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Modification of Ag Thick Film Microstripline Due to Superstrate Ni-Cu-Fe-Mn-O ceramics

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Abstract*—Modification in microstripline properties like microwave absorption and effective dielectric constant were done by simple superstrate Ni-Cu-Fe-Mn-O ceramics in 8 GHz to 18 GHz frequency range. The transmission of microstripline decreases with increasing microwave absorption due superstrate ceramic. The microwave absorption of microstripline increases upto 45 % in whole 8 GHz- 18 GHz frequency range and composition dependent behavior observed. The effective dielectric constant of microstripline increases due to Ni-Cu-Fe-Mn-O superstrate and it increases with Fe content also.

Index Terms—**effective dielectric constant, microstripline, superstrate method.**

I. INTRODUCTION

Electromagnetic waves cause interruption in the operation of electronically/magnetically controlled devices. Electromagnetic interference (EMI) can cause severe interruption of electronically controlled systems. It can cause device malfunction, generate false images, increase clutter on radar and reduce performance because of system-to-system coupling [1]. To overcome the problems which created by EMI, electromagnetic wave absorbers with the capability of absorbing unwanted electromagnetic signals are used and research on their electromagnetic and absorption properties is still being carried out [2]. For RF and microwave devices, the microstrip line offers planarization. The ML is transmission line geometry with a single conductor trace on one side of the substrate and a single ground plane on the other side. A dielectric material overlaid on the microstrip component perturbs its fringing field due to change in effective dielectric constant (a combination of substrate dielectric constant and the material above the microstrip component) of the microstrip component, This perturbation causes change in its electrical parameters such as transmission, reflection, resonance frequency and 'Q' value of the component [3,4]. The usual method of examining the microwave properties of overlaid materials is using patterning simple devices like straight resonator, ring resonator, microstripline etc. and measuring its response at microwave frequency and evaluating its properties. The simplest miniaturized microstrip structure is microstripline which is a non resonant component. The tremendous growth in IT sector causes the increase in demand for high frequency microstripline components [5]. Much less attention is given to measurements of Ni-Cu-Fe-Mn-O ceramics via radio-frequency (RF) methods than to measurements of their dc properties, although the effects observed in the RF range are more significant. The purpose of this paper is to study the response of Ag thick film microstripline due to superstrate $Ni_{0.6}Cu_{0.4}Fe_yMn_{2-y}O_4$ NTC ceramic. The effect of superstrate on microwave absorption of the microstripline and the effective dielectric constant of microstripline with different composition of Fe in Ni-Cu manganite.

II. SAMPLE PREPARATION AND SUPERSTRATE METHOD

The powder of composition $Ni_{0.6}Cu_{0.4}Fe_yMn_{2-y}O_4$ ($0 \leq y \leq 0.5$) was prepared by oxalic precursor method. For this, the following reactants of analytical grade were used: nickel acetate, manganese acetate, cupric acetate and oxalic acid as starting materials and ferric chloride were used for the iron doping. The prepared powder was dried at room temperature, presintered at 350 ˚C for 3 hr and mixed with PVA (polyvinyl alcohol) binder. For microwave superstrate study, the sintered powders were uniaxially pressed in a die to form pellet (thickness 1-2 mm and diameter 1 cm) using hydraulic press. The pelletized samples were sintered at 1000 ˚C for 8 hr in a muffle furnace and slowly cooled at room temperature in the furnace. The crystalline structure of the prepared ceramics was confirmed by X-ray diffraction [6]. The microstripline is an inhomogeneous transmission line structure and delineated on alumina substrate by screen printing technique. It consists of strip conductor on flat dielectric substrate, the reverse side of which is metallized to provide a ground plane. The thickness of the Ag thick film microstripline was ~ 8 μm and width of the line was ~ 25 mil. For performance evaluation, the setup consisting of X band (8 GHz - 12 GHz) and Ku (13 GHz -18 GHz) signal generator, isolator, attenuator, microwave to coaxial adapter and RF detector was used. The transmittance of microstripline is termed as a without superstrate (WS) and the transmission remains fairly constant over the frequency range studied with average transmittance of ~ 65 % in X band and ~ 60 % in Ku band. For superstrate studies, the $Ni_{0.6}Cu_{0.4}Fe_yMn_{2-y}O_4$ ceramic was kept in touch on the microstripline and transmittance measured with composition dependent and termed as a with superstrate. The schematic of experimental setup for microstripline superstrate technique is shown in Fig. 1. The transmittance and absorbance of Ag thick film microstripline was studied for the effect of $Ni_{0.6}Cu_{0.4}Fe_yMn_{2-y}O_4$ superstrate (overlay) on it.

