CAPACITIVE SENSITIVE ELEMENTS WITH FERROFLUID FOR SENSOR OF MAGNETIC FIELD

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Ferrofluids or magnetic fluids are colloidal suspensions of magnetic particles stably dispersed in a carrier liquid. Such fluids are able to interact with the magnetic field. The properties of the magnetic fluid are determined by the size of magnetic particles, their properties, surface-active substance and carrier liquid. Generally, the magnetic fluid consists of 10 nm magnetic particles. These particles are coated with a surface-active substance and the liquid carrier can be polar or nonpolar [1].

Magnitude magnetic susceptibility of the magnetic fluid increases with the size of magnetic particles and their concentration. However, as the particle size increases, the sedimentation stability due to adhesion particles is violated because they have big magnetic moments.

The magnetization of the magnetic fluid depends on the volume concentration of the magnetic particles, the magnetic moment of the particles, the applied magnetic field and the energy of thermal motion [2].

The aim of this work is the possibility of creation of capacitive sensitive elements with ferrofluid for the magnetic field sensor. These sensors have to be simple in construction and of low cost.

The first model of the sensitive element for the magnetic field sensor is a glass-ceramic plate with the structure on the surface (capacitor). The capacitor is made of gold (Fig.1).

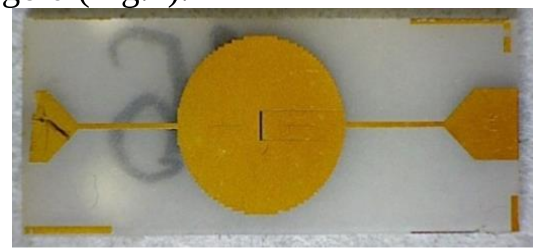

Fig. 1. Capacitor on a glass-ceramic plate

The thickness of the glass-ceramic plate h = 470 μm. The thickness sputtering h_{spu}= 6.21 μm.

A drop of the magnetic fluid is placed between the electrodes of the condenser. The magnetic fluid consists of a polimetilfenilsiloksan (PFMS-4) with 100 nm particles of nano-iron. However, the surface-active substance was not used, because the measurement was conducted within a couple of minutes, therefore, the magnetic fluid can be considered as a stable system and sedimentation of particles can be neglected.

To measure the capacity of this condenser under the influence of an external magnetic field from the percentage content of iron particles in the magnetic fluid, four samples of magnetic liquid with a concentration of magnetic powder of 10%, 20%, 30% and 40% were prepared. The magnetic field was created by a permanent magnet with a diameter of 17.48 mm and a thickness of 1.61 mm. This magnet was brought to the condenser at a distance of 25 mm. The magnetic induction of the magnet at a distance of 25 mm was measured ith the microteslameter MT-10 and was equal to 150 μT.

The capacity change of the sensitive elements with different concentration of the particles in the magnetic fluid under effect magnetic field was measured by digital L, C, R meter type E7-12 with an adapter to reduce the influence of parasitic parameters at the frequency of the measuring signal of 1 MHz.

The experimental results showed that with increase of the concentration of particles in the magnetic fluid, the changes in the capacity (ΔC) increase.

$$\Delta C = \frac{C(H) - C(0)}{C(0)};(1)$$

where ΔC is the relative change of the capacity, C(H) is the value of the capacitor with the magnetic fluid by effect magnetic field, C(0) – value of capacitor with magnetic fluid not affected by the magnetic field.

Table 1 presents the relative change of the capacity depending on the concentration of magnetic particles in the liquid carrier under the effect of the magnetic field.

Table 1. The relative change of the capacity from the concentration of magnetic particles

Concentration, %	10	20	30	40
ΔC, %	1	1.4	5	15.3

A transistor case without a crystal was used as the second sample for comparison with the plate condenser (Fig. 2).

