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Study of Microwave properties due to Electropolymerised Polyaniline thin films overlaid on Thick and Thin film Microstripline

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Abstract: This paper reports the microwave transmittance and reflectance of polyaniline thin films electropolymerised on stainless steel substrate in X-Band (8-12GHz) and Ku-Band (13-18GHz). The overlay method has been used for the microwave studies. The behavior of thick and thin film microstriplines changes due to polyaniline thin films. The change in transmissions and reflectance is more in thin film than thick film microstripline. The effect of moisture on polyaniline thin films has been also reported. The larger changes are observed after moisture exposure. The thickness dependent properties are not very prominent but the frequency dependent changes are observed

Key words: Polyaniline thin film; Transmission; Reflection; Thick and Thin film microstripline; Moisture

I. INTRODUCTION:

The traditional conductors are metals, which have the problems of the poor adhesion and corrosion under extreme environments. Conducting polymers may prove to be an alternative for metallization in microelectronics. Conducting polymers have created at great interest due to their wide variety of properties and technological applications. In particular, variation of their conductivity with the frequency of an incident radiation suggests their use for microwave absorption applications [1]. Polyaniline (PANI) is one of the most versatile conducting polymers with interesting electrical, electrochemical, optical characteristics along the excellent environmental stability and its raw material can be obtained easily [2-11]. Our lab has been working on both thin and thick film microstrip passive components and its response to various types of in-touch dielectric overlay [12-14].

This paper reports the transmittance and reflectance change of thick and thin film microstripline due to PANI overlay in both X-Band and Ku-Band. For this studies overlay technique has been used. The PANI films deposited by electropolymerisation on stainless steel (SS) has been used as overlay. The effect of moisture on PANI thin films is also reported.

II. EXPERIMENTAL:

The PANI thin films were deposited by Electropolymerisation method using three electrode galvanostatic cells [15]. A saturated calomel electrode was used as a reference electrode and high density and high surface area graphite rod was used as the counter electrode. The PANI thin films were deposited on the SS substrate at constant current in a conventional three electrode cell. The electrolyte solution contained 1M aniline and 2M H₂SO₄. Adherent dark yellowish green (shiny matt) coloured thin films were obtained. The PANI films SS-A, SS-B, SS-C, SS-D are different thicknesses of 2.5, 5, 10 and 15µm respectively. The thickness of PANI films was measured by gravimetric method [16].

The thin film microstripline of width 25 mil was fabricated using vacuum evaporation + electroplating + photolithography. The thick film microstripline was fabricated using screen printing technology. The width of thick film microstripline was 25 mil. The metallization was Cu for thick film and Ag for thin film microstripline. The substrate was alumina (Kyocera, Japan) for both lines.

The PANI thin films on SS were kept as in-touch overlay over the Ag thick film and Cu thin film microstripline and change in the transmittance and reflectance of the line studied. The size of substrate was 1x1cm. The microwave system consists of waveguide microwave set up used for the measurement in both X-Band and Ku-Band.

III. RESULTS AND DISCUSSIONS:

A. Response of Thin film and Thick film microstripline without overlay:

Fig.1 shows the transmittance and reflectance of thin and thick film microstripline without overlay in X-Band (8-12GHz) and Ku-band (13-18GHz). From the figure it is seen that in the X-band, the transmittance of