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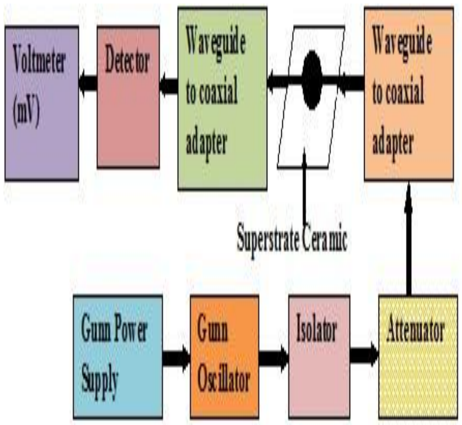

Fig. 1. Schematic of experimental setup used for Ag thick film microstripline superstrate study.

III. RESULTS AND DISCUSSION

The simple miniaturized microstripline is a non-resonant component. When any material is kept on top of the microstrip component (microstripline) it is termed as superstrate (overlay). To study the effect of the superstrate on the microstrip components, the pellets of the ceramics of different compositions $Ni_{0.6}Cu_{0.4}Fe_yMn_{2-y}O_4$: $0 \leq x \leq 0.5$, were kept as in-touch superstrate (overlay) above the microstrip component.

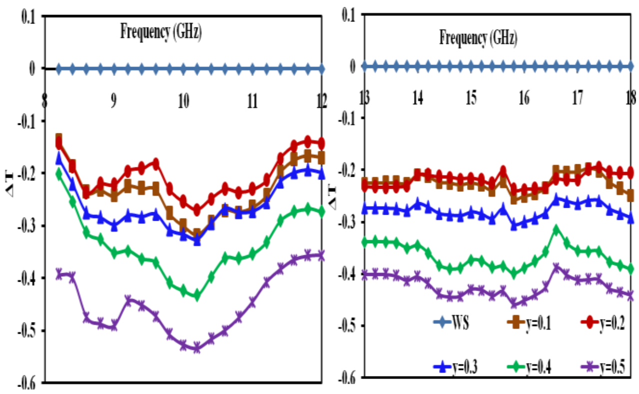

Fig. 2. The change in transmittance of microstripline due to superstrate $Ni_{0.6}Cu_{0.4}Fe_yMn_{2-y}O_4$ ceramic.

The transmittance of microstripline with and without superstrate was measured. The transmittance of Ag thick film microstripline without superstrate was subtracted from the transmittance of microstripline obtained with $Ni_{0.6}Cu_{0.4}Fe_yMn_{2-y}O_4$ ceramic superstrate for the different iron concentration in order to study the effect of superstrate on the transmittance of the microstripline. Therefore, the graphs are plotted as a change in transmittance versus frequency is shown in Fig.2. The magnitude of change in transmittance is found to be composition dependent. It is also observed that as iron concentration increases transmittance of microstripline decreases systematically in complete 8 GHz to 18 GHz frequency range. The y=0.5 concentration in $Ni_{0.6}Cu_{0.4}Fe_yMn_{2-y}O_4$ ceramic show the lowest microstripline transmittance. It is observed that in X band at 10.2 GHz a peak decreases in transmittance is observed. Due to lower concentration of iron ($\leq$ 0.3) very little variations in transmittance is observe for higher concentration ($\geq$ 0.4) the transmittance rapidly decreases.

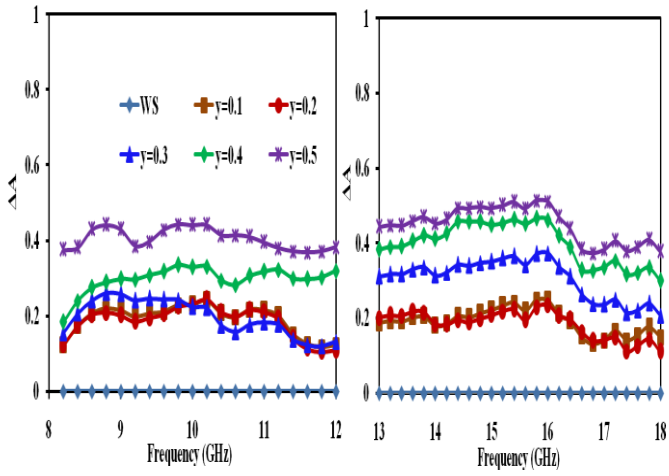

Fig. 3. The change in absorbance of microstripline due to superstrate $Ni_{0.6}Cu_{0.4}Fe_yMn_{2-y}O_4$ ceramic.

