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INFLUENCE OF HEMATITE AS MICROWAVE ABSORBING MATERIAL ON X-BAND FREQUENCY RANGES

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Abstract

This study has been investigated the effect of hematite as microwave absorbing materials (RAM) on X-Band frequency ranges. Hematite was succesfully processed by coprecipitation method and calcined at 500 °C for 5 hour. It was synthesized from natural iron stones from Tanah Laut, South Kalimantan, Indonesia. The products were characterized by X-ray diffraxtion (XRD), conductivity measurement, Vibrating Sample Magnetometer (VSM), and Vector Network Analyzer (VNA). The result was shown that hematite has conductivity value on $(2.5–3).10^{-7}$ S/cm and be included as dielectric materials. The hysterisis curve was shown that hematite was a super paramagnetic materials. The product was mixed on paint with procentage 10% of total weight and coated on steel grade AH36 with spray methods. Then, the maximum of reflection loss on x – band's frequency range (8,2-12,4) GHz was -7 dB on frequency of 10.5 GHz. It mean that almost 50% electromagnetic energy was absorbed by hematite.

Key words: Hematite, dielectric, super paramagnetic, radar absorbing material

INTRODUCTION

RADAR is a technology that affort to detect the location, altitude, and direction of an object at resting or moving [1]. Detection of RADAR is based on Radar Cross Section (RCS), area on target that reflect electromagnetic waves (EM) [2]. Reflected waves was accepted by receiver and converted into data (location, velocity, and direction) of object. Along with the development of radar technology is also developed a system that can avoid radar detection, called stealth technology.

Stealth technology worked by manipulating the shape of the object so the reflection of waves can't be received by radar and using a material that can absorb and reduce the electromagnetic energy, called RAM. RAM reduces radar waves by mechanism of destructive superposition and impedance matching [3]. Energy absorption was obtained from polarization of electrical charges (dielectric loss), motion of magnetic domains on saturation magnetization (magnetic loss), motion of free electrons, and vibration of atoms. This processing depends from the characteristics of each material [4]. Based on electrical and magnetical properties, materials was divided into magnetic materials, dielectric materials, or dielectric and magnetic materials.

Recently, the RAM has been used ferrite material that has a good magnetical and electrical properties [5]. Magnetite and Barium M-Hexaferrite (BaM) were ferrite material that has been applied as RAM. Both of them has a high reflection loss and means that almost of EM energy has been absorbed by material. Hematite was similar properties with magnetite but it was be acted as weak ferromagnetic at room temperature. So with this reason, hematite should have potencial to apply as RAM materials.

Magnetic nano materials have different properties of magnetic materials commonly where the magnetic nano materials will have a super paramagnetic properties. A material is called as nano magnetic if it has diameter size between on 1-100 nm. Super paramagnetic occurs on single domain of ferromagnetic and ferrimagnetic materials. It will acted as paramagnetic material when an external fields is applied on surrounding. The small size of particle made it becomes very reactive to an external magnetic field but the value of magnetization becomes zero when the field lost.

Indonesia has abundant natural iron stones that have a potency to be applied becomes a magnetic materials as RAM, such as hematite. Iron stones from Tanah Laut, South Kalimantan, have a high iron content about 98% so it can be changed becomes Hematite. This study synthesized hematite from iron stones and done characterization of the products. The goal of this study determined influence of hematite as RAM on X-Band's frequency.

RESEARCH METHOD

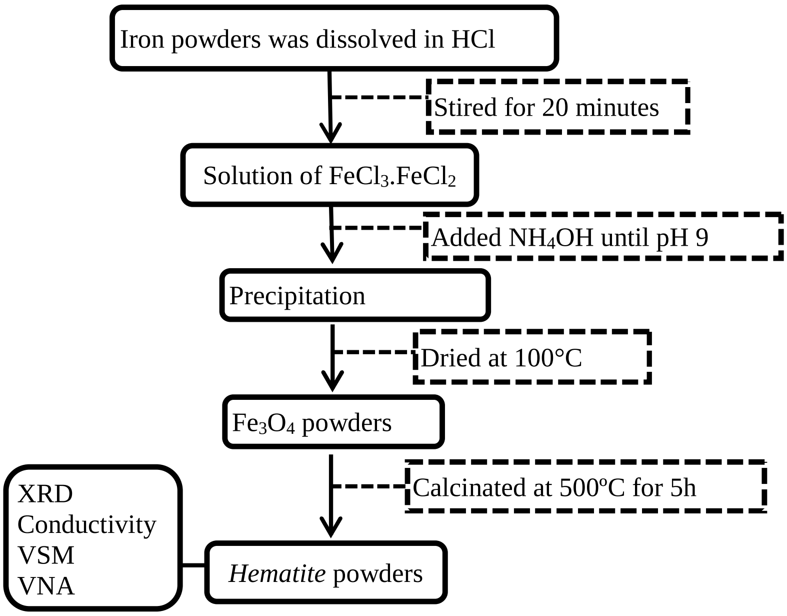

Fig. 1. Flow chart of the process of synthesis of hematite from natural iron stones by co-precipitation methods