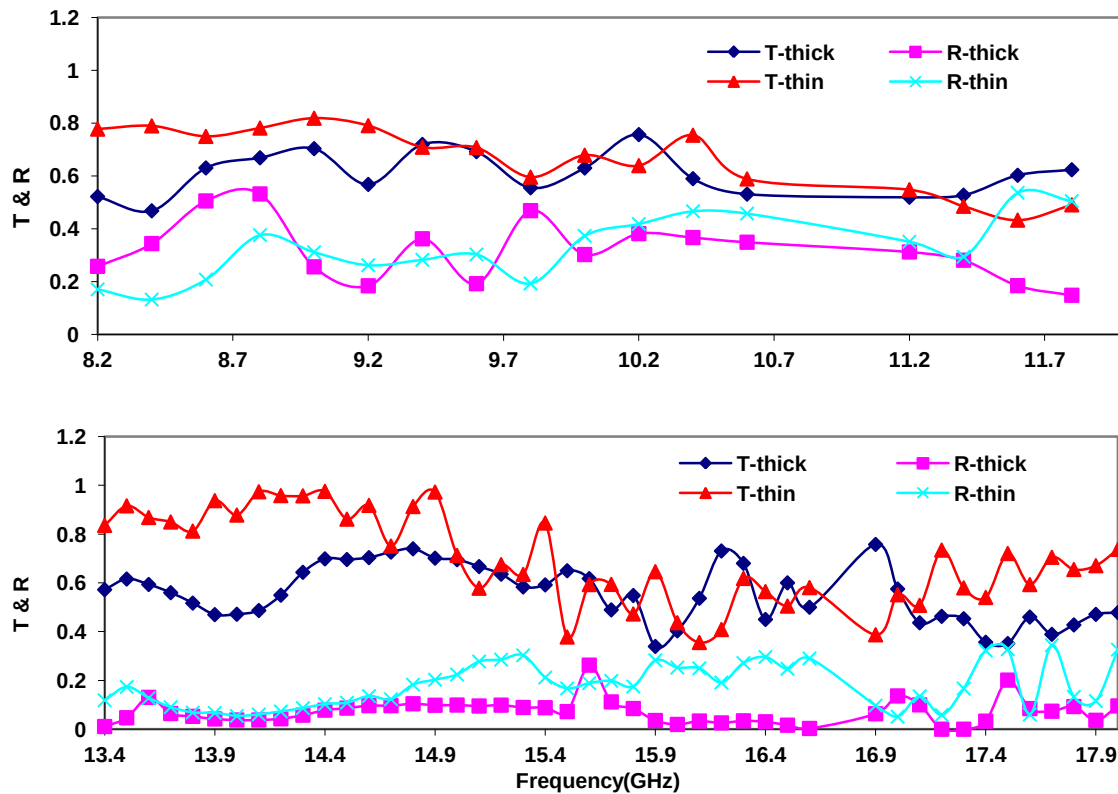


Fig.1: The Transmittance and Reflectance of Thin and Thick film microstripline in X-Band and Ku-Band.

both thin and thick film microstripline is uniform, with the thin film line showing higher values below 9.5 GHz. The reflection lies between 0.2 - 0.4 for both the lines. In the Ku band the thin film microstripline show more oscillatory behavior and higher transmittance than the thick film microstripline. The average transmittance for thin film microstripline is ~ 0.7 and that of thick film microstripline is 0.58. Compared to X band, in the Ku band both the lines show lesser reflectance (below ~ 0.2)

B. Response of Thin film microstripline to PANI thin film overlay:

The change in transmittance (ΔT) and the change in reflectance (ΔR) in X-band and Ku-band due to various polyaniline thin films are shown in fig.2. From the figure it is seen that in general the transmittance decreases ($-ve \Delta T$) and reflectance also decreases ($-ve \Delta R$). The decrease in transmittance is more than the decrease in reflectance. Due to the film deposited on stainless steel, thickness of film dependent changes is not observed.

In the Ku-band below 15 GHz the transmittance of the microstripline decreases due to PANI overlay. The decrease becomes -0.9 at some frequencies. Above 15 GHz ΔT is still $-ve$ but value becomes $\sim 0.2-0.4$. The reflectance also decreases due to the overlay. Below 15 GHz, the ΔR value is ~ -0.1 . The thickness dependent changes are observed at 15.7GHz with larger change in reflection. Compared to X band, in the Ku band more thickness dependent changes are observed.

C. Response of Thick film microstripline to PANI thin film overlay:

The change in transmittance and reflectance of thick film microstripline due to polyaniline overlay is shown in fig.3. Due to PANI on stainless steel overlay on thick film, most of the frequencies in X-Band except 8.6 - 8.8 GHz, ΔT is $-ve$, the value reaching -0.75 at 9.6 GHz. The ΔR curve shows increased reflectance ($+ve \Delta R$) below 8.5 GHz and between 9.4 to 10.5 GHz, beyond 10.5 GHz the reflectance again decreases. Differences in the behavior of the thin film and thick film microstripline due to PANI overlay are observed. The shapes of the ΔT and ΔR curves of both the microstriplines are different.

