Studies on Permittivity and Moisture Content of Sunflower Seeds Using Microstrip Equilateral Triangle Patch Antenna

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Abstract

This paper reports the Ku band (13-18GHz) response of thick film equilateral triangle microstrip patch antenna to moisture laden sunflower (*Helianthus Annuus*) seeds using overlay technique. From the frequency response the moisture dependent microwave permittivity has been reported. The thick film patch antenna is sensitive even to ~ 4.25% moisture content in the overlay material. The actual moisture content and predicted moisture content match indicating that this technique can be used for even moisture sensing at low moisture levels. Key words : Thick film patch antenna, Ku band, Frequency response, dielectric constant, moisture content

I. Introduction

Sunflower seeds (*Helianthus Annuus*) are very useful oilseeds for human consumption. The protein, oil, fibre and moisture contents in these seeds affect their usefulness and self life. A small change in the seed moisture content has a large effect on the storage life of the seeds. Grain permittivity and moisture measurements have become a necessity because of highly automated industrial processes and the growing need for real time decision making.

The radio frequency dielectric method measures moisture content in the seed by sensing the dielectric constant of the seed. The dielectric constant being a measure of a material's ability to store electrical energy when placed in an electric field, the water (H_2O) because of its molecular structure has very high dielectric constant (~ 60) in the microwave region. The other constituents of the seed is protein, oil, starch etc has a dielectric constant between ~ 2-5 [1]. This wide difference in the dielectric constants between water and seed constituents makes the RF dielectric moisture measurement quite insensitive to the seed composition. The moisture distribution within the seed influences the microwave measurements significantly.

Miniaturised antennas are a very important component for space and remote sensing applications. The overlay technique [2-5] is a very cost effective technique for characterisation of materials in any form or size. For biomaterials like seeds which vary from sample to sample, this technique is very useful for dielectric characterization and moisture content determination. A single seed is sufficient for this purpose.

The in touch overlay technique on Ag thick film microstrip equilateral triangular patch antenna was used for the studies. The effect of changes in the moisture content in the sunflower seeds on the various properties of the patch antenna is reported. The changes have been used to predict the permittivity and moisture content.

II. Experimental

The Ag thick film equilateral triangular microstrip patch antenna with the microstrip feedline was fabricated using screen printing technology on 96% alumina substrate. The antenna had a resonance at 17.5 GHz with a peak intensity of ~ 37 % and band width of 130 MHz. The Q of the antenna was 134.6. The frequency response of the microstrip patch antenna is given in fig 1.The detailed experimental procedure is given elsewhere [6]. The investigations were done for fresh seeds, fully soaked for 24hrs and dried naturally upto 96 hrs. The fresh sunflower seed had a moisture content of ~5.54 % and fully soaked ~ 34.78 %. The dried seed after 96 Hrs had a moisture content of ~ 4.25 %. The moisture content was measured gravimetrically.

III. Results and Discussion

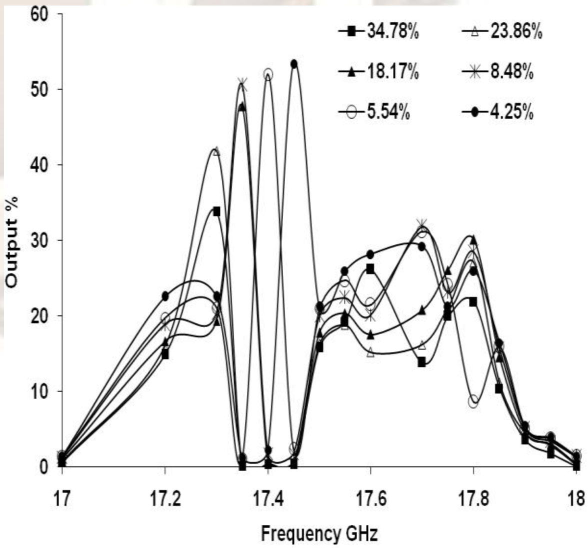

Fig. 1. The frequency response of the microstrip patch antenna

The effect of sunflower seed overlay of different moisture content is given in fig 2. From the figure it is seen that there is a shift in the resonance peak towards lower frequency due to the overlay. As moisture content in the seed increases the peak shifts further with decrease in peak amplitude. In the figure 0% moisture content indicates antenna without overlay.

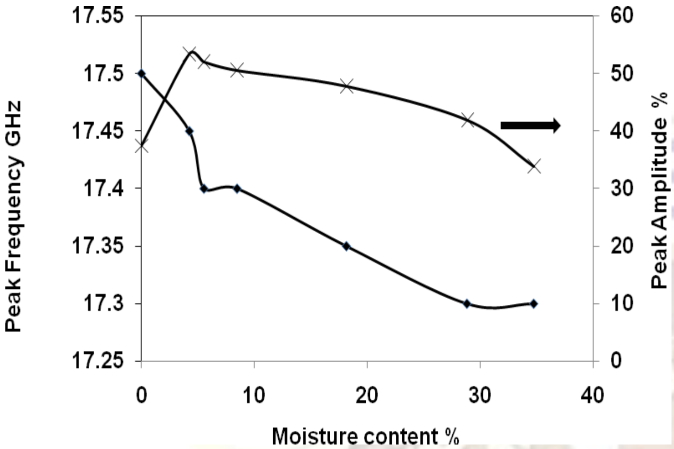

Fig. 2. Effect of moisture content

The shifts in the resonance frequency and reflectance data has been used to calculate [7] the moisture dependent permittivity of the sun flower seed. Fig 3 shows the variation of the dielectric constant (ε') and dielectric loss (ε") of the sun flower seed as a function of moisture content. The dielectric constant and dielectric loss are in the range expected for these oil seeds. By using resonance frequency (f_r), of the equilateral triangular microstrip patch antenna the moisture content of sunflower seeds can be predicted. From figure 2 it is seen that as moisture content increases resonance frequency decreases.

