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GIANT MAGNETORESISTANCE SENSOR FOR FERRIC CHLORIDE DETECTION USING MAGNETIC DISTURBANCE METHOD

Ahmad Aminudin[1)*], Mitra Djamal[2)], Suprijadi[2)], Daryono Hadi Tjahyono[3)]

[1)] *Physics Study Program, Faculty of Mathematics and Natural Sciences, Bandung Institute of Technology*
[2)] *Department of Physics, Faculty of Mathematics and Natural Sciences, Bandung Institute of Technology*
[3)] *Farmacy School, Bandung Institute of Technology , Ganeca street 10 Bandung 40132*
**aaminudin@upi.edu*

Abstract

We report the results of research relating to measurement of ferric chloride. This measurement system is using magnetic disturbance method. Magnetic field influence solution of ferric chloride. Giant magnetoresistance sensor is used to sense magnetic field of ferric chloride after magnetization. Stage of preparation of the solution ferric chloride with various concentration. Magnetization solution was performed by means of ferric chloride flowing through a magnetic field of 0,5 T. The flow rate can be controlled through the flow controller. Flow Controller can control the flow of 2.5 to 4ml /s. The results of research is shown with relationship between voltage of GMR sensor (V_{GMR}) versus concentration of ferric chloride with V_{GMR} = 0.007 $FeCl_3$ + 0.250 mV/mM, which has a sensitivity of 0.007 mV / mM and zero drift of 0.250 millivolts. The distance between the permanent magnets to the GMR sensor is more than 6 cm to avoid the directly influence of permanent magnetic field.

Key words: *Ferric cloride, GMR Sensor, measurement, Sensitivity*

INTRODUCTION

GMR (Giant Magnetoresistance) is a sensor that works based on the effect of changes very big obstacle when it is in an external magnetic field. GMR sensor has several advantages when compared with other sensors, such as high sensitivity, high temperature stability, low power consumption, size is relatively small, and the price is quite cheap and magnetic properties can be varied within a very wide range[1]. At first GMR reported in the 1980s from the French research group headed by Albert Fert [2]. Results of experiments show GMR material change in resistance in response to an external magnetic field can be seen in Figure 1.

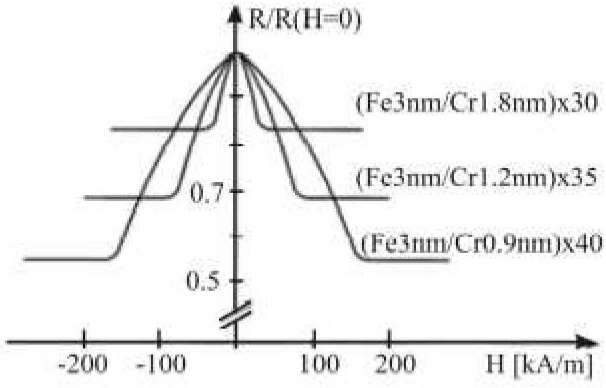

Figure 1. Effect of magnetic field on the change in resistance
(First announced by Baibich et al 1988)

In other experiments revealed GMR resistance value changes with MR is obtained by comparing the change in resistance without magnetic field and the magnetic field with a resistance without a magnetic field, which is defined by [3]:

$$MR = \frac{\Delta R}{R} = \frac{R\ H\ - R(H{=}0)}{R(H{=}0)} = \frac{R\ maks\ - R(min)}{R(min)}$$

GMR sensors can be used to measure the shift, vibration, flow and variety of biosensor applications. GMR sensors can sense weak magnetic field of about 1.5 up to 70 Oe at the level of molecular size[4]. Weak magnetic fields can occur in several molecules. One molecule that is easily magnetized iron. Iron (Fe) is a ferromagnetic material, so easily magnetized. Some iron-containing compounds such Fe_2O_3, Fe_2O_4, $FeCl_2$, $FeCl_3$, hemoglobin and others. This research uses Ferric chloride ($FeCl_3$) as a sample

Iron (III) chloride, or ferric chloride, is a chemical compound that is a commodity industrial scale, with the chemical formula FeCl3. These compounds are commonly used in wastewater treatment, drinking water production as well as a catalyst, both in industry and in the laboratory. The color of the crystal iron (III) chloride depends on the angle of view: from the reflected light it dark green, but of the light beam purple-red it. Iron (III) chloride is deliquescent, frothing at the damp air, due to the emergence of HCl, which is hydrated to form fog. When dissolved in water, iron (III) chloride hydrolysis which is an exothermic reaction (generating heat). This hydrolysis produces brown solution, acid, and corrosive, which is used as a coagulant in wastewater treatment and drinking water production. This solution is also used as an etcher for copper-based metal on a printed circuit board (PCB). Of anhydrous iron (III) chloride is a fairly strong Lewis acid, and is used as a catalyst in organic synthesis. (6) Iron has a strong magnetic properties, when bonded to Cl to form FeCl3, then Ferric chloride will also be influenced by the magnetic properties of the iron. Ferric chloride measurement can be determined by measuring the concentration of Fe. One of the magnetic sensor that can measure weak magnetic fields due to the iron is giant magnetoresistance sensor (GMR). Therefore, through this research I have done testing Ferric Chloride detection using GMR sensors.