This study began an extraction process of natural iron stones to become iron powders. Then, it was cleaned by 96% amount of alcohol using ultrasonic cleaner to remove and reduce impuritas. Synthesis processing was done by co-precipitation method using HCl and NH_4OH solutions. First, iron powder was dissolved in hydrochloric acid solution and was heated to (60±5)°C for 20 min. The ammonium hydroxide solution was then slowly added to the iron (III) chloride solution under constant stirring until pH scale on 9. The final mixed solution was dried to (120±5)°C until turned into a dark powder. To produce the hematite, the dried precursor was calcined at 500°C for 5h. The phase of Hematite was characterized by X-rays Diffraction (XRD X'Pert PRO; CuKα radiation, λ = 1.54060 Å) with a step size 0.017°. The conductivity value was measured by two point probe methods and magnetic measurement was done by Vibrating Sample Magnetometer (OXFORD VSM 1.2H).

Coating process was began by mixed paint and hematite in a weight ratio of 1:9. Mixing process was done by mixer with velocity 800 rpm for 10 min. The final mixed solution was then coated on grade AH36 steel plate using a thinner and the thickness of coating was 3 mm. Microwave absorption on X-band frequency was measured by Vector Network Analyzer (VNA; VNA ADVANTEST type-3770).

RESULT AND DISCUSION

The XRD for hematite powder, indicating only a single, essentially rhombohedral hematite phase, α-Fe_2O_3 is shown in Fig.2 . The index *hkl* based on ICSD no. 201096. The absence of any other impurity phase confirms that Hematite (α-Fe_2O_3) was succesfully synthesized by coprecipation methods. The similar research was also done by Mufid [6], K. Supattarasakda [7], X. Yao [8], Radoslaw Przenioslo[9], etc.

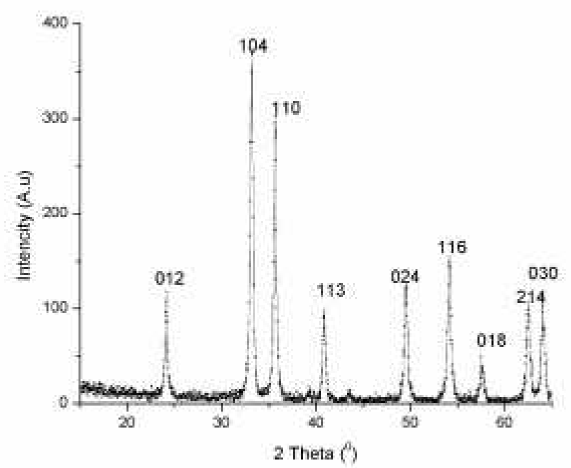

Fig 2. The XRD pattern of Hematite (α-Fe_2O_3)

The electrical conductivity for hematite sample is given in Fig 3. The plot are almost linier in the logaritmic scale indicating that conduction increases with increase in frequency. Based on the results, Hematite is a dielectric material that has electric conductivity between (1-0.35) 10^{-7} S/cm. Electric conductivity in dielectric material depended by charge polarization contribution. The polaron hopping mechanism can also result in electronic polarization contributing to low frequency dispersion [10]. Increasing frequency made localized electric charge carriers and electric conductivity increased.

The magnetization versus applied field was measured by VSM and was given in Fig 4. The saturation magnetization (M_s) and remanent magnetization (M_r) value from hematite were 3.2 emu/g and 1.2 emu/g. The coercivity field showed that it has value approach to zero. It means that hematite is super paramagnetic material. Super paramagnetic occurs at single domain of nano magnetic material, that has a diameter size on 1-100 nm. It will be paramagnetic material when an external magnetic field to be applied. Magnetic dipoles available inside paramagnetic materials rotate with the applied external magnetic field and become aligned with the magnetic field direction.