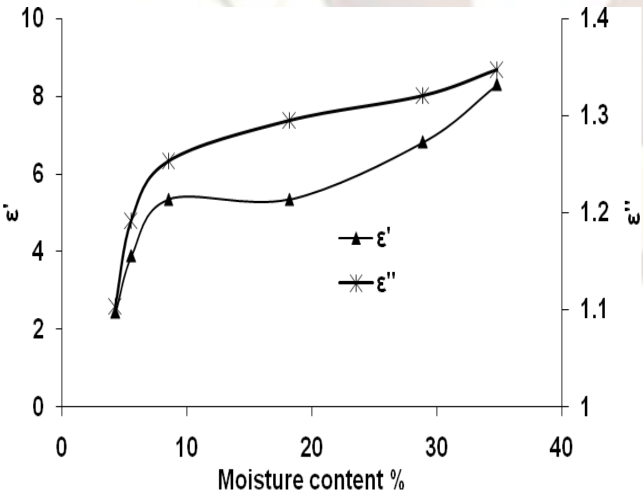

Fig. 3 Permittivity of sunflower seed as a function of moisture content

For moisture content prediction, compensation has to be done for the density effects. A calibration equation [6] has to be used to provide single moisture content for a particular frequency. The best linear fitting equation for resonance frequency fr = 17.45- 0.004M has been used. Here fr is in GHz. The slope of linear fit gives the sensitivity of the sensor. The linear fitted frequency variation and the predicted moisture versus actual moisture content is shown in fig 4. From the figure it is seen that the experimental points match with the straight line passing through the origin indicating that these measurements can be used to predict moisture content in seeds.

The fringing fields between the edges of the patch conductor and the ground plane. Patch antenna in the presence of a lossy medium like moisture laden biomaterials consume much power due to the ohmic losses in the near zone of the antenna. The overlay being kept in-touch, the near zone effects can be a dominant phenomenon. The dielectric constants are in the range obtained by other method indicating that the overlay method can be used to characterize biomaterials like oilseeds which have a mixture of various dielectric inclusions.

In the Ku-band and beyond water dominates the dielectric properties of the seeds. The relative permittivity of pure water is ~60at 15GHz.

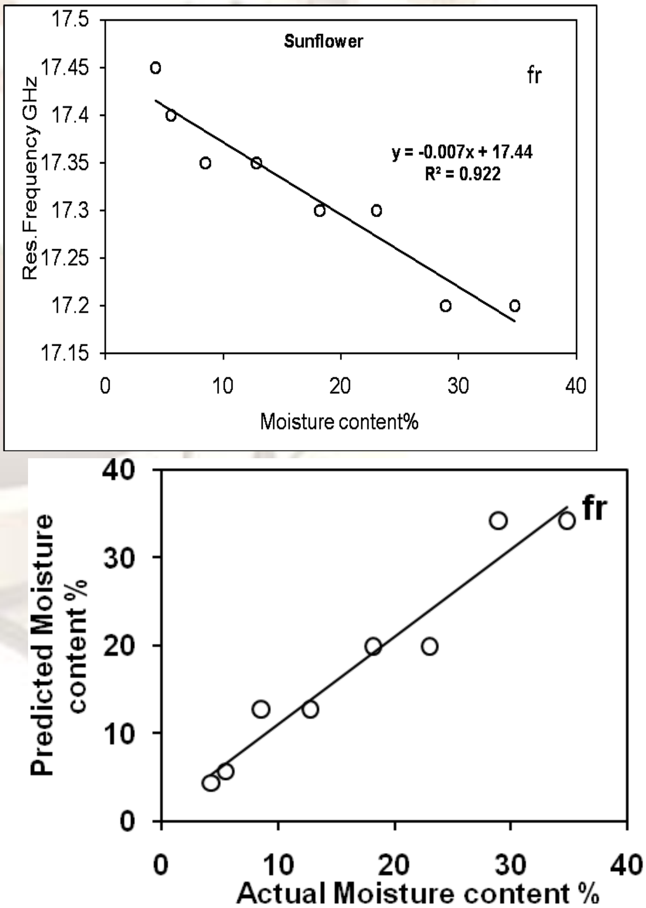

Fig. 4. The linear fitted frequency variation and the predicted moisture versus actual moisture content

Such high dielectric constant material placed over the antenna is bound to cause changes in the characteristics of the antenna. Radiation from a microstrip antenna mainly occurs from the

IV. Conclusions

Ag thick film equilateral triangle microstrip patch antenna has been used to predict the permittivity and moisture content of moisture laden sunflower seeds. This can be a cost effective miniaturized non destructive sensor for measuring dielectric constant and moisture content in individual seed that is easy to use. The permittivity of sunflower seeds increases with increase in moisture. The graph of actual moisture content and predicted moisture content showing straight line indicates that these types of overlay on patch antenna can be used for sensing moisture especially for biomaterials, since any size and shape of the overlay can be used.

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