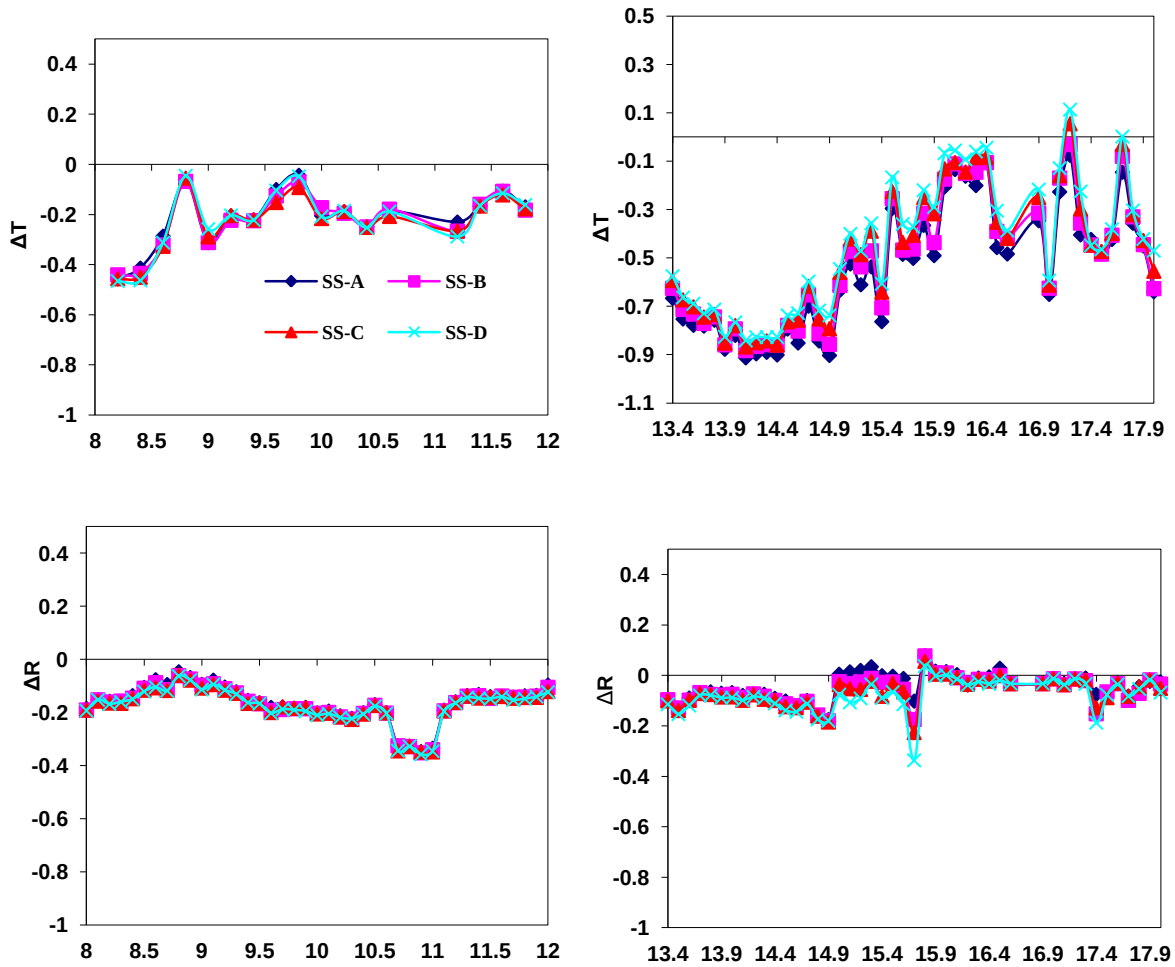


Fig.2: Change in Transmittance (ΔT) and Change in Reflectance (ΔR) of Thin film microstripline due to PANI thin films overlay in X-Band and Ku-Band.