The change in microstripline absorbance of microwaves due to superstrate of $Ni_{0.6}Cu_{0.4}Fe_yMn_{2-y}O_4$ ceramic is shown in Fig. 3. From the figure, it can be seen that the microwave absorption of microstripline increases due to superstrate $Ni_{0.6}Cu_{0.4}Fe_yMn_{2-y}O_4$ ceramics in the whole 8 GHz to 18 GHz frequency range. Composition dependent variations are observed in absorption of microstripline due to superstrate $Ni_{0.6}Cu_{0.4}Fe_yMn_{2-y}O_4$ ceramics. As iron content increases in $Ni_{0.6}Cu_{0.4}Fe_yMn_{2-y}O_4$ ceramic the absorption of microstripline also increases systematically in X and Ku band. The absorbance of microstripline increases due to superstrate, it is increases from ~20 % to 50 % as iron concentration increases in whole 8 GHz to 18 GHz frequency range. The microstriplines transmit the electromagnetic waves launched at one end of the microstripline to the other end by the propagating fringing fields. The fringing fields are present on the surface of microstripline. The transmittance of microstripline was decreased and attenuation increased. When a material with dielectric constant higher than air is kept in touch over the microstripline, the fringing fields of the microstripline gets perturbed due to overlay due to increase in effective capacitance/permittivity which results in the enhancement of width of microstripline experienced by the microwaves i.e. pseudo width. [9]. Hence, when overlay is used the fringing fields are perturbed. This cause changes in transmission (S21) and reflection (S11). The micro strip line transmittance is observed to be lower due to superstrate of $Ni_{0.6}Cu_{0.4}Fe_{0.5}Mn_{1.5}O_4$ ceramic. The high microwave absorption of microstripline observed due to superstrate $Ni_{0.6}Cu_{0.4}Fe_{0.5}Mn_{1.5}O_4$ ceramic. The substitution of Fe decreases simultaneously the Mn content in the material, eventually increasing density of the material. This favors the high dielectric constant of the superstrate material, which may be the reason behind the variation in transmittance as well as absorbance of Ag thick film microstripline. The highly oscillatory behavior of the simple microstripline due to

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overlay might be mismatches inherent in the non overlaid microstripline which continues due to overlay. The effective dielectric constant of microstripline due to superstrate $Ni_{0.6}Cu_{0.4}Fe_yMn_{2-y}O_4$ ceramic is shown in Fig. 4. It is observed that in the X band as frequency increases effective dielectric constant of microstripline also increases and it increases up to 10.4 GHz and then decreases drastically for all composition exception being due to y=0.2. The ε_{eff} of microstripline increases with iron content from 10.9 -11.11. In the Ku band the ε_{eff} of microstripline decreases from 13 GHz to 16 GHz and then increases with frequency. The ε_{eff} of microstripline is 10.8 due to y=0.1 and 10.4 due to y=0.5 at 13 GHz and decreases up to 10.6 to 10.3 at 16 GHz respectively. Above 16 GHz, due to all composition the ε_{eff} of microstripline increases up to 11.3 at 18 GHz.

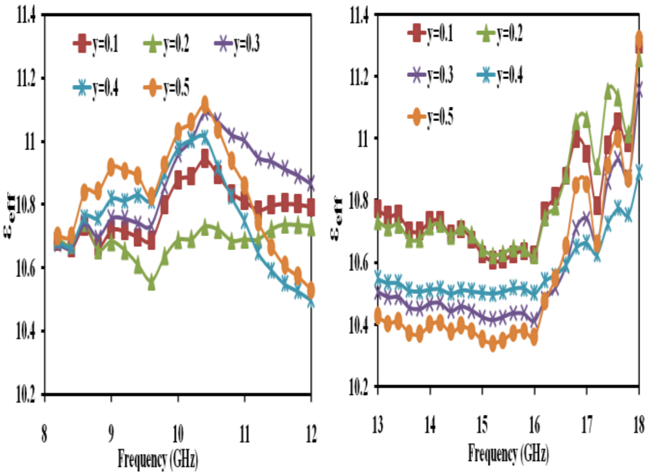

Fig. 4. Effective dielectric constant of microstripline due to superstrate $Ni_{0.6}Cu_{0.4}Fe_yMn_{2-y}O_4$ ceramics.

When the microstrip component is covered by a dielectric material as superstrate or overlay, the fringing field of the microstrip components interacts with the dielectric, which results in the increased effective dielectric constant of the system, which in turn results in the changes in the characteristics of microstrip component. The impedance, phase velocity and losses change with the dielectric constant, loss tangent and thickness of the superstrate material. The microwave dielectric constant of superstrate material depends on their shape and size of the grains [10]. As iron concentration increases in nickel copper manganite its grain to grain contact increases and ceramic become compact which increases the density in other hand porosity as well as anisotropy decreases which results in increase in effective dielectric constant of microstripline.

IV. CONCLUSION

The superstrate $Ni_{0.6}Cu_{0.4}Fe_yMn_{2-y}O_4$ ceramic with different Fe concentration decreases the transmittance and increases the microwave absorption of microstripline from ~ 15 % to 55 % and 10 % to 50 % respectively. The effective dielectric constant of the microstripline increases due to superstrate $Ni_{0.6}Cu_{0.4}Fe_yMn_{2-y}O_4$ ceramic. The high dielectric constant microstrip component can be used in microwave devices. The specific compositions with Fe content in $Ni_{0.6}Cu_{0.4}Fe_yMn_{2-y}O_4$ can be used to control the power level of the microwave transmitting through the microstripline by just keeping the pellet in-touch over the microstripline. The amount of decrease in transmission depends upon composition of the ceramics used as overlay. By varying the composition of the overlay the transmission of the required percentage can be obtained.

VI. ACKNOWLEDGMENT

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