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Microstrip Component and Metallization Dependent Effects of Ficus Benghalensis Leaf Overlay

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Abstract
Microwaves play an increasing role in modern life. Microstripline components are miniaturized components useful for transmission purposes. In this paper the transmission charactristics of microstriplines and reflectance characteristics of λ/2 rejection filters with FicusBenghalensis leaf overlay were reported. The frequency dependent effects were investgated in X band. An approximate estimation of effective dielectric constant of leaf has been made using overlay technique.
Keywords: *Microstipline, λ/2 rejection filter, FicusBenghalensis, thick and thin films.*

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I. Introduction

Leaves form a major portion of the vegetation available. How the microwave transmission is affected by the changes in the leaves is a very important aspect. The type of leafy vegetation cover in the region is indicative of the availability of water, soil condition and temperature condition prevailing in that particular region. The water content measurement of the vegetation cover at different places has importance in remote sensing application and plant water relation. Microwave interacts with leafy vegetation mainly due to presence of water in almost all of them. Feasibility study of a novel moisture sensor microstripline component fabricated on Al_2O_3 substrate for moisture measurement in leaf has been reported by Yogi et al [1]. The same sensor has also been used to study bicoloured leaves [2]. The microstrip ring resonator has been used to study wheat grains [3-6]. The characteristics of different microstripline components due to leaves overlaid were reported [7-9].

In this paper the changes in transmittance of thick and thin film microstriplines and rejection characteristics of thick and thin film λ/2 rejection filter with FicusBenghalesis leaf overlay are reported. The data at 9 GHz, 10 GHz and 11 GHz frequencies were reported. The values of ε' and ε" have been obtained at 10 GHz.

II. Experimental

Thick film microstripline components were fabricated using screen printing technology with a peak firing temperature of 700 °C in a three zone furnace. A firing schedule of 45 minutes was maintained. For thin film components, the metallization used was copper which was deposited on precleaned alumina substrate. Vacuum evaporation + electroplating methods were used. The ficusBenghalensis leaf was used for study. It was cut from the center vein along with subsidiary veins. The dimensions of leaf were 1.5 cm x 1.5 cm. Initially the weights of leaves were taken using a microbalance. Six types of measurements were conducted in each case.

1) USP : Upper surface of leaf in contact with central vein parallel to the direction of propagation
2) LSP : Lower surface of leaf in contact with central vein parallel to the direction of propagation.
3) USPR : Upper surface of leaf in contact perpendicular to the direction of propagation.
4) LSPR : Lower surface of leaf in contact perpendicular to the direction of propagation.
5) USMA : Upper surface making angle 45 ° with the main strip.
6) LSMA : Lower surface making angle 45 ° with main strip.

The leaf was held in place with pressure block on it to ensure better contact between circuit and leaf and to avoid air gap. For this thermocol block was used. The direction of propagation for the filter is considered from the input side to the output side. Both thick and thin film microstriplines were 25 mil in width. The λ/2 rejection filter was designed to have notch at 10 GHz.

III. Results and Discussion

The data of transmittance at different frequencies due to leaf overlayon thick and thin film microstriplines is given in table 1.

Table 1

Sr. No.	Condition of Leaf	Thick Film			Thin Film		
		X band			X band		
		9 GHz	10 GHz	11 GHz	9 GHz	10 GHz	11 GHz
1	**USP**						
	Fresh	0.08	0.1	0.1	0.56	0.02	0.24
	24 Hrs.	0.78	0.44	0.46	0.6	0.36	0.88
	48 Hrs.	0.64	0.38	0.62	0.56	0.28	0.65
2	**LSP**						
	Fresh	0.74	0.52	0.3	0.54	0.02	0.28
	24 Hrs.	0.71	0.44	0.24	0.6	0.3	0.6
	48 Hrs.	0.7	0.36	0.46	0.56	0.28	0.56
3	**USPR**						
	Fresh	0.48	0.3	0.12	0.56	0.02	0.72
	24 Hrs.	0.78	0.4	0.24	0.56	0.24	0.72
	48 Hrs.	0.74	0.4	0.44	0.55	0.22	0.68
4	**LSPR**						
	Fresh	0.7	0.4	0.3	0.66	0.02	0.45
	24 Hrs.	0.75	0.46	0.24	0.58	0.28	0.6
	48 Hrs.	0.62	0.46	0.25	0.52	0.22	0.68
5	**USMA**						
	Fresh	0.56	0.28	0.14	0.58	0.02	0.25
	24 Hrs.	0.7	0.44	0.22	0.62	0.26	0.7
	48 Hrs.	0.54	0.5	0.26	0.55	0.24	0.7
6	**LSMA**						
	Fresh	0.68	0.36	0.28	0.64	0.02	0.35
	24 Hrs.	0.7	0.46	0.22	0.62	0.26	0.95
	48 Hrs.	0.55	0.55	0.28	0.55	0.25	0.65

Table 2 shows the rejection data of thick and thin film λ/2 rejection filters at different frequencies.