In Ku-Band, the decrease in transmittance is more in the 14.4 to 15.5 GHz range as compared to less than 14.4 GHz range and for reflectance, below 15.2 GHz the ΔR values lie in the 0 to -0.1 range only. Beyond this frequency highly dependent changes are obtained, the ΔR reaching +ve values at some frequencies. On thick film thickness of PANI dependent effects are not seen much.

IV. EFFECT OF EXPOSURE OF PANI THIN FILMS TO MOISTURE:

The PANI thin films were subjected to saturated humidity. These films were used as overlay over the thin and thick film microstriplines. All the readings were taken within 10 minutes after removing from the humidity chamber. For X and Ku band separate films identical properties were used.

A. Effect of Change in transmittance and reflectance of thin film microstripline in X-band and Ku-Band:

Fig.4 shows the change in transmittance and reflectance of the thin film microstripline due to overlay of polyaniline thin films exposed to moisture. From fig.4 it is seen that due to moist PANI the transmittance of the thin film microstripline becomes +ve in the 8.5 to 9 GHz frequency range. The shape of ΔT versus frequency curve appears to be similar with a shift in ΔT towards +ve values. As frequency increases ΔT becomes more negative. The shape of ΔT curve is different from that without moisture exposure (Fig.2).

The reflectance of the thin film microstripline due to PANI thin films decreases to a value of ~ -0.3 to -0.4 , in the frequency range 8.2 to 9.8 GHz. For higher frequencies the value is ~ -0.2 .

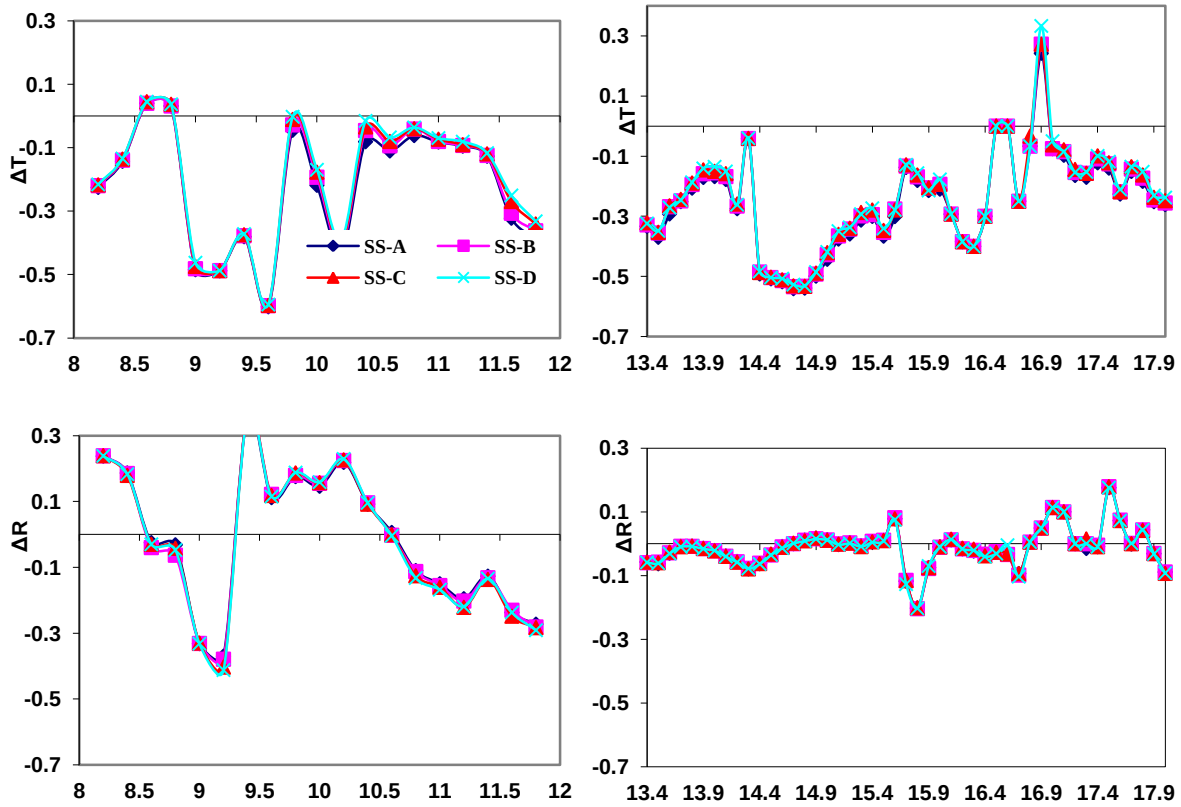


Fig.3: Change in Transmittance and Change in Reflectance of Thick film microstripline due to PANI thin films overlay in X-Band and Ku-Band.

