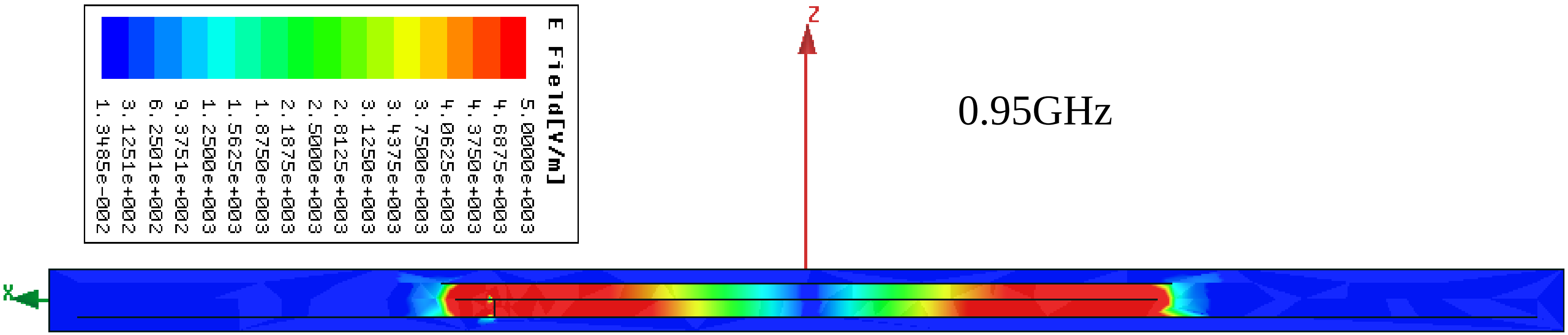
FR4(upper)/FR4(lower) model

0.9GHz





0.95GHz

ANNEX: ELECTRIC FIELD DISTRIBUTION

