Design and Performance Analysis of Doubly Doped Nano Meta material substrate of Microstrip patch antenna for E-band applications

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***Abstract*—Microstrip patch antennas gives high efficiency due to its advantages of light weight, low cost, hand held etc.., for these antennas a novel substrate has been developed using Nano Meta Material. Nanometa materials (Mg Nd_x Er_y Fe_{2-x-y} O_4; x=0.04;y=0.06) had been synthesis through sol-gel route and this materials were sintered through the microwave furnace for the temperature at 650˚C. In this proposed work , the microstrip patch antenna is implemented in real time with RT-Duroid substrate which will improve the antenna parameters such as return loss by using Spectrum Analyzer and also calculate the porosity value and corrected permittivity by using pellet. The samples were characterized by XRD, electrical properties (LCR Meter), Semiconductor test were confirmed the particle size, lattice constant, electrical properties and magnetic properties. Since, these antennas are suitable for military application, satellite communication, radio, cell phone receiver or are mounted on an aircraft or spacecraft.**

Keywords*— XRD, 4 Probe, LCR Meter, Micro strip patch antenna.

1. Introduction

Nano-Ferrites have technological importance as they can play a role in the miniaturization process of several microwave components. The present work reports due to their partially filled 4f inner shell are responsible for the characteristic magnetic properties of the lanthanides [1]. Magnesium ferrites have attention in recent years as one of the candidates for high density magnetic recording, microwave absorbents, sensors and electronic device, high frequency devices ,color imaging etc., because it has high magnetic permeability and high electrical resistance[2]. There is an improvement in demand for microstip patch antennas with improved performance for wireless communication applications. Microstrip patch antenna are widely used for purpose because of their planer structure, low profile, less weight reasonable efficiency and ease of integration with active device[3].

An antenna is specialized transducers that change radio-frequency (RF) fields into alternating current (AC) or vice-versa. Microstrip patch Antennas are broadly used in wireless communication applications because of their [4].

In this work the Microstrip patch antenna with fabricate RT- DUROID substrate and obtain the return loss by using the spectrum analyzer. The purpose of this work is to design a Microstrip patch antenna using different simulation software like IE3D, ADS,COMSOL etc,. In my work COMSOL Multiphysics simulation and optimization software useful for antenna design.

2. Methodology

In this proposed work the methodology consists of following steps: Sol-Gel route, Determine the porosity and corrected permittivity value and semiconductor test (P type or N type) by using 4 probe , LCR Meter to fine the capacitance value, characterization of material and fabrication of microstrip patch antenna with RT-Duroid Substrate.

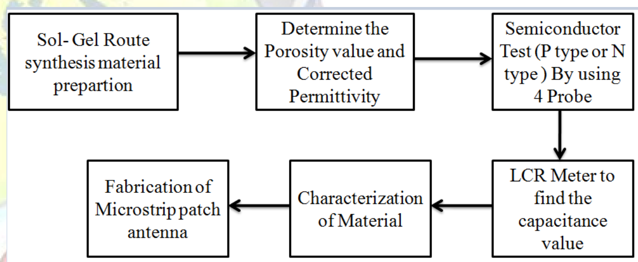


Figure 1: Block diagram of Methodology

2.1 Sol-Gel Route

The nano sized powder was prepared by mixing the Mg Nd_x $Er_Y Fe_{2-x-y}$ o_4 are taken as the molecular ratio of 1.1.The Powder dissolved in distilled water upto 250ml. The solution is agitated by stirrer machine with the temperature of 10˚C for 24hours. The P^H of the solution was adjusted to 7 by pouring ammonia solution drop by drop. Then the solution is heated to transform into gel. [5]After this dehydration process, a brown color dried gel will obtain. The brown color is further crushed in agate motor which results in nano sized powder, then the nano sized powder is subjected to hydraulic press leads to the formation of pellet. After the pellet formation, the pellet is then heated in a muffle furnace in order to make the pellet a strong one. Then thickness and diameter of the pellet was measured by using the travelling microscope.[6]

2.2 Determine the porosity and corrected permittivity value

The total porosity of a porous medium is given by the ratio of the pore volume to the total volume of a representative sample of the medium.[7] The porosity value can be measured by the Denver balance measurement. The porosity formula is given by, M=0.722

P=1-db/dx, d_b = density value, d_x= porosity value

d_b= M/V=0.348*10^3, d_x= mass pellet/ (mass pellet- absorbed water) = 1.491

P=1-(1.491/0.348*10^3) =0.995

Corrected Permittivity Value

It is a measure of resistance that is encountered when creating an electric field in a medium. In simple words, permittivity is given by a measure of how an electric field effects and is effected by a dielectric medium.

