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Response of Ag Thick Film Microstripline due to Superstrate Strontium Substituted Bismuth Manganites

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The purpose of this paper is to describe the use of strontium-substituted bismuth manganites bulk ceramic superstrate on Ag thick film microstripline, to modify its response and measure complex permittivity as a function of strontium. Bismuth strontium manganites ($Bi_{1-x}Sr_xMnO_3$) have been synthesized by solid state sintering technique. The perturbation obtained in the transmittance and reflectance of thick film microstripline due to the $Bi_{1-x}Sr_xMnO_3$ ($0.20 \le x \ge 0.50$) overlay has been used to obtain the permittivity at microwave frequencies in X and Ku band range. Due to the overlay of Bismuth strontium manganites (BSM) pellets a substantial increase in the effective dielectric constant was observed in X band more compared to Ku band. The in-touch overlay method provides ease loading and unloading. The perturbation obtained in the transmittance and reflectance of thick film microstripline due to the bismuth strontium manganites overlay has been used to obtain the permittivity.

Keywords: Electromagnetic waves, Microwaves, Microstriplines, Dielectric constant.

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1. INTRODUCTION

Dielectric materials are of interest for various fields of microwave engineering. Today's wireless communications and information systems are heavily based on microwave technology. High-permittivity dielectric electro-ceramics attracts considerable attention for applications in the electronics industry. Mixed valence manganites with the perovskite structure have been studied for almost five decades. The system offers a stage of chemical flexibility which supports the relation between the oxides structure, electronic and magnetic properties to be examined in a systematic way [1]. They are widely investigated for numerous applications in electronic components such as decoupling capacitors, dielectric substrates, phase shifters, dielectric resonators, etc. The degree of polarization and loss of dielectric materials are important topics of solid state physics. When a dielectric material overlaid on the microstrip component perturbs its fringing field due to change in a combination of substrate dielectric constant and the material above the microstrip component (i.e effective dielectric constant) which cause change in its electrical parameters such as resonance frequency (f_r), quality factor(Q), microwave transmittance (S_{21}) and reflectance (S_{11}) [2].

The simple perovskite oxides, $ABMnO_3$, have many different types of ferroic phases. The materials with the general formula of $ABMnO_3$, where the A site is a trivalent ion (La, Bi, Pr) and the B site a divalent ion (Sr, Ba, Ca) known as manganites, have been studied vary widely in the recent years [3].Various properties of bismuth strontium manganites have been widely studied by [3-6].The $Bi_{1-x}Sr_xMnO_3$ (BSM) where $x = 0.20$, 0.25, 0.40 and 0.50 sample was prepared by a low cost, conventional solid state synthesis technique [7-9]. For microwave superstrate (overlay) study, the sintered powders were uniaxially pressed in a die to form pellet (1.5 cm diameter and around 0.2 cm thickness) adding polyvinyl alcohol using hydraulic press at 10 ton/cm² for 5 min. The pelletized samples were sintered at 800 °C for 6 hr in a muffle furnace and slowly cooled at room temperature in the furnace to remove polyvinyl alcohol binder. The crystalline structure of the prepared ceramics was confirmed by X-ray diffraction [7-9].

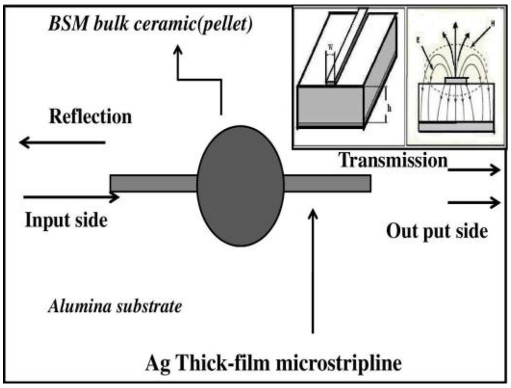

Fig. 1 – The schematic of Ag thick film microstripline with BSM overlay and along with electric and magnetic field lines (incite)

2. EXPERIMENTAL

The main objective of this work was to use the superstrate (overlay method) technique on the simple miniaturized Ag thick film microstripline which is a non resonant component to predict the permittivity. The bismuth strontium manganite bulk (pellets) was kept as in touch overlay (superstrate) at the centre of the microstripline and change in the transmittance and

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reflectance at strontium contents variations. The investigations are conducted in the very high microwave frequencies 8-18 GHz (in X and Ku-Band) in the absence of external dc magnetic field. To the authors knowledge using Ag thick film microstripline the dielectric studies of bismuth strontium manganites has been reported for the first time.