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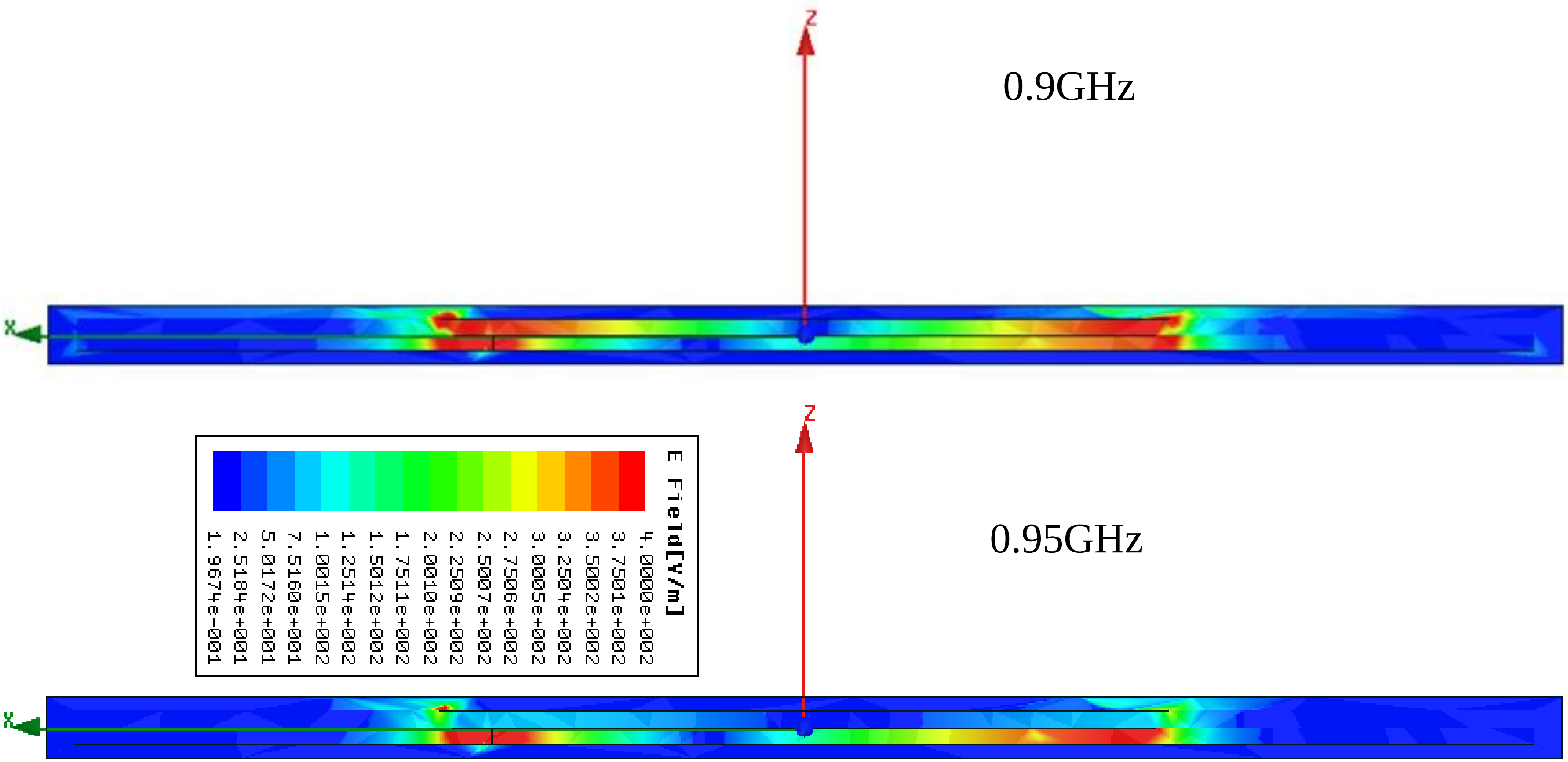
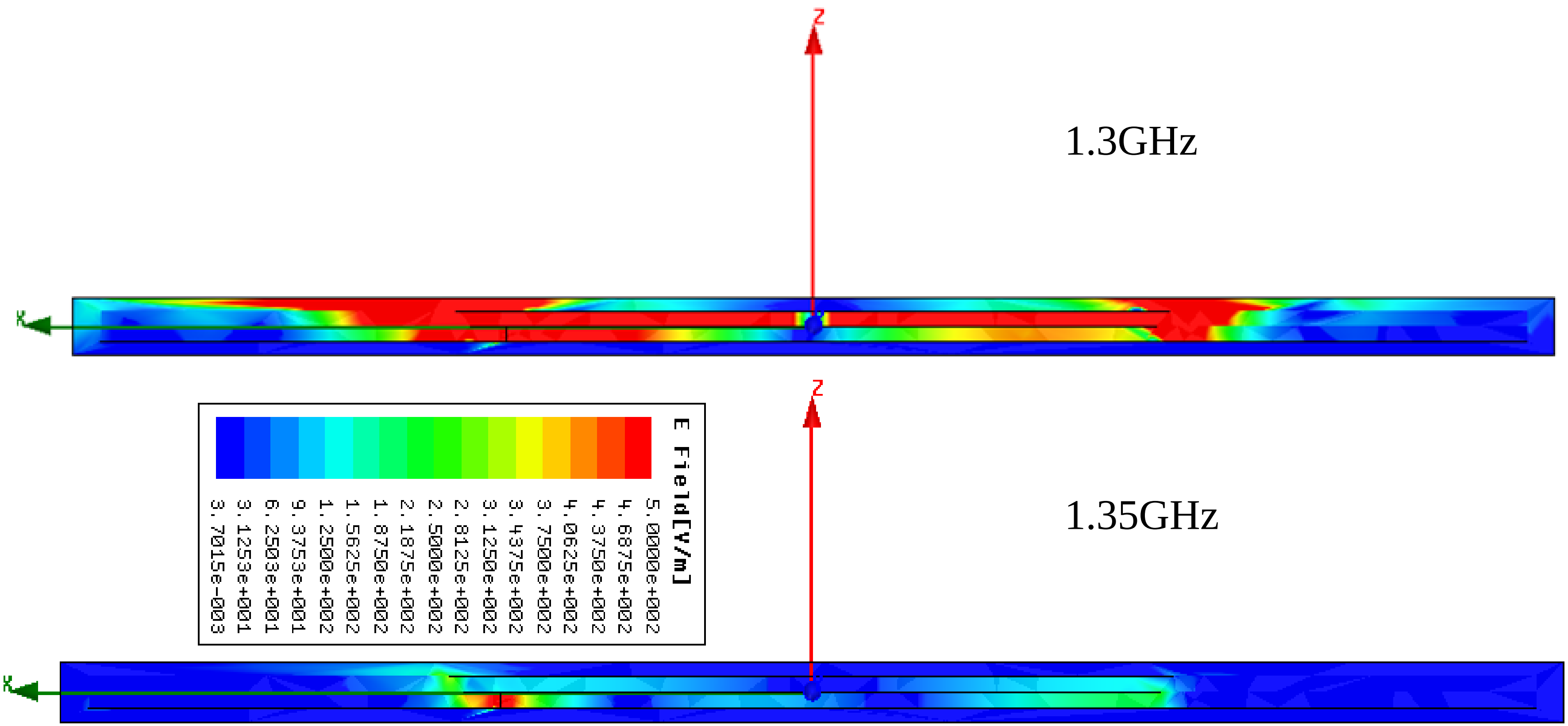
FR4(upper)/Teflon(lower) model



