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ANALYSIS OF SAND DIELECTRIC PROPERTIES FOR MICROWAVE COMMUNICATION APPLICATION

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***Abstract* -** This paper presents the analysis of sand dielectric properties for microwave communication application such asantennaandmicrowaveabsorber.Theexistingmaterialtobeusedfor communicationapplicationisexpensiveandcontainsalot of chemical in it. So, to overcome this problem, the sand material is studied in the range between 1 GHz until 3 GHz. The sand material was mixed with the resin namely Epoxy Der 331 and the hardener agent, Polyamine Clear Hardener. Then, the measurement of dielectric properties is measured by using open ended coaxial probe technique.

Keywords - Sand, Dielectric Properties, Microwave Communication Application.

I. Introduction

Sand is defined as a loose material that consists of rocks or mineral grain. It is composed of silica, carbon carbonate, and other materials. Sand composites has the potential to be used as a substrate material to replace the conventional substrate. Sand also capable to be used as a resonant material for dielectric resonator antenna application since the conventional resonant material contains a lot of chemical [1]. From the analysis of resultsshowninpaper[2]and[3],it showsthatsandcomposites contain silicon material. Silicon material is used to enhance the performance of dielectric properties materials. Table 1 shows the chemical composition of sandsamples.

Table I. Chemical Composition of Sand Samples [2]

Constituent	Chelford (%)	Warri River Sand (%)	Ethiope River Sand (%)	Ughelli River Sand (%)	Lagos Bar Beach Sand (%)
SiO_2	97.91	96.18	98.12	97.01	53.16
Al_2O_3	1.13	2.76	0.91	1.96	19.40
Fe_2O_3	0.50	0.06	0.16	0.13	4.70
CaO	-	-	-	-	2.66
MgO	-	-	-	-	2.08
K_2O	0.25	-	-	-	-
Loss on ignitation	0.21	1.00	0.72	0.90	18.0
Total	100.00	100.00	100.00	100.00	100.00

Dielectric properties measurement is a chemical properties and physical properties characterization related to the storage and loss of energy in various type of material [4] –[7].Toanalyze the sand material, the dielectric properties are represented by the relative complex permittivity, ε_r (equation 1) [4]

$$=\varepsilon' - j\varepsilon'' (1)$$

Where ε' is the dielectric constant which describes the ability of the material to store energy. While ε" is the dielectric loss factor, which reflects the ability of a material to dissipate the electric field energy.

Dielectric constant also known as permittivity in definition, is a quantity that measure the ability of a substance to store electrical energy in an electric field [4,6,8]. Equation 2 shows the formula for dielectric constant.

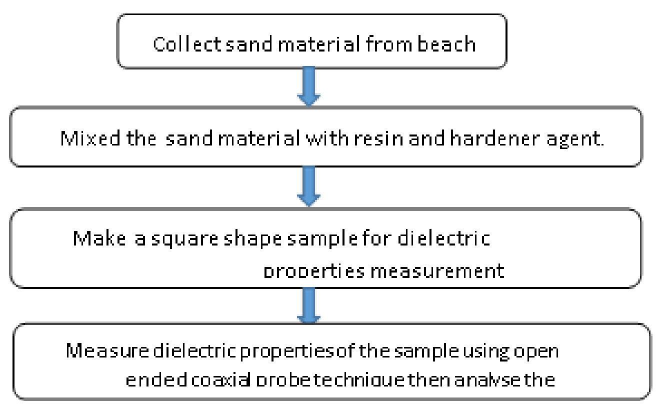

Fig.1. Flow chart of project

Fig.1 above shows the flow chart of project for this paper. Firstly, the sand material is collected from the Bukit Keluang beach, Terengganu, Malaysia. Fig. 2. Show the image of sand. Then, the sand is filtered by using sieving technique to separate

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$K = ^{\varepsilon} = \varepsilon = \varepsilon' - j\varepsilon''(2)$

Sand particles of different sizes. The small sifter device is used

$\varepsilon_O \quad r \qquad r \quad r$

Where;

K= dielectric constant εr= relative permittivity ε= absolute permittivity

ε0= free space of permittivity interaction of a material in the presence of an external electric field.

Loss tangent is a criterion of a dielectric material that quantifies its inherent dissipation of electromagnetic energy [7].

In this technique to get the sand powder. Fig.3 shows the sieving technique used. This is to make sure that the sand can easily stick together with the chemicalused.