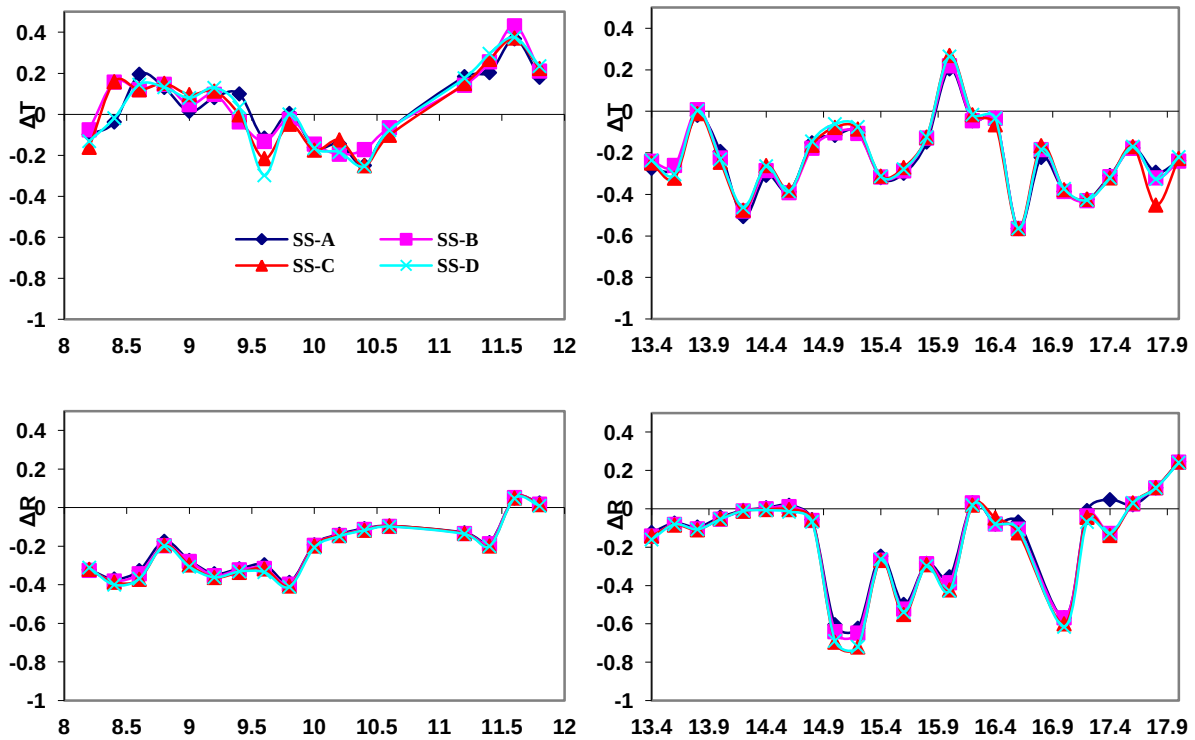


Fig.4 : Change in Transmittance and Change in Reflectance of Thin film microstripline due to exposure PANI thin films to moisture overlay in X-Band and Ku-Band

In Ku-Band, the frequency dependent changes in ΔT are different after exposure to moisture, as compared to before exposure (Fig.2). In general there is decrease in transmittance (-ve ΔT) the decrease being lesser from unexposed films. In the frequency range 14.8 to ~ 17 GHz substantial decrease in reflectance is obtained on exposure to moisture.

B. Effect of Change in transmittance and reflectance of Thick film microstripline in X band and Ku-band:

In X-Band, on comparison with the curves due to unexposed films (Fig.3 and fig.5), it is seen that due to exposure to moisture the behavior of ΔT and ΔR with frequency is similar to unexposed films with some minor changes at particular frequencies.