$\varepsilon' = \varepsilon_r(1-3p(\varepsilon_r-1)/ 2\, \varepsilon_r+1)) = 2.21$

2.3 Semiconductor Test (Magnetic Property)

. Four probe measurements were performed to check the semiconductor property of the material. These studies are temperature dependent electrical resistivity of the prepared materials.[8] They have two types of semiconductor, if the voltage decreases with the increase in temperature, then the material is n-type. If voltage increases, then the material is p-type. From figure 1, the prepared sample's voltage decreases with the increase in temperature. Thus the prepared sample is confirmed to be n-type material.

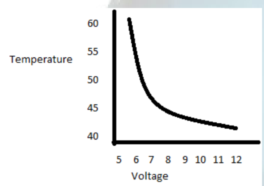


Figure 2: Wavefrom of semiconductor test

2.4 Capacitance value

The Electrical estimation was performed by utilizing the N4L LCR meter (London) which is used to measure the series C, Tan Delta, impedance from the figure 2. The test set up for measuring the dielectric properties in the microwave region consists of a pellet holder associated with the N4L LCR meter interfacing the machine. The microwave properties of the specimens Nd and Er doped magnesium ferrite (x=0.04, y=0.06) were explored at the frequency range from 20 KHz to 20 MHz.

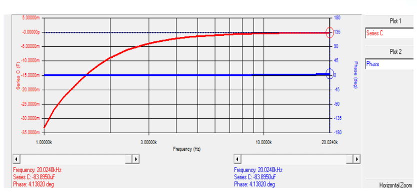


Figure 3: wave form of capacitance value

2.5 Characterization Of Material

X-RAY DIFFRACTION (XRD): The X-ray diffraction (XRD) meant "if crystals were composed of regularly spaced atoms which might act as scattering centres for x-rays, and if X-rays were electromagnetic waves of wavelength about equal to the inter atomic distances in crystals, then it must be possible to diffract X-rays by means of crystals"[11] . The X-ray diffraction is most extensively used technique for the characterization of the materials. This is an appropriate technique for all samples, i.e. powder and bulk as well as thin film and collect a lot of information can be extracted from the XRD data. The information observing the crystalline nature of a material, nature of the phase, lattice parameter and grain size were collected by using this method. From the position and shape of the lines, one can obtain information regarding the unit cell parameters and micro structural parameters (grain size, micro strain, etc), respectively.

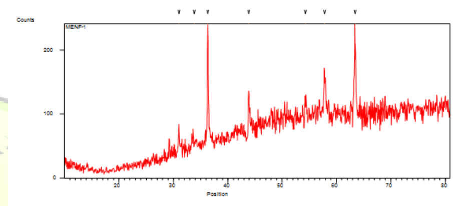


Figure 4: XRD Patterns Of MgNdErFeO4 (x=0.04,y=0.06)

Sample		**Lattice constant**	**Particle Size**
X	**Y**		
0.04	**0.06**	**8.345**	**55.5**

Table 1: lattice constant an crystallite size for $MgEr_xNd_yFe_{2-x-y}O_4$

2.6 Fabrication of Microstrip Patch Antenna

In this design Neodymium and Erbium doped magnesium ferrite MSPA length and width of the patch was determined as 32.45 mm and 39.27 mm. The feeding point of the length and width was kept as 1.96 mm and 7.25 mm respectively. The Microstrip patch antenna was fabricated in the RT-Duroid substrate and was simulated using the spectrum analyzer to obtain the return loss.