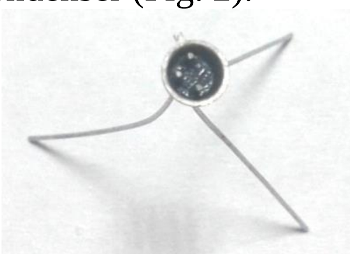

Fig. 2. Transistor case without a crystal

The magnetic fluid with a concentration of magnetic powder of 10% and 40 % was introduced in the transistor case. Table 2 shows the relative change of the capacity depending on the concentration of magnetic particles in a liquid carrier under the effect of the magnetic field.

Table 2. The relative change of the capacity from the concentration of magnetic particles

Magnetic field	H = 0	H>>0	H = 0	H >> 0
Concentration of magnetic particles	C_{Fe}= 10%	C_{Fe}= 10%	C_{Fe}= 40%	C_{Fe}= 40%
Measurement 1, pF	0.217	0.199	0.392	0.385
Measurement 2, pF	0.214	0.205	0.396	0.386
Measurement 3, pF	0.217	0.200	0.397	0.386
Measurement 4, pF	0.216	0.199	0.398	0.386
Measurement 5, pF	0.218	0.201	0.401	0.384
Mean value, pF	0.216	0.200	0.397	0.381
ΔC, %	7.4		4	

In this experiment, the change in capacity is less than that for the glass-ceramic plate.

The third sample for comparison with the plate condenser was a glass capillary with an interior diameter of 0.7 mm and the distance between electrodes of 3 mm.

The magnetic fluid was placed in the glass capillary. The concentration of the magnetic powder was 40 %. Table 3 presents the relative change of the capacity depending on the concentration of the magnetic particles in the liquid carrier under the effect of the magnetic field.

Table 3. Relative change of the capacity depending on the concentration of magnetic particles

Magnetic field	H = 0	H >> 0
Measurement 1, pF	0.329	0.226
Measurement 2, pF	0.328	0.280
Measurement 3, pF	0.331	0.260
Measurement 5, pF	0.343	0.260
Measurement 6, pF	0.341	0.230
Mean value, pF	0.334	0.251
ΔC, %	24.8	

The experiment apparently shows that sensitivity of the glass capillary is higher than that in the first and second cases.

Under the influence of the magnetic field on the capacitive sensor element with the magnetic fluid, the particles aggregate in chain aggregates due to interaction of the magnetic moments [3]. In this way, the presence of the magnetic moments leads to their orientation along the magnetic field vector. Such structure formation leads to the change of the electrical properties of ferromagnetic fluids, including changes in dielectric permeability. As is known, the capacity of any condenser depends on the dielectric permeability of the medium between the plates [4]. As a result, the capacity of the condenser with a ferromagnetic fluid changes. This change is due to changes of the dielectric permeability of the ferromagnetic fluid under the effect of the magnetic field.

According to the results of the experimental study we can draw a conclusion that capacitive cells with ferromagnetic fluid are responsive to an external magnetic field due to orientation of magnetic particles and their interaction. We plan to use a different particle size and properties in order to increase the sensitivity of the capacity elements for a magnetic field sensor.

References

1.Bloom E. Y, Mayorov M. M., Cebers A. O, Magnitnie zhidkosti. - Riga: Zinatne, 1989. -386 pp (in Russ.)

2.Gubin S. P., Koksharov Y. A., Homutov G. B., Yurkov G. Y. Uspehi himii. 2005. - Vol. 74 (6). - pp. 541-574 (in Russ.)

3.Kantorovich S. S. Cepochnie agregati v polidispersnih magnitnih zhidkostyah.PhD thesis. -Yekaterinburg, 2004. -175 pp. (in Russ.)

ACOUSTIC DEPTH SOUNDER

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Ultrasonic energy is currently widely used for ultrasonic distance measurement. Range finders and all levels of measurement can be performed through ultrasonic technique. Ultrasonic testing is relatively rapid, convenient, simple, and easy to do real-time control. The measurement accuracy meets practical requirements, so a wide range of applications has been developed in the mobile robot.

The presented ultrasonic ranging system designer is mainly controlled by Micro Control Unit (MCU). MCU controls the timer, the ultrasonic transmitting circuit, the display circuit and the temperature probe. The ultrasonic depth finder was designed and tested for different depth, and the error analysis was conducted.

Consider the block scheme shown in Fig. 1.