The moisture exposed PANI thin films shows smaller changes the transmittance and reflectance in Ku-Band. The shape of ΔT and ΔR Vs frequency curves are almost similar to that observed without exposure to moisture.

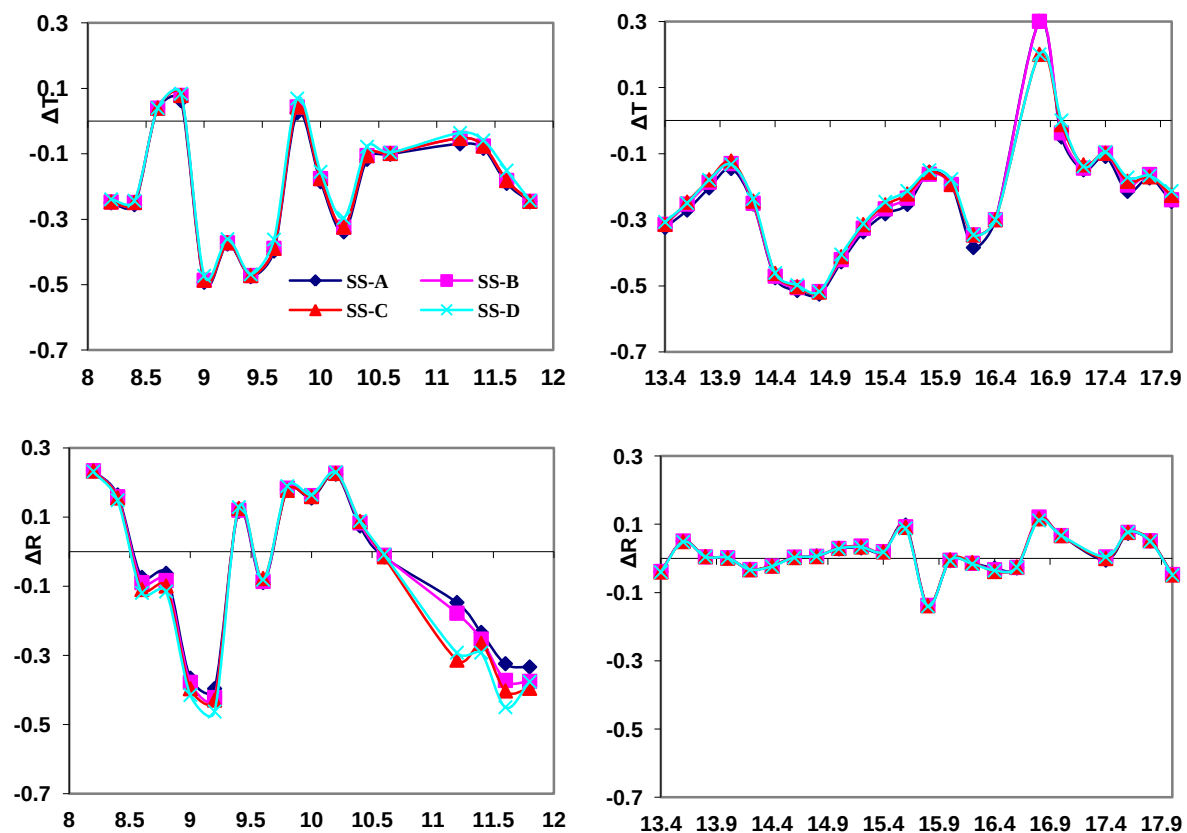


Fig.5 Change in Transmittance and Change in Reflectance of Thick film microstripline due to exposure PANI thin films to moisture overlay in X-Band and Ku-Band

V. CONCLUSION:

Differences in the behavior of the thin film and thick film microstripline due to PANI overlay are observed. The shapes of the change in transmittance and change in reflectance curves of both the microstriplines are different. The frequency dependent changes are more observed in Ku-Band than X-Band.

The behaviors of thick and thin films are more changes due to moisturized PANI films on comparison with the curves due to unexposed films. The changes in the change in transmittance and change in reflectance is increases as frequency increases in thin film microstriplines and in thick film microstriplines, moisturized PANI films shows smaller changes the transmittance and reflectance change in Ku-Band.

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