

Subminiature eddy current transducers for studying semiconductor material

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Abstract. Based on an eddy-current transducer (ECT), a probe has been designed to study the semiconductor material. The structural diagram of the probe is given and the basic technical data are stated (the number of windings is 10–130 turns, and the value of the initial permeability of the core $\mu_{\max} = 500$). Due to the high confinement of the magnetic field, it is possible to acquire data from small areas of semiconductor plates. Response versus ECT positioning diagram is also provided.

1. Introduction

The demand for improvement and development of semiconductor material production technology brings up a concern of efficient quality control. Production of materials for microelectronics requires implementation of high-precision measuring methods and instruments in the industry, adoption of modern nondestructive inspection techniques[1].

Today, diagnostics of semiconductor plates is mainly performed using the 4-point probe technique. This technique has a number of disadvantages. The nondestructive inspection (NDI) using the eddy-current method (ECM) is based on registration of variations in the eddy-current electromagnetic field, which are induced by the exciting coil of eddy-current transducer (ECT) in the electrically conducting unit under inspection. The advantage of electromagnetic inspection is the possibility to perform measurement without a contact between the transducer and the object of measurement. Interaction between them usually takes place at narrow intervals (0.1-2mm). That's why this technique can yield good results, when the unit under inspection is moving.

One more advantage of ECM is the relative simplicity of the transducer's design. Coils are placed into a protective case and then encapsulated in a compound. As a result, they are resistant to mechanical and weather stresses, and they are able to work harsh environments with wide ranges of temperature and pressure.

2. The main part

In general the scheme of the sensor is presented in Fig.1. In this scheme there are actuating (AW) and measuring (MW) windings, placed in the VCT.

A digital signal comes from the virtual generator to the input of the digital analog transformer (DAT) of the sound card and then it is transformed into the analog one. After passing through the power-



amplifier (PA) the analog signal is sent to the actuating winding (AW) of the transformer. While passing through the actuating winding of the VCT, the sinewave signal makes the electromagnetic field, that creates EMF in the measuring winding (MW) of the VCT. The tension is received by the microphone input of the sound card and, after coming through the preamplifier (PA), it goes to the input of the analog digital transformer (ADT) sound card. The analog signal is transformed into the digital one and is sent to the treatment and operation unit of the software. The treatment and control unit fixes the level of the digital signal in conventional units that correspond to the voltage values in the measuring winding[2].

