

Magnetic Properties Observation of Cerium-Iron-Boron Amorphous

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Abstract— Bangka Belitung island province is one of the tin producing areas. In the process of processing tin produces a monasite waste in which monasite minerals contain rare earth metals. One application of rare earth elements is as a candidate for RE-Fe-B based magnetic material. In this study, we investigated the magnetic properties of $Ce_{14}Fe_{80}B_6$ thin layer based on magnetic moment configuration. Changes in magnetic moment configuration occur due to the presence of an external magnetic field applied to a thin layer of $Ce_{14}Fe_{80}B_6$. Providing an external magnetic field also results in saturation and energy changes in the system. The strength and weak magnetic properties possessed by the $Ce_{14}Fe_{80}B_6$ thin film can be clearly drawn through the loop hysteresis curve.

Keywords: rare earth, magnetization, energy, coercivity

I. INTRODUCTION

Province of Bangka Belitung is one of area that much of monazite minerals. It can be found after processing ore of tin. Monazite mineral is consist of some compounds and rare earth unures. Rare earth unures in monazite minerals are Ce, Nd, Yb, and Th [1]. The application of rare earth unures are showed by figure 1.

Based on figure 1, it has been seen that rare earth unure can be applied as magnetic materials. It means that rare earth unures are material candidates in magnetic recording technology. This condition is pushed researchers to do some researches like creating of magnetic composites even magnetic nanocsale thin film based on rare earth unures.

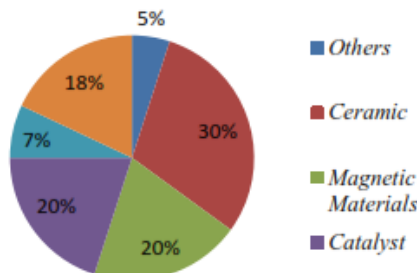


Fig. 1. Application of rare earth-unsures [2].

Neodymium-Iron-Boron is one example of magnetic material have hard magnetic characteristic. Maximum value of energy production of this compound is 400 kJm^3 [3]. Hard magnetic is magnetic material with more than 400 kA/m coersivity. whereas material magnetic have coersivity less than 10 kA/m [4] is soft magnetic. Neodymium's amount is just 16.11% in monasit mineral, so that it is one of weakness of this compound. It has to be another alternative to get magnetic materials based on rare earth. Cerium is an unsure which have higher percentage than neodymium in monasit mineral. It's amount is 27,30 % [1] Researchers has consideration of use as magnetic material candidate.

Using 3D micromagnetic simulation software, magnetic moment's configuration of $Ce_{14}Fe_{80}B_6$ amorphous was influenced by disk size, magnetocristaline anisotropy constant, and dimensions [5]. When the thickness of CeFeB amorphous was 10 nm, domain wall's type was cross tie with the shape of rectangle [6]. According to some researches, author tried to explain magnetic properties of $Ce_{14}Fe_{80}B_6$ considered from hysteresis loop, magnetic moment configuration, and demagnetization energy when $Ce_{14}Fe_{80}B_6$ amorphous is applied by magnetic field.

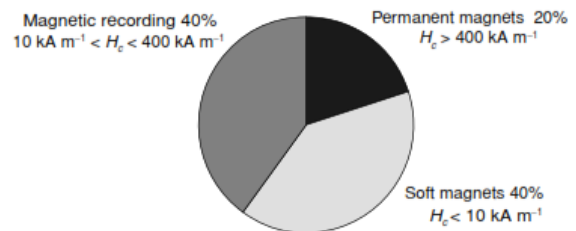


Fig. 2. Breakdown of market for magnetic material in every type [4]

II. METHODS

Simulation was done using OOMMF software. Parameters of $Ce_{14}Fe_{80}B_6$ are $M_s=9,3 \times 10^5$ A/m, $K=0$, $\alpha=0,5$, $A=4 \times 10^{-12}$ J/m. $Ce_{14}Fe_{80}B_6$ was applied by magnetic field. Amount of magnetic field are 0 mT to 400 mT, 400 mT to -400 mT, and -400 mT to 400 mT in x directions. Shape of $Ce_{14}Fe_{80}B_6$ is rectangle with size 500 nm x 200 nm x 10 nm.