RESEARCH METHOD

Materials and instruments required:

1. Ferric Chlorite : 100 gram
2. Aquade : 5 L
3. 250ml measuring cup : 1
4. Glass bottle : 10 bottles
5. Elastic pipe : 2 metre
6. Plastic ruler : 1,5 metre
7. GMR sensors : 2 integrated in bridge circuite
8. Permanent magnets : 2
9. Voltmeter : 1
10. power supply 5Volt DC : 1
11. Flow controller : 1
12. Static board : 1

Experiment Procedure :

The first stage: The test distance GMR sensor response to Disturbance Magnet. This test is used to determine at what distance the sensor can not directly respond to magnetic fields. This test uses permanent magnets, sensors, plastic ruler, power supply and voltmeter as shown in Figure 1. The sensor is placed in the position of 0cm, 0,5cm, 1cm, 2cm, 3cm, 4cm, 5cm and 6cm of the magnet. Input voltage of GMR sensor from 5Vdc the power supply. Output Voltage of GMR sensor is measured using a voltmeter GDM352A Series.

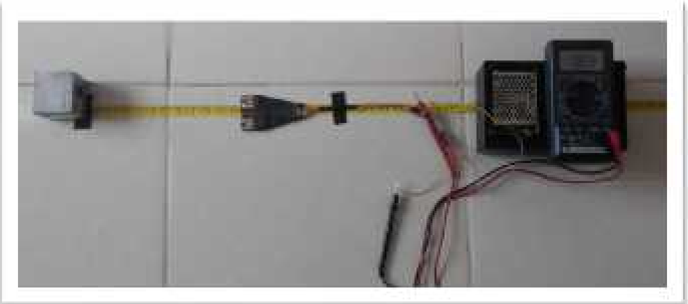

Figure 2. The test distance GMR sensor response to Disturbance Magnet

The next stage : Prepairing of Ferric Chloride samples with concentrations 74,3mM, 148,6mM, 222,9mM, 297,2mM, 371,6mM, 445,9mM, 520,2mM, 594,5mM, 668,8mM and 743,1mM. These samples included in a glass bottle with 250ml of each volume as shown in Figure 3.

Figure 3. Ten Bottles Ferric Chloride Sample

To Realize the intended experiment, the Researchers used a method object interference. In general, the object of measurement mechanism can be seen in Figure 4 the which includes three parts: part a disturbance, the measured object and the sensor. Disturbance interaction with objects produce further changes in measurement parameters sensed by sensors on the measuring instrument.

Figure 4. Mechanism Object Detection

In this study, the disturbance is the magnetic field, the measured object is detected using a solution of $FeCl_3$ and GMR sensors. Ferric chloride solution put in a container with a rather high position of the which then flowed through a hose connected to the container as shown in Figure 5a. The container-shaped tube with a diameter of 10cm and height 15cm. The bottom of the tube is connected via a hose with an inner diameter of 2mm long 150 cm. Containers can put at a height of 40 up to 80 cm. The distance between the permanent magnets of the GMR sensor is approximately 6 to 10cm to avoid the direct influence of the magnetic field of the permanent magnetic field and sensing capabilities (Figure 5b). The flow rate can be controlled through the flow controller. Flow Controller can control the flow of 2.5 to 4ml /s (Figure 5c)