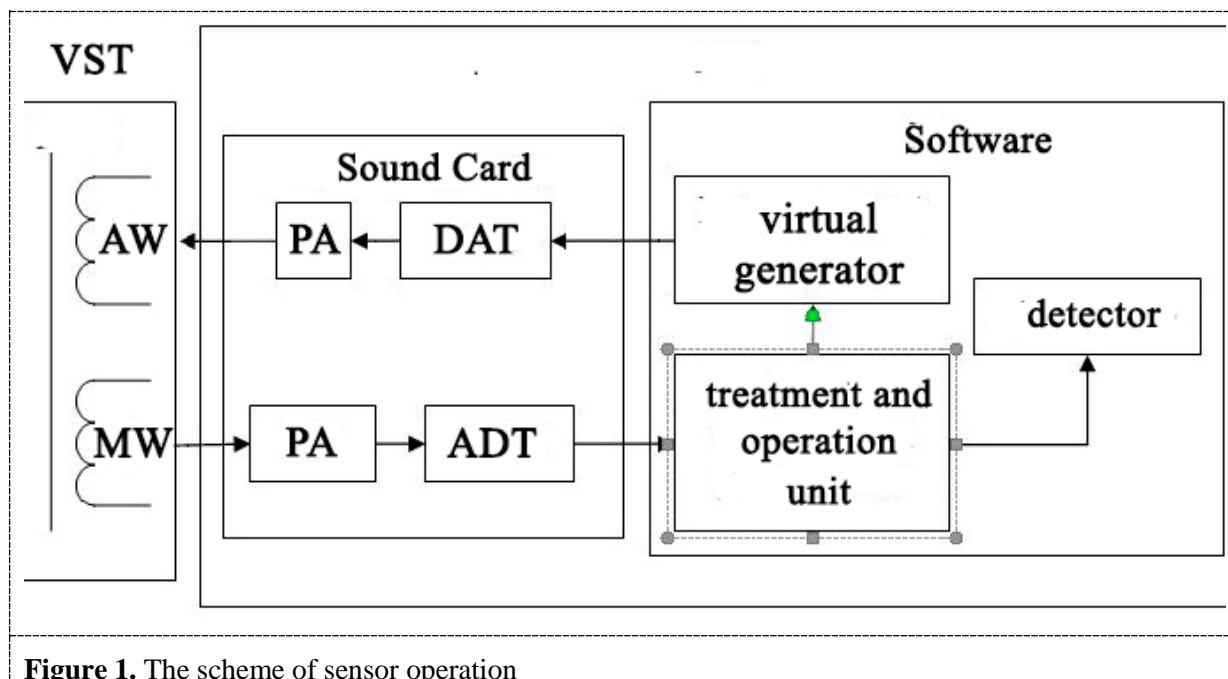


Figure 1. The scheme of sensor operation

This level is accepted as a zero one that corresponds to the voltage level on the measuring winding without the control object. Without the control object the indicator shows zero, it corresponds to the zero value of conductivity.

Along with the considerable price reduction of the device, the virtualization of the generator and signal receiver makes it possible to mark out the frequency range, at which the process of scanning of the control object gets very effective. The effectiveness is reached due to the quick varying of the current frequency, given by the virtual generator to the VCT. Thus, researchers can define the frequency, at which changing the amplitude of the signal on the measuring winding (when it is passing through the imperfect area) is at a maximum. Besides, frequency varying enables us to find the depth of the defect hiding, because the depth of the electromagnetic field distribution of the VCT directly depends on the frequency of the field sent to the actuating winding [3].

The principle of operation of the VCT is based on the alternating magnetic field, localized in the controlled object with the help of the oxide pyramid shaped core. The shape of the core is conditioned with the necessity to localize the magnetic flux from the actuating (generator) coil. The core of this model was made of a midrange metadiscipline ferrite NM3, chosen according to the value of the maximum initial magnetic conductivity 500. The actuating winding of the subminiature transformer consists of 10 winds and its diameter is 0.12-0.13 mm. The measuring winding includes 130 winds and its diameter is 0.05-0.08 mm. The compensation winding is included into the scheme to minimize the influence of the actuating winding on the received signal. The compensation winding is connected

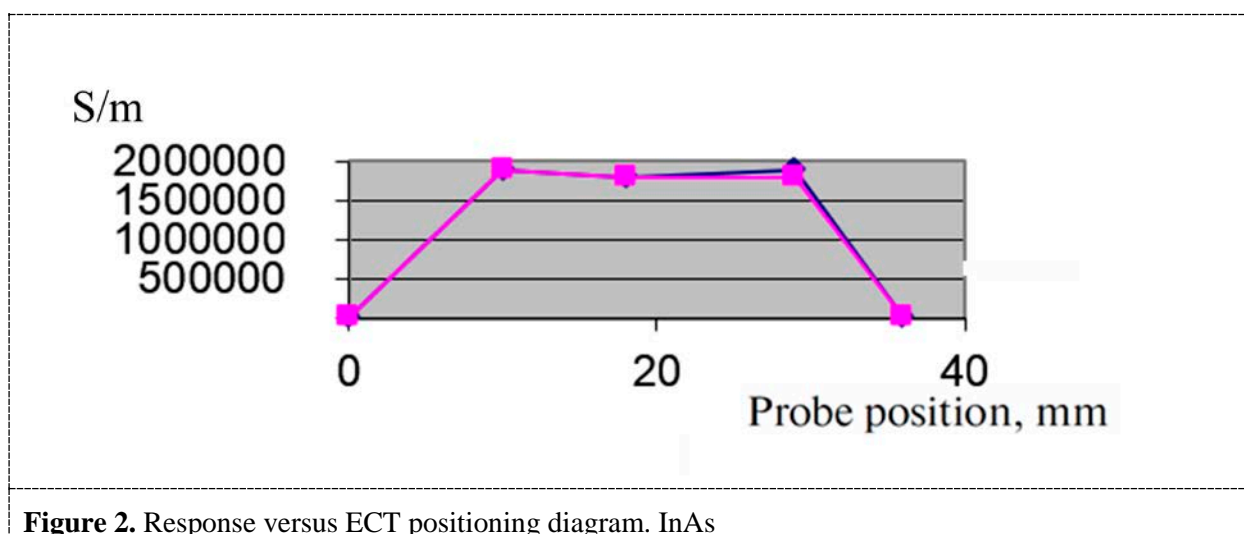
with the measuring winding so that the researcher could subtract the tension of the actuating winding. It consists of 20 winds. A copper wire, that is 0,005 mm thick, is used to reel the winds. The windings are wound round the pyramid shaped core.

