AN TERAHERTZ SENSOR USING METAMATERIAL ABSORBER FOR METHANOL SENSING

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This paper presents a chemical sensor using a metamaterial absorber, which consisted of an Au Bottom layer, a FR4 substrate and a double-split-square-resonator (DSSR).The resonance generated by DSSR, which is extraordinarily sensitive to changes of the effective dielectric constant around the capacitive gap. The proposed sensor shows a great sensitivity and a high value of Q by a creative periodic DSSR structure and the Au Bottom layer. In addition, the relationship between the absorption frequency and chemical concentration is demonstrated by simulation.

As is known to us, chemicals in liquid phase have been used in a lot of industrial applications. At the same time, they are much frequently used in laboratory so that we are exposed in such a situations, in which we may be hurt. Because we know that some chemicals in liquid phase we used in the experiments are poisonous. They will influence our healthy terribly. We must think of ways to detect these liquid chemicals accurately to identify and label them.

Chemical sensors based on DSSR are very common, which have been studied by many groups, Yuan Y works at Dual-band planar electric metamaterial in the terahertz regime at Opt, express [1]. Our method differs from that of group Pan [2] in the structural design and of group Yoo [3] in the working principles.

The sensor based metamaterial selectively absorbs incident wave by the periodic resonant unit which can be regarded equivalently as periodic structures of electric LC (ELC) resonators, such as split-square-resonators (SSRs). The resonance frequencies of metamaterial resonator structures are very sensitive to variations in capacitive and inductive effects because their fundamental resonance response can be modeled by an LC resonant circuit. This characteristic makes metamaterial absorbers suitable for metamaterial sensor applications. When the solution to be tested is smeared on the surface of the detected area, the resonant frequencies of the sensor will shift. So we can accurately detect the chemical concentration.

The proposed sensor(the thickness of the substrate is 0.5, the sickness of solution is 0.005, unit:mm) is shown in Fig.1,which consists of a Au Bottom layer, a FR4 substrate and a double-split-square-resonator (DSSR), as shown in Fig.2 (a), the 3-dimension of the structure of the unit is shown in Fig.2(b),the thickness of the substrate is 0.5The finite element simulation is realized by Ansoft HFSS, and the simulation result is shown in Fig. 3. It shows the electrical field distribution on the surface of the sensor smeared with different concentration of methanol.

The experimental setup is outlined in Fig.5.The simulation result is shown in Fig. 4, when the concentration of methanol is changed from 40%--80%, the resonant frequency shifts from 564.6Ghz--578.4GHz. And we can also see that the linearity of the sensor is very good. So we can detect the concentration of the methanol which varies from 40%--80% accurately.

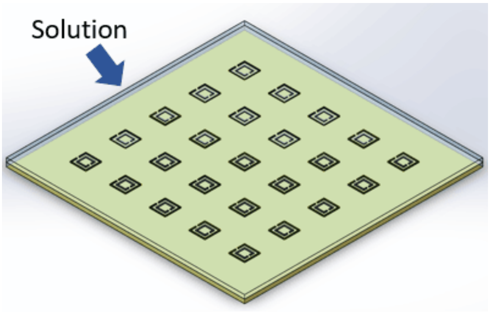

Fig.1: the periodic structure of sensor with the solution smeared on the surface.

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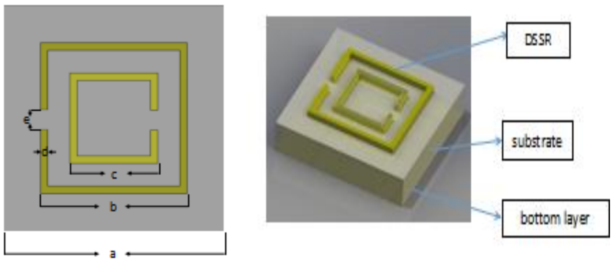
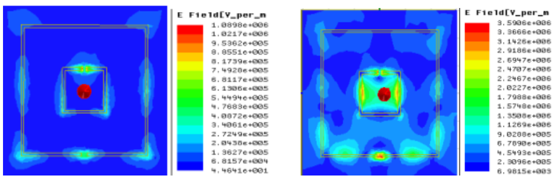


(a) (b)

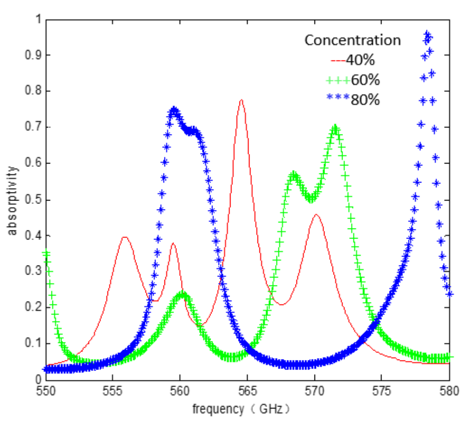
Fig.2: (a) the size of the unit, DSSR dimension: a=0.3, b=0.23, c=0.08, d=0.01, e=0.01. (unit:mm) (b)3-dimensional view.



(a) (b)

Figure 3: (a) E-field distribution (empty state), and (b)E-field distribution(methanol 40%),both at the frequency of 564.6GHz.

(a)



(b)

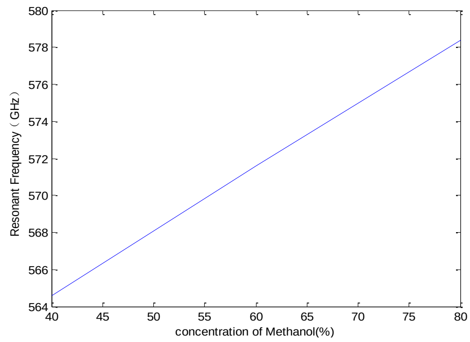


Fig.4: (a) simulation absorptivity and (b) resonant frequency for methanol with different concentration 40%--80%.

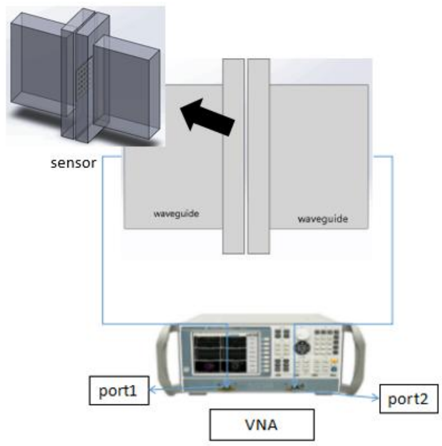


Fig.5:measurement environment using the rectangular waveguides.

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