Dielectric Resonator-Based Left-Handed Metamaterials: Guided Wave

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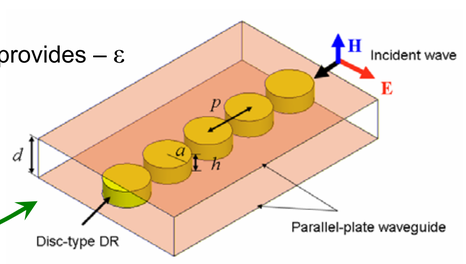
Introduction 1

Left-Handed Metamaterials (LHMs)

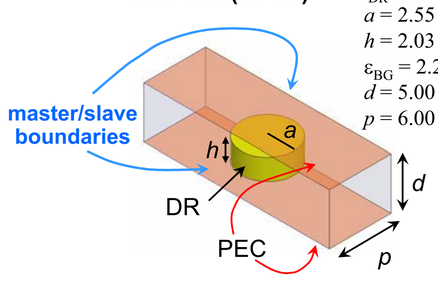
- **Properties**
  - Negative permittivity and permeability (support backward wave: $v_p = -v_g$)
  - Negative index of refraction
- **Conventional Implementations**
  - Split ring resonators (- μ) with metal wires (- ε)
  - Transmission line approach: series capacitance & shunt inductance
- **Dielectric-Resonator (DR) LHM Implementation**
  - Use $TE_{01\delta}$ of DR to provide –μ
  - Place DR in cutoff background which provides – ε

1-D LHM: cylindrical DRs in TE mode cutoff parallel plate waveguide



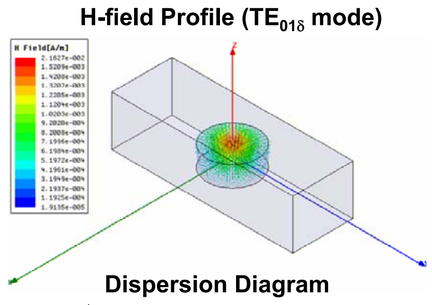
1-D DR-LHM Unit-Cell Verification 2

Unit-cell (HFSS)



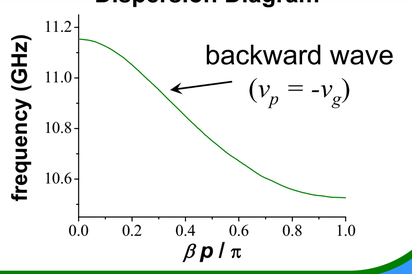
$\varepsilon_{DR} = 38$
$a = 2.55$ mm
$h = 2.03$ mm
$\varepsilon_{BG} = 2.2$
$d = 5.00$ mm
$p = 6.00$ mm

H-field Profile ($TE_{01\delta}$ mode)

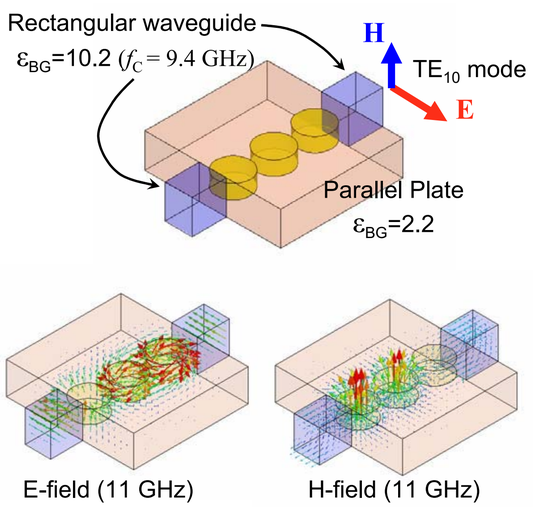


- Cut-off frequency of parallel-plate TE_1 mode:
  $f_C = c / 2(\varepsilon_{BG})^{1/2} d \sim 20.2$GHz
- Resonant frequency of $TE_{01\delta}$ mode for isolated DR disc in host medium (air) :
  $f_R \sim 10.45$ GHz (10.6 GHz)