The electromagnetic field of the generating winding gives an impulse to eddy currents in the electroconductive controlled object. Eddy current density in the object depends on the geometric and electromagnetic values of the object and on the back-to-back location of the measuring VCT and the object. The magnetic field of the eddy currents is opposed to the primary magnetic field of the generating winding, as a consequence the resulting field depends on the electromagnetic characteristics of the controlled object and on the distance between the VCT and the object, as the distribution of the eddy current density depends on these factors. There is EMF in the measuring winding of the VCT; it serves as a signal, hands over the information about the object into the measuring unit.

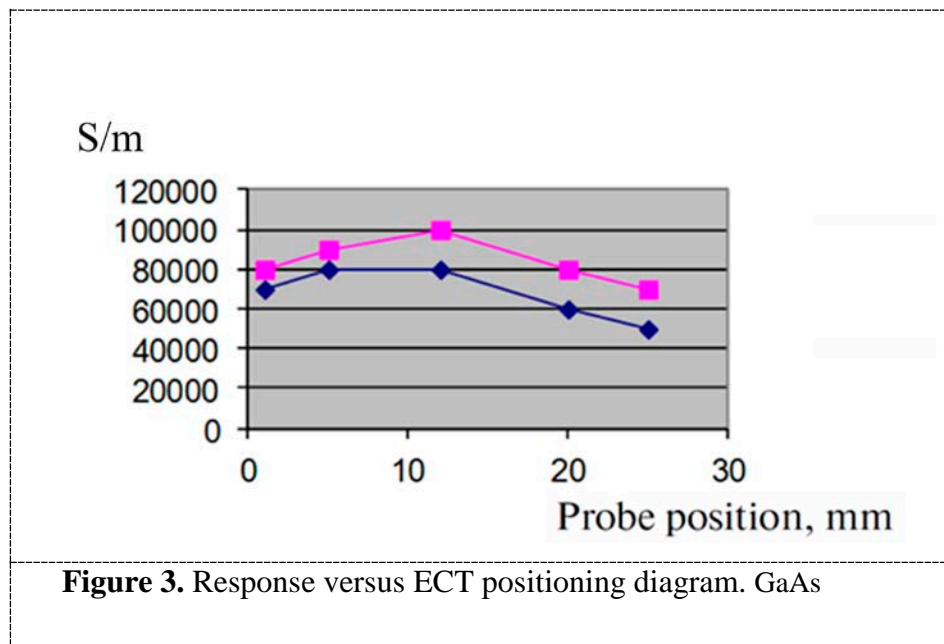
In this case EMF of the measuring winding decreases due to the opposite magnetic field produced by the eddy currents.

3. The results of the experiment and their discussion.

An experimental installation for electromagnetic diagnostics of semiconductor plates through eddy-current method was created at the premises of the Altai State University. Information gathering system in the form of eddy-current probe is the installation's main module. In order to test the device, a series of measurements was performed for electrical conductivity of reference semiconductors with a-priori known conductivity values. Response versus ECT positioning diagram is shown in Fig. 2.



By means of reference semiconductor plates with known values of specific conductivity, the response was plotted against specific conductivity. Gallium-arsenide plate conductivity versus the probe's position above the plate is plotted in Fig. 3.



On the presented diagram, we can note sufficient variations in the conductivity depending on the probe's position above the object. This fact provides the evidence of the semiconductor's structural discontinuity and (consequently) of the low quality.

4. Conclusions.

Semiconductor conductivity measurement results gathered during the research show the potential of the eddy-current method for quality control of semiconductor materials.

Due to the high confinement of the magnetic field, it is possible to acquire data from small areas of semiconductor plates, which allows for the conclusion about semiconductor impurity distribution in small areas. Therefore, this method offers exciting possibilities for evaluation of quality of semiconductor plates.

References

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