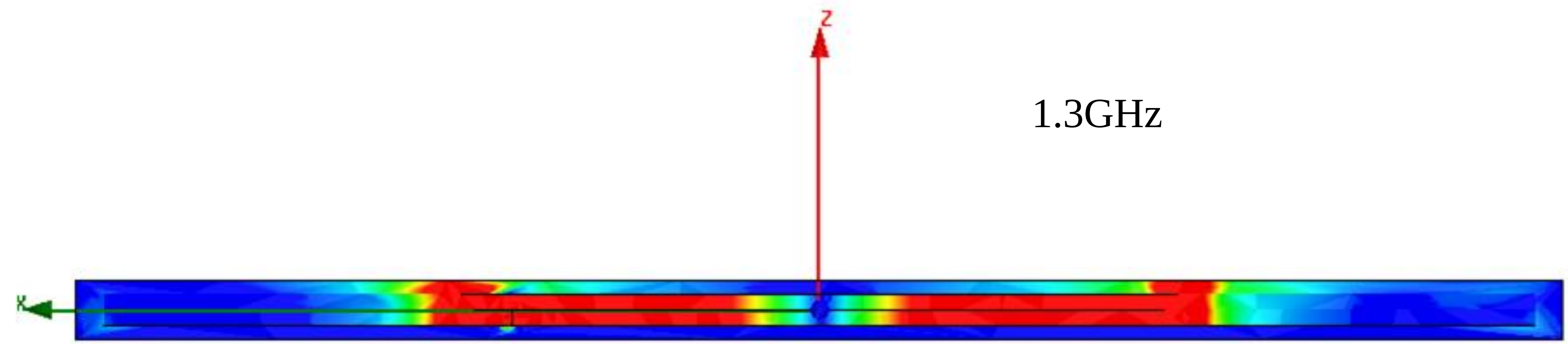
ANNEX: ELECTRIC FIELD DISTRIBUTION

Teflon(upper)/FR4(lower) model

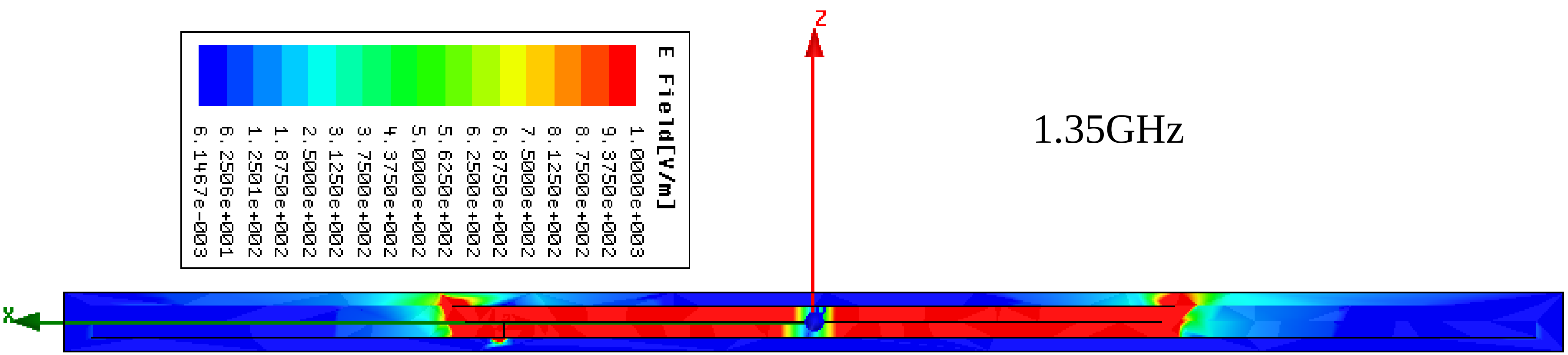


ANNEX: ELECTRIC FIELD DISTRIBUTION

Teflon(upper)/Teflon(lower) model



1.3GHz



1.35GHz