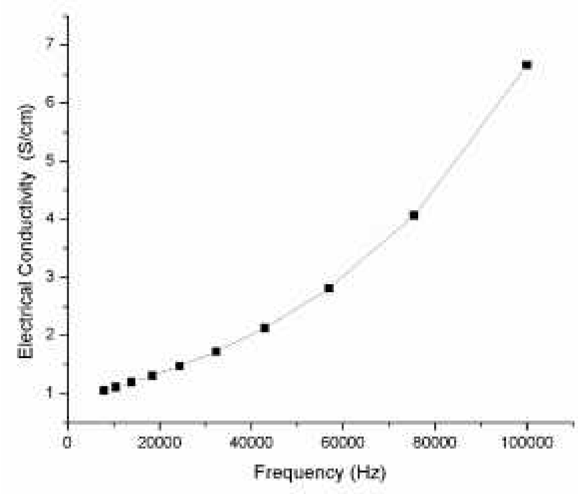

Fig.3 Graph between frequency and electrical conductivity of Hematite (α-Fe_2O_3)

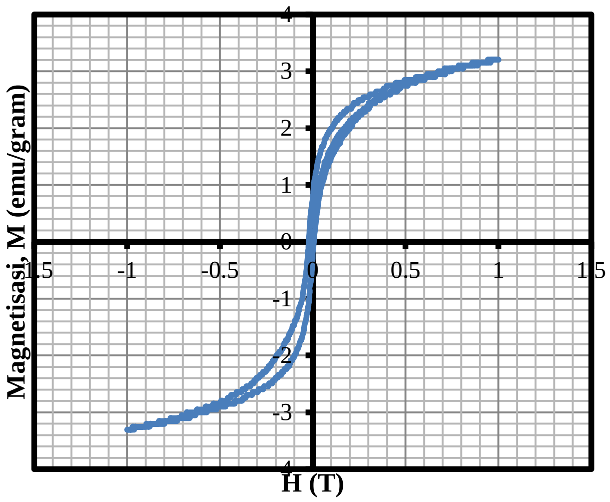

Fig.4 **T**he hysteresis curve of Hematite (α-Fe_2O_3)

Vector Network Analyzer (VNA) was performed to determine the reflection loss of material, in this study used hematite. Fig. 5 indicated that the maximum value of reflection loss by hematite was -7 dB on 10.5 Ghz. The other research determined that fifty percent of electromagnetic energy is absorbed at -3 dB. Then, it means that hematite can absorb more than fifty percent electromagnetic energy.

The absorption mechanism in hematite can be occurred at dielectric and magnetic material. The absorption electromagnetic energy by a dielectric material was done through the mechanism of polarization by the electric dipoles. Due to application of electric field, electric dipoles inside the dielectric material are aligned in the direction of the applied electric field. Electromagnetic energy was be converted to mechanical energy via dipole movement. Time required for electronic displacement was very short when compared to dipole rotation and thermal polarization. The other mechanism may be occurs if between the two dipoles have opposite direction so both of them was reduceeach other. The absorption by magnetic was done through rotation dipole magnetic. When an external magnetic field was applied, the overall dipole moment of the magnet will react according to the characteristics from the material.

Magnetic dipoles in the paramagnetic material will attempt to rectify the direction of the dipole with the external magnetic field.

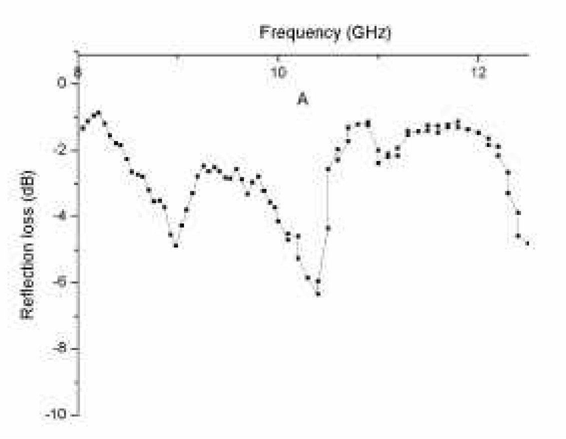

Fig.5 The Reflection Loss of Hematite (α-Fe_2O_3) on X-Band frequency

CONCLUSION AND SUGGESTION

The results of this study can be write down conclusion, that are

1. Iron stones from Tanah Laut, South Kalimantan, Indonesia, can be synthesized into magnetic materials, such as Hematite.
2. Hematite producted at 500°C is dielectric material that has conductivity value (1-0.35) 10^{-8} S/cm.
3. Hematite has super paramagnetic properties with coerciyity value narrow to zero.
4. Hematite can be applied as Radar Absorbing Material (RAM) on X-Band frequency.

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