3. HARDWARE DESCRIPTION

The glowing patch elements on the dielectric substrate have various shapes like square, rectangular, circular, elliptical, triangular etc. In this paper, rectangular micro strip patch antennas are taken under consideration because the patch size are designed based on required frequency range of 3 GHz .They have lot of feeding techniques in that Microstrip Line Feed is used in this work. In this type of feed technique, a conducting strip is connected directly to the edge of the microstrip patch. This type of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure.[9]

Design can be done using following formulation

The Effective dielectric constant can be expressed as,

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}}$$

The width W and The effective length of the patch L_{eff} is calculated using formula

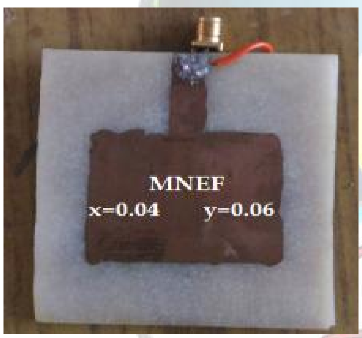
$$W = \frac{c}{2 f_0 \sqrt{\frac{\varepsilon_r + 1}{2}}}$$

$$L_{EFF} = \frac{c}{2 f_0 \sqrt{\varepsilon_{reff}}}$$

The effective length of the patch is characterize by formula

$$L_{eff} = L + 2\Delta L$$

The Microstrip patch antenna was fabricate with RT-DUROID plate, by the following steps: First the RT-DUROID plate after that photolithography and wet print is done. The etching of the printing plate is done by diluting the solution of $FeCl_3$ till the required solution is obtained. The plate is taken out and cleaned. Drilling and soldering is done in order to connect the SMA connectors. A feed connection is connected to the external devices such as measurement devices. The fabricated antenna is connected to the spectrum analyzer.



The figure 6 shows the real time fabricated MNEF-MSPA connectected with High Frequency function generator.

3.1 SPECTRUM ANALYZER

A spectrum analyzer measures the magnitude of an input indicator versus frequency within the full frequency range of the instrument. The primary use is to measure the power of the spectrum of specified and unspecified signals. The input signal to a spectrum analyzer measures is electrical, however, spectral compositions of other signals, such as acoustic pressure waves and optical light waves, can be considered through the use of an appropriate transducer. Optical spectrum analyzers also exist, which use direct optical techniques such as amonochromator to make measurements. The return loss are obtained and compare their results at 1GHz, 2GHz, and 3GHz.

For frequency 1 GHz

Figure 7: Return Loss of 1GHz

For frequency 2 GHz

Figure 8: Return Loss of 2GHz

For frequency 3 GHz

Figure 9: Return Loss of 3GHz

4. SOFTWARE DESCRIPTION

The Microstrip patch antenna was simulated in the COMSOL Multiphysics. COMSOL Multiphysics software is a finite element analysis and Simulation software or software package for various physics and engineering applications. The simulator have lot of Version 4.2b, 43b.,etc. In this project will be simulate by COMSOL 4.3b. COMSOL Multiphysics is an valuable spontaneous atmosphere modeling and solving a wide range of scientific and engineering issues. The software provides a powerful incorporated desktop environment with a Model Builder where you get full overview of the model and access to all functionality. With COMSOL Multiphysics you can easily extend conventional models for one type of physics into Multiphysics models that solve coupled physics phenomena and do so simultaneously[10].The power supply and feed structure are not modeled explicitly, and it is assumed that a Uniform voltage difference is applied across these faces and out information of math or numerical analysis.

The return loss (S11 parameter) are obtained and compare their results at 1GHz, 2GHz, and 3GHz.

Frequency	S11parameter(Return loss)
1 GHz	-12dB
2 GHz	-20dB
3GHz	-25dB

Table 2 compare the different frequency

5. Result and Comparison

E.Sricithra et.al's Worked on the T shape antenna return loss was -13.6 dB, where as in C.Sonia et.al's Work for circular yagi patch antenna the return loss was -19dB, Where as in our work for Rectangular Microstrip patch antenna return loss came to be -78.3 dB. This result shows the high efficiency of our patch antenna.

6. Conclusion

In this work, the aim was targeted at reducing the return loss of Microstrip antennas constructed with dielectric material with lower dielectric constant, because the lower dielectric constant valve improves the antenna efficiency. Executed analysis of constructed MSPA constructed using magneto dielectric substrate reduces the size and weight and gives an upgraded S_{11} parameter of the RT-DUROID substrate antennas. We have selected three different operating frequency and the simulated results compare the return loss of Microstrip patch antenna. Our work is more efficient because the return loss obtain for Microstrip patch antenna is very lower than other antennas.

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