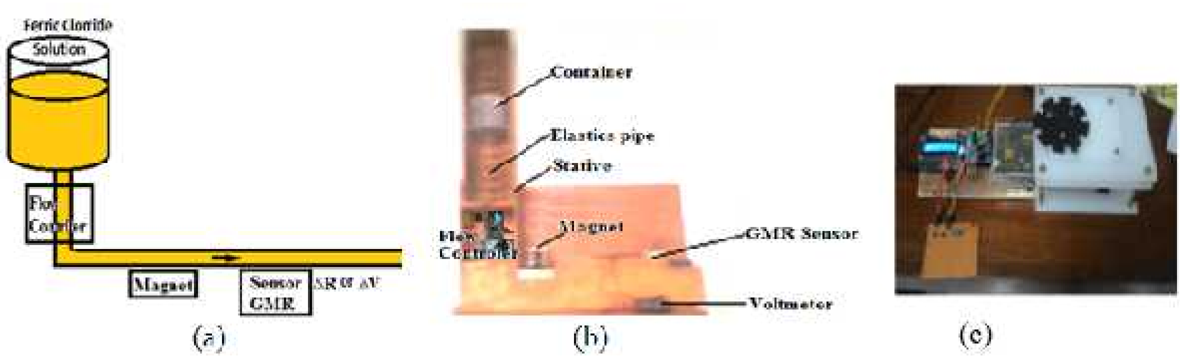

Figure 5. Measurement Ferric chloride using GMR sensors

Ferric chloride solution flowing through the hose run into 3stage: before magnetization stage, the magnetization stage and sensing stage. Flow through the magnetic ferric chloride before having a magnetic moment at random as shown in Figure 6a. When a solution of Ferric chloride are in the permanent magnetic field, change the orientation of the magnetic moment so that the direction (Figure 6b) were then sensed using GMR sensors (Figure 6c).

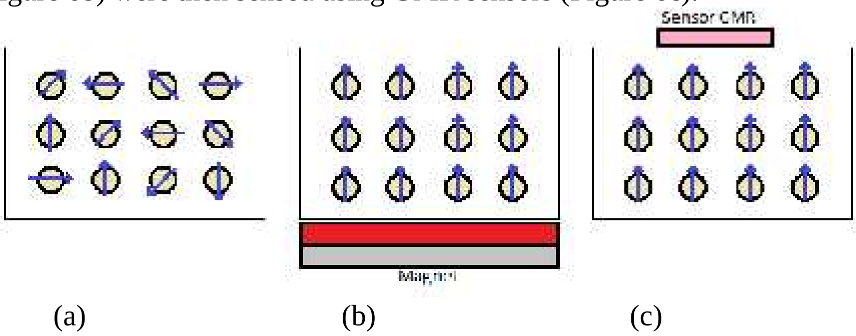

Figure 6. (a) random magnetic moment (b) direction of the magnetic moment (c) sensing the GMR sensor

Iron that bound ferric chloride is one of the ferromagnetic material, therefore iron is easily magnetized. If the ferromagnetic material is in an external magnetic field B, a suitable Hamiltonian is [6]:

$$H = -g\mu_{B_i} \sum_i S_i \cdot (B + B_{mf})$$

The Hamiltonian equation applies to the material's magnetic field B + B_{mf} is external magnetic field and B_{mf} magnetic field is the molecular field acting align the magnetic moment neighbors.

RESULT AND DISCUSSION

Before the permanent magnets used for magnetization ferric chloride solution, testing the reach of the GMR sensor response to the source field. It is necessary to determine the position of the distance between the magnet and the GMR sensor to avoid measurement errors. This test to done by placing GMR sensor position relative to the magnet with a variation distance (r) as shown in figure 7

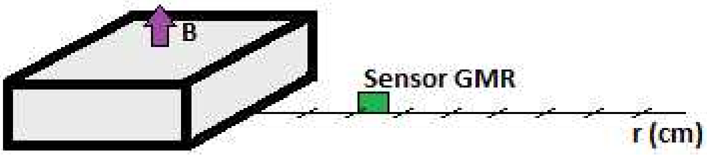

Figure 7. Testing the GMR sensor response to magnetic fields

The results show further away from the source of the magnetic field, then GMR sensor has a smaller value as shown in Figure 6. Based on the graph in Figure 8 at a distance of 6cm GMR sensor voltage value close to 0, this means the direct influence of the magnetic field close to 0. Trend graphs show the more distant position GMR sensor then influence the magnetic field is getting smaller. This is the basis for determining the positioning of the GMR sensor measurements Ferric chloride solution that is in the position of having more than 6cm so GMR sensor sensing only the magnetic field of the flow Ferric chloride.

