Enhancement of Saturation Magnetization through Mechanical Pressure on $Y_3Fe_5O_{12}$ during Sintering Process

Min-Sun Jang[1*], Seung-Hyub Baek[2], Ki-Suk Lee[1]
[1]School of Materials and Science Engineering, Ulsan National Institute of Science and Technology (UNIST), Ulsan 689-798, Republic of Korea
[2]Electronic Materials Research Center, Korea Institute of Science and Technology (KIST), Seoul 136-791, Republic of Korea

I. Introduction

In recent years, the ferrimagnet insulator-$Y_3Fe_5O_{12}$ (YIG) has been attracted much attention due to its outstanding spin-caloritronic effects which can be applicable to a future green energy source [1, 2]. Subsequently, many researchers have been focused on the way to enhanced magnetic properties of YIG by finding optimized annealing temperature [3], doping rare-earth materials [4], developing novel fabrication methods such as a pulsed laser deposition [5], an RF/DC sputtering [6], a spin coating [7], and a sol-gel method [8]. Here, we develop the novel process in the sol-gel method for high saturation magnetization (M_s) value and homogeneous texture by using the external mechanical pressing during sintering process. In this presentation, we report that the temperature of heat treatment and the external mechanical pressure can play a critical role for the magnetic properties of YIG.

II. Experiments

We prepared raw materials of the yttrium nitrate ($Y(NO_3)_3.6H_2O$, 99.99%), iron nitrate ($Fe(NO_3)_3.9H_2O$, 99.99%), citric acid ($C_6H_8O_7.H_2O$). The solution of the citric acid was dissolved into 100mL of distilled water at room temperature for 18 hours with stirring speed of 300-rpm. The solution of the citric acid was maintained at 1pH. 100 mL of citric acid was added to the yttrium nitrate ($Y(NO_3)_3.6H_2O$, 99.99%) and the iron nitrate ($Fe(NO_3)_3.9H_2O$, 99.99%)in regular sequence. The resulting solution was followed by stirring for 24 hours at 80 ℃ to obtain a homogenous gel. And then the powder YIG was obtained from the grinding the completelydried solution. The calcination process was carried out at 850 ℃ in air for 2 hours at a heating rate of the 7.7 ℃/min to get rid of residual impurities and the crystallization. After calcined process, we did the pressing process. Lastly, sintering has been done for 4 hours. X-ray Diffractometer (XRD; Bruker AXS, D8 ADVANCE) was used for finding phase identifications of the composite. In addition to, the elemental composition of sample surface was carried out to measure the kinetic energy of each material with a beam of the X-ray photoelectron spectroscopy (XPS; Thermo Fisher, K-alpha). Moreover, bubble shaped microstructures of the pressed YIG were obtained by Field Emission Scanning Electron Microscope (FESEM; Hitachi, S-4800). The high magnetic properties of YIG; before and after pressing process were measured using SQUID Vibrating Sample Magnetometer(SQUID VSM; Quantum Design, Model 6000) at room temperature (25 ℃).

III. Results & Discussion

In order to understand the effect of external mechanical pressing, we compared the microstructure and M_s

value of YIG samples after the sintering process with and without the mechanical pressing. As reported in the previous studies [9], heat treatment in the sol-gel method affects mainly the microstructure evolution and enhancement of magnetic properties. Here, we found that the mechanical pressing also improves materials properties by reducing porosities and being homogeneous grain size which is verified though FESEM images. From the XRD patterns which show good agreements with the Joint Committee on Powder Diffraction Standard (JCPDS number # 43-0507) of the pure YIG. Because YIG-after pressed is well matched up with standard's peak position. From XPS spectrum, however, we found different background value of metal oxides and relatively reduced surface area from pressed- YIG which means the grain size of pressed-YIG is larger and uniformed than previously. Furthermore, magnetic properties are changed dramatically through the pressing process: A huge enhancement of M_s (> 3 times than it after the sintering process without the pressing) was observed in the VSM hysteresis loop. Consequently, we found that the pressing process can play a crucial role for the magnetic properties of YIG.

IV. References

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