Magnetic configuration is obtained by LLG dynamic equation as a function of time [7].

$$\frac{dM}{dt} = -\gamma \times H_{\text{eff}} + \frac{\alpha}{M} M \times \frac{dM}{dt} \quad [1]$$

The demagnetization energy:

$$E_d = \frac{1}{2} \mu_0 \int H_d^2 dV \quad [2]$$

Magnetic properties of $Ce_{14}Fe_{80}B_6$ could be explained by plotting of histerisis loop, momen magnetic configurations, and amount of demagnetization energy.

III. RESULT AND DISCUSSION

Magnetic moment's configuration changed causing by applied of magnetic field (H). Saturation of magnetic moment indicated that $Ce_{14}Fe_{80}B_6$ was ferromagnetic material. Hysteresis loop showed amount of saturation of magnetic field, coercivity, magnetic remanent, and so forth. Their amount explained $Ce_{14}Fe_{80}B_6$ properties clearly. Figure 3 described configuration of magnetic moment of CeFeB influenced by external magnetic field.

According to figure 3, magnetic moment of $Ce_{14}Fe_{60}B_6$ saturated at of external magnetic fields in more than 272 mT. Under amount of external magnetic field is 400 mT, all of magnetic moment was saturated. When external magnetic field was vanished, $Ce_{14}Fe_{60}B_6$ still have magnetic remanence. Magnetic moment's configuration of magnetic reversal is showed by figure 2.

Figure 4 explained reversal magnetization.. This phenomena could be seen when $Ce_{14}Fe_{60}B_6$ was applied by external magnetic field as large as -272 mT dan -400 mT . Configuration of that was opposition of magnetic moment configurations of applied external magnetic fields at 272 mT dan 400 mT

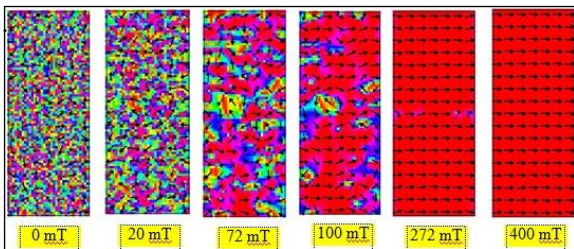


Fig. 3. Configuration of CeFeB's magnetic moment influenced by external magnetic field.

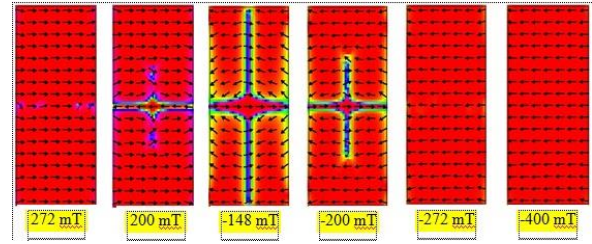


Fig 4. Magnetization reversal of CeFeB.

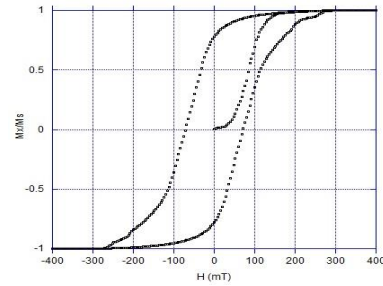


Fig. 5. Hysteresis loop of $Ce_{14}Fe_{80}B_6$.

The magnetic properties of $Ce_{14}Fe_{60}B_6$ can be analyzed in more detail through the loop hysteresis curve shown in Figure 5. The curve shows remanent magnetization and its coercivity field.

The area of $Ce_{14}Fe_{80}B_6$ coercivity was around 76 mT. This indicated that the $Ce_{14}Fe_{80}B_6$ thin layer is between soft magnetic and hard magnetic. This property was also shown by magnetic remanent which is quite small on the loop hysteresis curve. The demagnetization energy of the $Ce_{14}Fe_{80}B_6$ thin layer in the external magnetic field of 0 mT to 400 mT is shown in Figure 6a.

Figure 6a showed the profile of a large reduction in energy demagnetization when the magnetic moment in the $Ce_{14}Fe_{80}B_6$ thin layer approached saturation. The amount of energy continues to decreased as the external magnetic field increased, and experienced a constant value when the saturation processed. Furthermore, the pattern of changing in demagnetization energy in reversal magnetization phenomena is shown in Figures 4b and 4c.