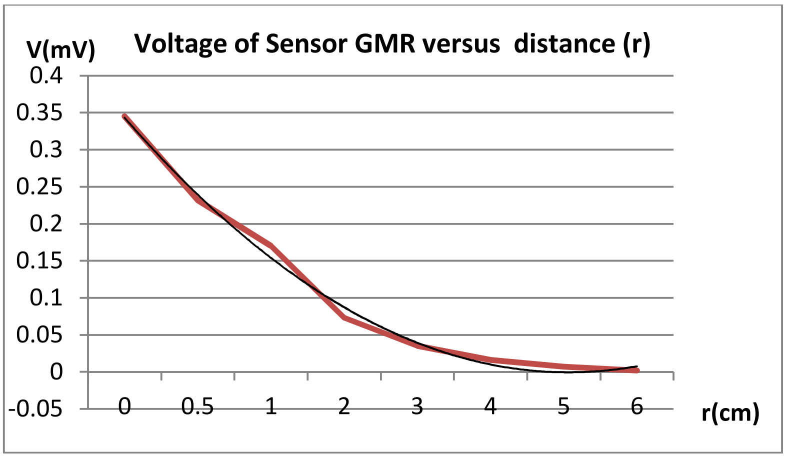

Figure 8. Graph of Voltage of GMR sensor versus the distance

After determining the position of the sensor and then apply it to the detection of the concentration of ferric chloride. Test results GMR sensor response to changes in ferric chloride concentration shown in Figure 9. The graph in Figure 9 shows the linear relationship between the voltage of the GMR sensor Ferric chloride concentration, the higher the concentration of Ferric chloride GMR sensor voltage value greater. GMR sensor voltage relationship of the concentration can be expressed in a linear equation $V = 0.007\ n + 0,250$, where V states GMR sensor voltage in the order of milli volts and n the concentration of ferric chloride in order millimolar. From these equations indicate the sensor has a sensitivity of 0.007 mV / mM with zero drift of 0,250 millivolts.

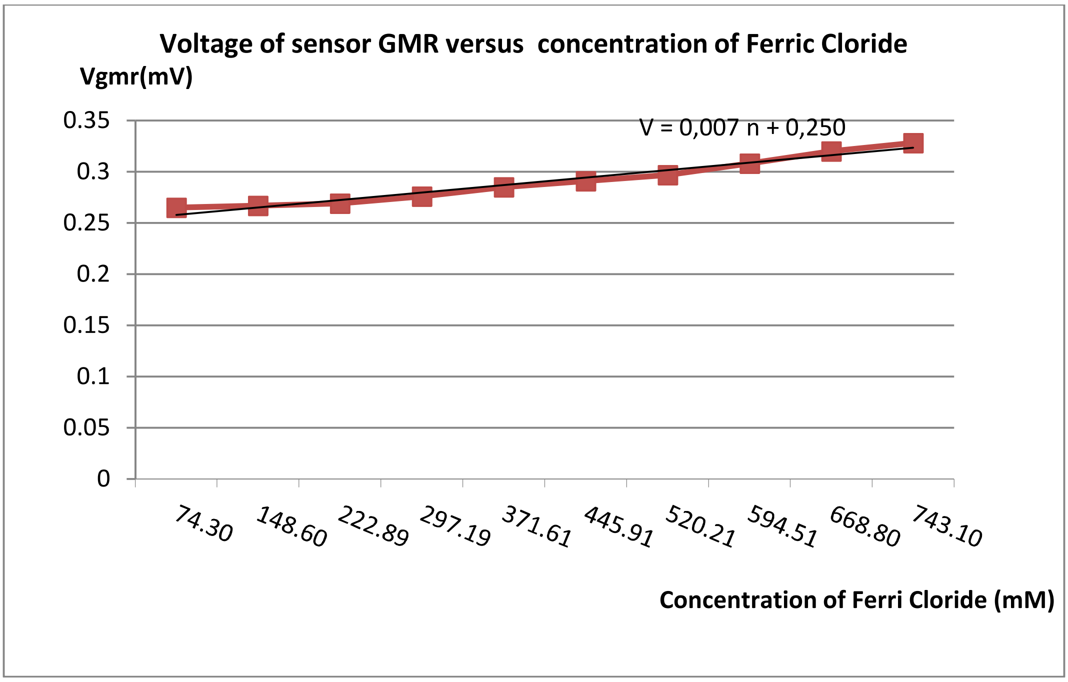

Figure 9 Graph Voltage of GMR sensor versus Ferric chloride concentration

CONCLUSION AND SUGGESTION

This measurement system is using magnetic disturbance method can be measure concentration of solution of ferric cloride. Giant magnetoresistance sensor is used to sense magnetic field of ferric cloride after magnetization. Magnetization solution was performed by means of ferric cloride flowing through a magnetic field of 0,5 T. The flow rate can be controlled through the flow controller. Flow Controller can control the flow of 2.5 to 4ml /s. The results of research is shown with relationship between voltage of GMR sensor (V_{GMR}) versus concentration of ferric chloride with V_{GMR} = 0.007 $FeCl_3$ + 0.250 mV/mM, which has a sensitivity of 0.007 mV / mM and zero drift of 0.250 millivolts. The distance between the permanent magnets to the GMR sensor is more than 6 cm to avoid the directly influence of permanent magnetic field.

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