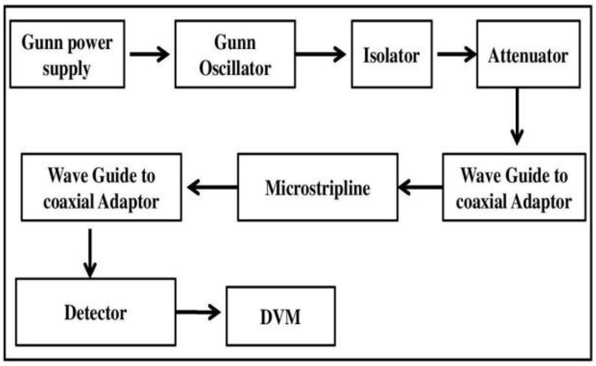

Fig. 2 – Schematic of experimental setup used for Ag thick film microstripline superstrate study

The Ag thick film microstripline (figure 1) was delineated by screen printing silver on 96 % alumina (Kyocera, Japan) substrate and fired at 700 °C by conventional thick film firing cycle. The width of thick film microstripline was 25 mil. The microwave transmittance (S_{21}) and reflectance (S_{11}) measurements were made point by point in the frequency range 8-18 GHz with the help of microwave bench consisting of Gunn source, isolator, attenuator, directional coupler and detector shown in Fig. 2. In this technique, the change in transmission and reflection of the microstripline with a $Bi_{1-x}Sr_xMnO_3$ (BSM) with different strontium contents kept at the centre the microstripline were measured. Figure 1 shows the microstripline with overlaid BSM bulk samples.

3. RESULTS AND DISCUSSION

The effect of BSM bulk superstrate (overlay) on the transmittance of the microstripline is depicted in Fig. 3. Since the aim is to see the changes occurring due to superstrate in the microwave transmission and reflection as compared to without overlay, the graphs are plotted as the change in transmittance and reflectance as a function of frequency. Fig. 4 depicts the effect superstrate on reflection coefficient as a function of frequency. From figure it is seen that the effect of BSM superstrate is to decrease the transmittance of the microstripline (ΔT negative). The decline is more in the Ku band than in the X band. The reflectance shows an oscillatory behavior both in the X band. Composition dependent behavior is more evident in the reflectance due to bulk overlay especially in the X and Ku band. The positive ΔR indicates increase in the reflectance indicating that the component becomes lossy due to the superstrate. The microstriplines transmit the electromagnetic waves launched at one end of the microstripline to the other end by propagating fringing fields. The fringing fields are present on the surface of microstripline. The transmittance of microstripline is decreased whereas attenuation increased.

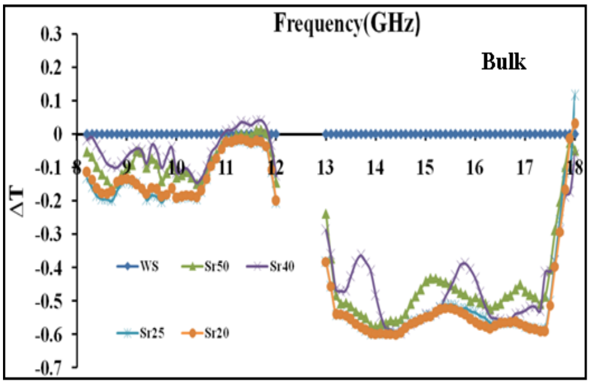

Fig. 3 – Change in transmittance of microstripline due to BSM pellet

The change in microstripline absorbance due to superstrate of BSM ceramic bulk (in pellets form) is shown in Fig. 4. From the figure it is observed that absorption of microstripline increases due to superstrate BSM ceramic bulk in the whole 8 GHz to 18 GHz frequency range due to all the compositions. The response is complementary to that of transmittance and reflectance. The absorption due to bulk is more than 0.50 in the frequency range 13.1-17.5 GHz regions. The highly periodic behavior of the microstripline due to in-touch overlay might be mismatches inherent in the non overlaid microstripline which continues due to superstrate.The high absorption in a large band of frequencies indicates potential for microwave applications as band rejection filters. Absorption is the heat loss under the action between electric dipole or magnetic dipole in material and the electromagnetic field.