Figure 6b was a phenomenon of changes in demagnetized energy when an external magnetic field was applied to 400 mT to -400 mT. On the effect of field reduction of 400 mT to 0 mT, the pattern that occurred opposed of figure 6a. But above the magnetic field outside 0 mT to 400 mT The curve showed the pattern of energy increased, This is due to changed in the magnetic moment configuration of the material. Figure 6c shows the reverse pattern from Figure 6b. This is because the magnetic moment configuration under the influence of the field is the opposite of magnets reversal under the influence of an external magnetic field 400 mT to -400 mT

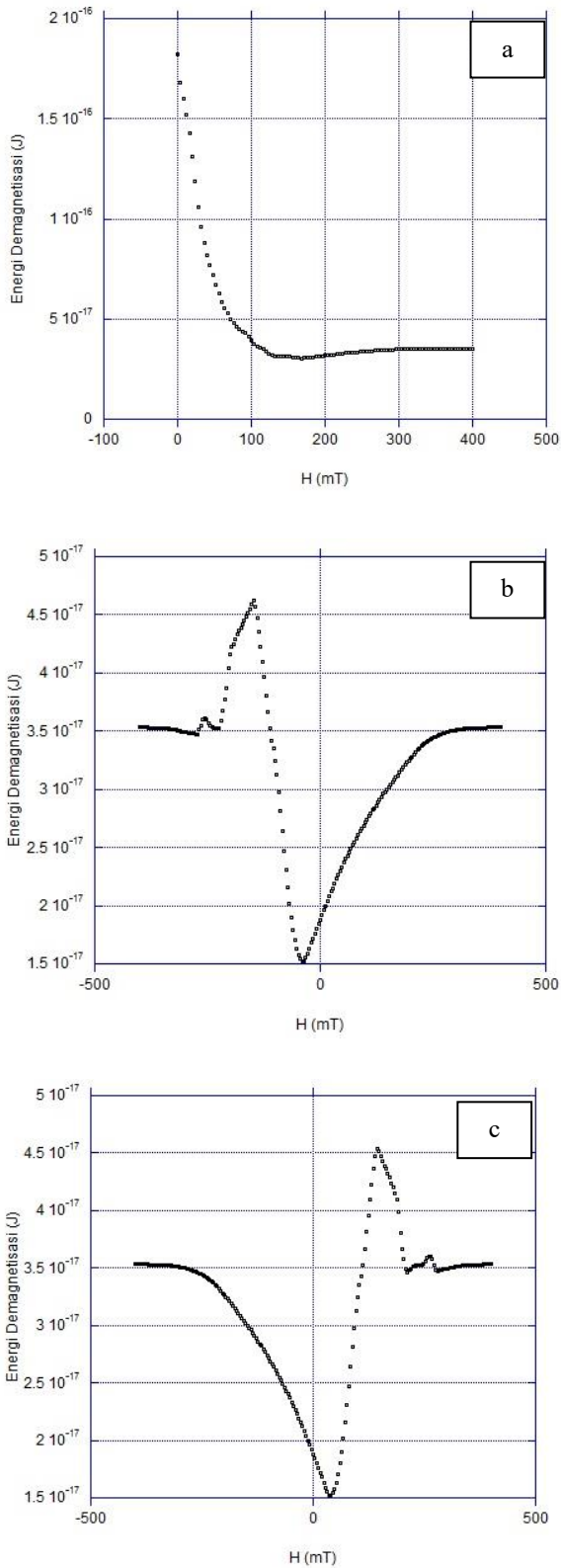


Fig. 6. (a) demagnetization energy at 0 mT-400 mT external magnetic field.
(b) demagnetization energy at 400 mT-(-400 mT) external magnetic field.
(c) demagnetization energy at -400 mT-400 mT external magnetic field

Based on the form of loop hysteresis curve, coercivity field value, magnetic remanent and demagnetization energy, the nature of the $Ce_{14}Fe_{80}B_6$ magnetism can be known. Furthermore $Ce_{14}Fe_{80}B_6$ can be applied according to its magnetic properties, and by looking at these characteristics.

IV. CONCLUSION

$Ce_{14}Fe_{80}B_6$ is a ferromagnetic material with properties between soft magnetic and hard magnetic. This is due to the value of the coercivity field between soft magnetic and hard magnetic materials. Furthermore, the value of demagnetized energy has not shown strong magnetic properties

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