$\tan\delta = \frac{\varepsilon'}{}\varepsilon''(3)$

Fig. 2. Image of sand.

Equation 3 shows the equation of loss tangent, tan δ. The relative loss of a material is the ratio of the energy lost (ε"r) to the energy stored (ε'r).

II. Methodology

This project is classified into 4 phases consisting collecting, mixing, sampling, and analysing.

Fig. 3. Sieving technique

Then, the sand powder is mixed with the resin namely Epoxy Der 331 as a glue agent for bonding the material and Polyamine Clear Hardeneractedas the hardener agent. The mixture is then stirred for about 3 to 5 minutes to avoid air gap. Fig. 4. Shows the steps of mixture process.

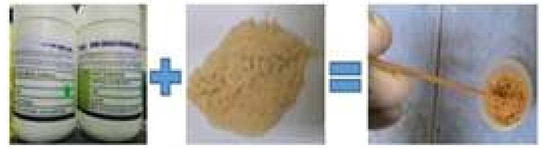

Fig. 4. Step of mixture process

After that, the mixture will be placed into a square mold with size length = 41mm, wide = 27mm, and the thickness is 3mm. The mixture will be left into the square mould for 2 or 3 days in order to ensure the mixture become hardened. Fig. 5. Shows the square mold of sand.

Fig. 5. Square mold of sand

Fig. 6. Shows the sample of sand after taken out from the square mold. Then, the dielectric properties of the sand sample are measured by using open ended coaxial probe technique. The measurement is taken at two points which is point A and point

B. This technique used Agilent Technologies 85070 measurement software. Before measuring the dielectric properties of the sand sample, calibration is needed to avoid the error occurred during the measurement. Fig. 7. Shows the image of open ended coaxial probe technique.

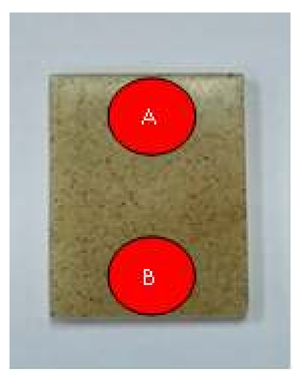

Fig. 6. Sample of sand

Fig. 7. Open ended coaxial probe technique

III. Results and Discussion

Permittivity or dielectric constant and loss tangent results are obtained from the dielectric propertiesmeasurement by using open ended coaxial probe technique. The network analyzer covers the frequency from 1 GHz until 3 GHz. Before the measurement, the calibrations are taken a few times to get the best results of dielectric constant and loss tangent. The value of dielectric constant of air measured at the first place for 3 times with dielectric constant ε_r= 0.999 as the average reading to avoiderror.

Table 2 represents the table dielectric constant of sand sample for 1-3GHz at two point. Point A shows higher results compared with point B. Hence, the results at point A is more suitable to be used for antenna application. The overall results indicate that the higher the frequency, the higher the dielectric constant reading. This results are acceptable for antenna application due to the high reading of dielectric constant.

Table II. Dielectric constant of sand sample

Frequency (GHz)	Dielectric Constant	
	Point A	Point B
1.0	5.11	4.64
1.5	4.96	4.50
2.0	4.95	4.47
2.5	4.90	4.45
3.0	4.87	4.41

Table3shows the results of loss tangent of sand sample taken at two point. Point A and B shows the same results of loss tangent. The overall results show that the higher the frequency, the higher the results of loss tangent. At frequency 1 GHz, the results show the lowest loss tangent compared with frequency at 3 GHz. The lowest result of loss tangent is the best result to be used for antenna application while the highest result of loss tangent is suitable to be used for microwaveabsorber.

Table III. Loss tangent of sand sample

Frequency (GHz)	Loss tangent	
	Point A	Point B
1.0	0.02	0.02
1.5	0.04	0.04
2.0	0.06	0.06
2.5	0.07	0.07
3.0	0.08	0.08

IV. Conclusion

The investigation shows that the different point will give the different performance of dielectric constant while loss tangent come out with the same results. Besides that, the high reading of dielectric constant is suitable for antenna application while the high reading of loss tangent is acceptable for microwave absorber application. The cost of the microwave absorber and other microwave communication application can be reduced by using sand as the main materials. Lastly, the main material for the commercial antenna and absorbers are not environmental friendly due to the usage of chemical materials. Therefore, the usage of sand material is introduced to replace the conventional material to avoid the use of harmful chemicals and at the same time support the campaign of green technology.

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