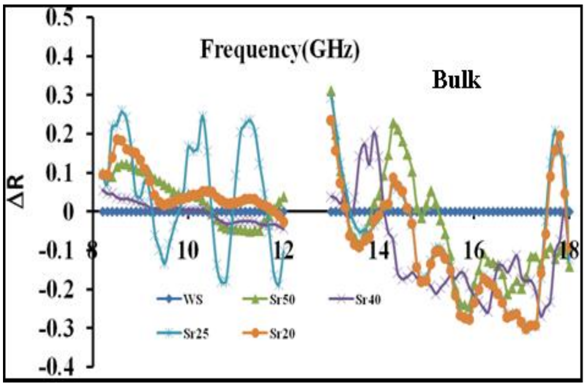

Fig. 4 – Change in reflectance of microstripline due to BSM bulk

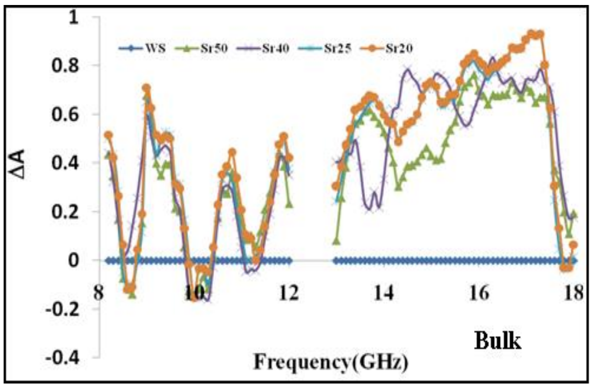

Fig. 5 – Change in absorbance of microstripline due to BSM bulk

When a dielectric constant material ($\varepsilon_r > 1$) is kept in touch over the microstripline, the fringing fields of the microstripline gets perturbed due to superstrate due to increase in effective permittivity (ε_{eff}) which leads to the enhancement of width of microstripline (pseudo width) experienced by the microwaves [10-11]. The effective dielectric constant of microstripline due to superstrate(overlay) of bulk BSM ceramic is shown in Fig. 6. It was observed that as the strontium content increased the effective dielectric constant decreased, dielectric dispersion in the frequency. The ε_{eff} due to bare alumina is ~ 10 up to 14 GHz and increases to ~ 15 at 18 GHz. In the X band resonant peaks are observed due to bulk superstrate of all compositions. Five resonant peaks are observed due to bulk in X band. The highest ε_{eff} of microstripline was obtained due to Sr20, Sr25, Sr40 and Sr50 at 8.6 GHz. The dielectric constant for Sr20, Sr25, Sr40 and Sr50 are 38.8, 38.1, 20.8 and 20.8 at 8.6 GHz. The effective dielectric constant of microstripline is observed in the range of 10.5-12.4 in Ku band with strontium content.