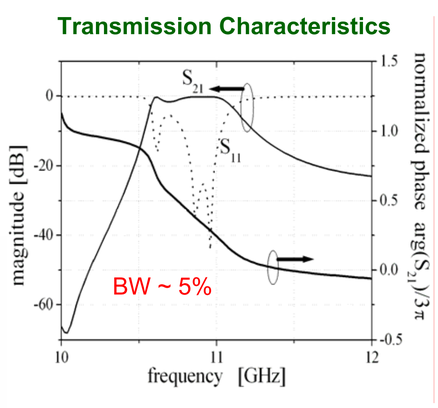
Dispersion Diagram



Driven Model: Transmission Characteristics 3

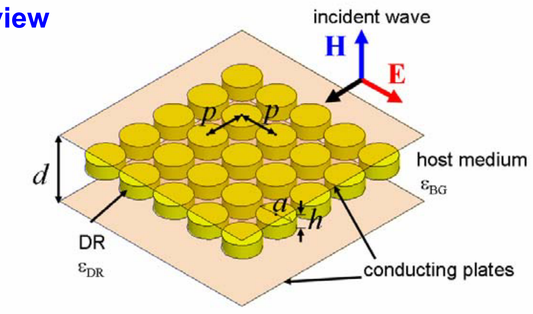


Transmission Characteristics

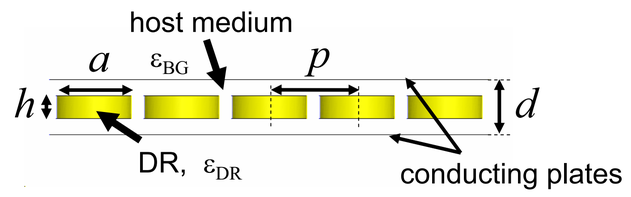


2-D DR-LHM Implementation 4

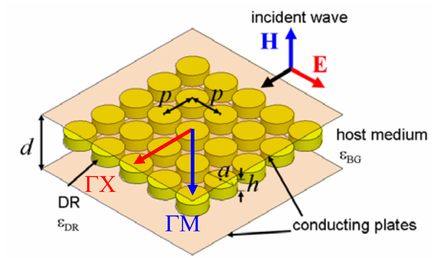
perspective view



side view



2-D DR-LHM: Dispersion Diagram 5



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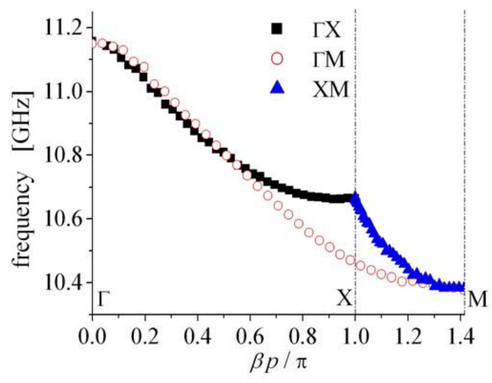
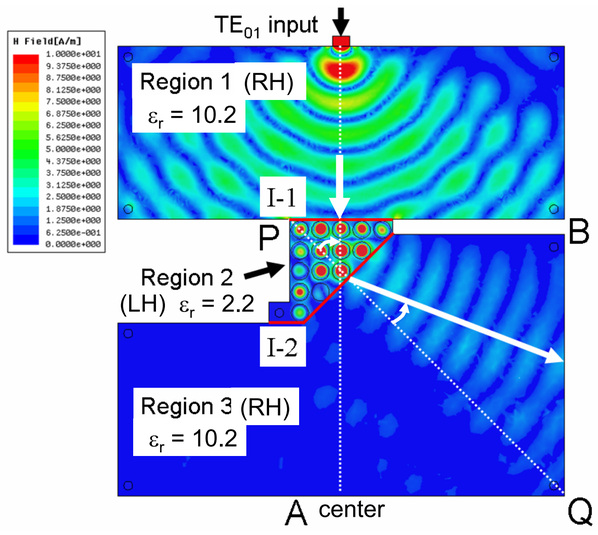
Dispersion Diagram



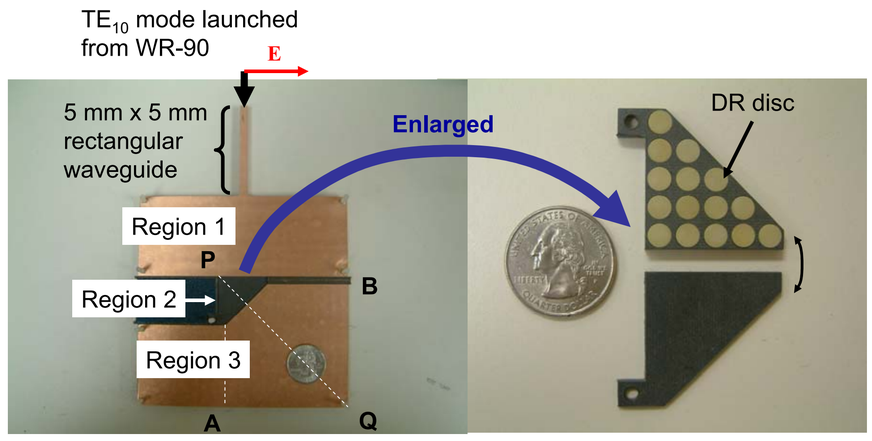
Negative Refraction Simulation in HFSS 6



***f* = 10.8 GHz**

- In Region 2, LH prism is inserted with 15 DRs.
- Beam propagation along ΓX
- Incident angle $\theta_{LH} = 45$ deg
- Transmitted angle $\theta_{RH} = -25$ deg

Negative Refraction: Experimental Setup 7

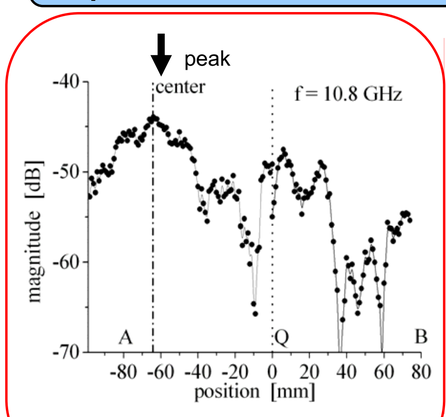


2-D RH-LH-RH structure (upper conducting plate removed)

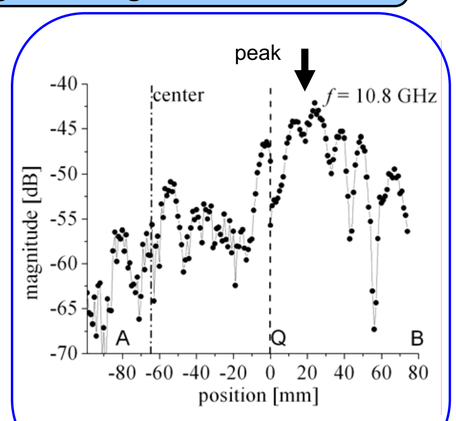
Triangular prism of LH region (Region 2)

Experimental Results 8

Measured by a loop antenna (magnetic probe) at positions outside 5mm away from edge lines BQ and QA



RH structure inserted in Region 2



LH structure inserted in Region 2