Table 2

Sr. No.	Condition of Leaf	Thick Film			Thin Film		
		X band			X band		
		9 GHz	10 GHz	11 GHz	9 GHz	10 GHz	11 GHz
1	**USP**						
	Fresh	-13.2	-19.4	-27.1	-8.1	-25,1	-13
	24 Hrs.	-2.1	-22.9	-0.9	-7.8	-23.8	-4.2
	48 Hrs.	-4.6	-27.4	-0.5	-1.2	-18.1	-4.1
2	**LSP**						
	Fresh	-11.1	-21.9	-3.8	-6.6	-25.1	-5.7

	24 Hrs.	-0.5	-22.9	-0.8	-7.6	-23.8	-3.7
	48 Hrs.	-4	-25.5	-0.9	-2.2	-18.1	-3.8
3	**USPR**						
	Fresh	-8.4	-13.7	-20	-6.2	-25.1	-12
	24 Hrs.	-1.2	-22.9	-0.1	-8.1	-23.8	-3.8
	48 Hrs.	-4	-16.3	-0.9	-2.6	-18.1	-3.4
4	**LSPR**						
	Fresh	-11.7	-21	-28.3	-8.9	-25.1	-7.6
	24 Hrs.	-1.3	-25	-0.9	-7.9	-20.3	-3.6
	48 Hrs.	-3.7	-29.9	-0.9	-1.1	-18.1	-3.6
5	**USMA**						
	Fresh	-12.4	-21.9	-25.7	-8.3	-25.1	-11.3
	24 Hrs.	-1.1	-23.9	-0.8	-8.3	-20.3	-3.9
	48 Hrs.	-4	-29.9	-0.7	-2.1	-18.1	-4.3
6	**LSMA**						
	Fresh	-15.1	-24.1	-34.3	-7.6	-25.1	-8.4
	24 Hrs.	-1.3	-20.4	-0.8	-8.3	-25.8	-3.5
	48 Hrs.	-3.7	-22.6	-0.6	-2.4	-18.1	-3.7

When fresh leaf was overlaid on thick film microstriplines the transmittance decreases in both thick and thin film microstriplines. The surface dependent effects were seen in both thick and thin film microstriplines. Compaired to the effects on thick film microstripline the change due to fresh leaf is more in thin film microstripline. Due to fresh leaf overlay the thick film λ/2 rejection filter has lost its characteristics. There is increase in attenuation in the entire frequency range. But due to fresh leaf overlay on thin film filter, it retains its notch properties.

Microstrip components are basically metallizations of a particular dimension. Metallization of the substrate therefore becomes an important aspect of the circuit fabrication. Copper was chosen as the metallization for thin film components because it is cheap and it is very conducive to vacuum evaporation and electroplating. For thick film technology copper requires nitrogen firing, whereas silver based thick film conductor can be processed in conventional furnaces. The conductivity of silver and copper thick film is almost same.

Leaf is basically water loaded material. The amount of water in the leaf is a dominant factor dictating the dielectric behavior of the leaf. In the X band the water dominates the dielectric properties of the leaf. The effective permittivity of the leaf is $\boldsymbol{\epsilon}_{eff}^{*} = \boldsymbol{\epsilon}_{eff}' - j\boldsymbol{\epsilon}_{eff}''$

This represents the wave matter interaction and can be considered as the electrical signature of the material. The real part $\boldsymbol{\epsilon}_{eff}'$ indicates the ability of the material to store energy from the field of the electromagnetic waves.The imaginary part $\boldsymbol{\epsilon}_{eff}''$ Indicates the ability of the material to dissipate energy.

The data of $\boldsymbol{\epsilon}'$ and $\boldsymbol{\epsilon}''$ for various leaves after keeping as overlay on microstriplines and λ/2 rejection filters are calculated using equations [10,11] and is given in table 3.

Table 3 : Data of dielectric constants of the FicusBenghalensis leaf for different conditions.

Sr. No.	$\boldsymbol{\epsilon}_{eff}$	Δϕ	$\boldsymbol{\epsilon}'$	Leaf Condition	$\boldsymbol{\epsilon}''$			
					Thick Film		Thin Film	
					Microstripline	λ/2 rejection filter	Microstripline	λ/2 rejection filter
1	68	123.3	124.8	Fresh				

				USP	199.5	17.7	286.9	49.9
				LSP	83.4	47.4	286.9	49.9
				USPR	180.3	52.3	286.9	49.9
				LSPR	83.4	36.5	286.9	49.9
				USMA	207.7	47.4	286.9	49.9
				LSMA	90.7	74.2	286.9	49.9
2	30.78	94	76.6	24 Hrs.				
				USP	29.9	46.7	14.6	26.7
				LSP	83.8	46.7	0.54	26.7
				USPR	83.8	46.7	19	26.7
				LSPR	83.8	66.7	6.3	6.6
				USMA	91	56.2	12.4	6.6
				LSMA	91	22.8	12.4	23.7
3	21.6	79.12	56.7	48 Hrs.				
				USP	4.2	77	5.4	23.8
				LSP	25.8	66.5	5.4	23.8
				USPR	29	13.9	22.6	23.8
				LSPR	69.2	97.9	22.6	23.8
				USMA	66.4	97.9	16.4	23.8
				LSMA	61.2	37.7	13.5	23.8

Overlay is defined as some material other than air which is in contact with the top metallization in the microstripline components. When overlay is used above these components the parameters will change. As the dielectric constant of overlay increases it will increase total effective dielectric constant which means the capacitive effect will increase.This change in effective dielectric constant is translated into changes in the transmittance and reflectance.

The real part ϵ' is more for fresh leaf and becomes lesser as the leaf dries.The component and metallization dependent changes in ϵ'' were obtained.

IV. Conclusion

The overlay technique can be very useful technique for studying leafy vegetation. The values of ϵ' and ϵ'' are different for different components. Also it changes due to orientation of leaf. For this study the leaf was plucked and a portion of it was cut and used for measurement.It is felt that if the whole leaf is used as overlay and if different parts of the leaf studied, better information about the dielectric properties of the leaves could have. This would lead to a better understanding of the plant water relation. The microstriplines and λ/2 rejection filtes have been proved very useful for sensing moisture status of the leaves.

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