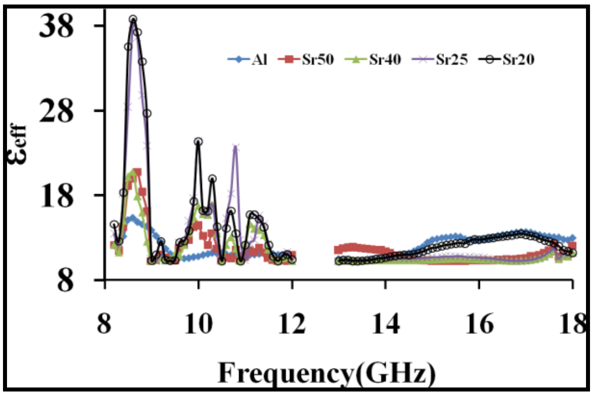

Fig. 6 – The effective dielectric constant (ε_{eff}) of BSM ceramics

It was observed that as strontium content increased the effective dielectric constant decreases as also observed in the case of dielectric dispersion in the frequency range 20 Hz to 2.5 MHz as explained in the dielectric studies [7]. The polarization in manganites is via a conduction mechanism due to electron-hopping between Mn^{3+} and Mn^{4+} ions. At high frequencies, the electron-exchange between Mn^{3+} and Mn^{4+} ions cannot follow the alternation of the applied ac electric field, hence effective dielectric constant fall to smaller values. The hopping mechanism appears to be favorable at lower applied ac electric field frequencies [7]. When the microstrip component is covered by a dielectric material as superstrate, the fringing field of the microstrip components interacts with the dielectric material, which leads in the increasing effective dielectric constant (ε_{eff}). The microstrip components like impedance, phase velocity (v_p) and losses change with the dielectric constant (ε'), loss tangent (ε'') and thickness of the superstrate material [12]. The microwave dielectric constant of superstrate material depends on their shape and size of the grains [13].

4. CONCLUSIONS

A non resonant cost effective miniaturized microwave component, Ag thick film microstripline has been used to predict the complex permittivity of bismuth strontium manganite ceramics for the first time. The highest ε_{eff} of microstripline was obtained due to Sr20, Sr25, Sr40 and Sr50 at 8.6 GHz. The high dielectric constant microstrip component can be used in microwave devices. Due to the superstrate of bismuth strontium manganites (BSM) pellets a substantial increase in the effective dielectric constant was observed in X band more compared to Ku band. The perturbation obtained in the transmittance and reflectance of thick film microstripline due to the bismuth strontium manganites superstrate has been used to obtain the permittivity. The absorption due to bulk is more than 0.50 in the frequency range 13.1-17.5 GHz regions. The high absorption in a large band of frequencies indicates potential for microwave applications as band rejection filters.

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REFERENCES

1. M.D. Coey, M. Viret, *Adv. Phys.* **48** No 2, 167 (1999).
2. S.A. Kanade, Vijaya Puri, *Microelectron. J.* **37**, 1302 (2006).
3. C.N.R. Rao, A. Arulraj, P.N. Santosh, A.K. Cheetham, *Chem. Mater.* **10**, 2714 (1998).
4. H. Chiba, T. Atoua, H. Faqir, M. Kikuchi, Y. Syono, Y. Murakami, D. Shindo, *Sol. Stat. Ion.* **108**, 193 (1998).
5. T. Kawasaki, Y. Ogimoto, N. Ogawa, K. Miyano, H. Tamaru, *J. Appl. Phys.* **101**, 123714 (2007).
6. B. Fisher, J. Genossar, K.B. Chashka, L. Patlagan, G.M. Reisner, *Appl. Phys. Lett.* **88**, 152103 (2006).
7. S.N. Mathad, R.N. Jadhav, R.P. Pawar, Vijaya Puri, *Electron. Mater. Lett.* **9** No 1, 87 (2013).
8. S.N. Mathad, R.N. Jadhav, Vijaya Puri, *Eur. J. Appl. Eng. Sci. Res.* **1** No 3, 67 (2012).
9. S.N. Mathad, R.N. Jadhav, R.P. Pawar, Vijaya Puri, *Sci. Adv. Mater.* **6**, 1276 (2012).
10. S.M. Iyer, R.N. Karekar, *Electron. Lett.* **28** No 9, 873 (1992).
11. S.N. Mathad, R.N. Jadhav, Vijaya Puri, *Microelectron. International* **30** No 2, 85 (2013).
12. R.S. Pawar, S.N. Mathad, N.D. Patil, Vijaya R. Puri, *Int. J. Eng. Innov. Technol. (IJEIT)* **3** No4, 220 (2013).
13. R.N. Jadhav, Vijaya Puri, *Microelectron. International* **28**, 53 (2011).