P-25

Sol-Gel spin coating법으로 제조한 YIG 박막의 FMR특성

부산대학교 김광석*, 이재동 김태옥

The FMR Characteristics of YIG thin films prepared by Sol-Gel Spin Coating Method

Pusan National University K. S. KIM*, J. D. LEE, T. O. KIM

1. Introduction

YIG is abbreviation of $Y_3Fe_5O_{12}$ that has Garnet structure. YIG has low losses at microwave frequencies so that it can applied to devices in the field of communications and radar[1]. Fe ions have spherical charge distribution and it means its orbital angular momentum(L) is zero[2]. This fact provide very weak coupling between excitations of the spin lattice(magnons) and excitations of the crystal lattice(phonons) that is so-called direct relaxation loss mechanism[3]. Therefore, YIG can have low losses at microwave frequencies.

Relatively little researches on sol-gel method in this field have been done and most researches were focused on magneto-optic data storage devices[4-5].

In this experiment, we focused on the preparation of YIG thin films using sol-gel spin coating method and its applicability for microwave devices. Microwave losses were observed by ferrimagnetic resonance (FMR)[6].

2. Experimental Procedure

Yttrium nitrate($Y(NO_3)_3 \cdot 6H_2O$) and iron nitrate($Fe(NO_3)_3 \cdot 9H_2O$) were dissolved into ethylene glycol($HOCH_2CH_2OH$). Solution was reacted for 150 minutes at 80 ℃. Sol-gel reactions were indirectly observed by measuring pH, viscosity and Temperature during the sol preparation.

YIG thin films were obtained by spin-coating a stable sol onto SiO_2/Si wafers, followed by drying for ten minutes at 300 ℃. To obtain good wettability, it is necessary to clean the substrates well. The substrates were cleaned with acetone in the ultrasonic cleaner after being heated on a hot plate at 400 ℃ that is thought to remove residual organic contaminants. Thicker films were obtained by repeating the coating and drying processes. The dried films were subject to heat treatment in air to induce crystallization.

3. Results and Discussion

The variation of pH and internal temperature of sols were observed with microcomputer pH meter(Hana instruments-HI8424) and viscosity change was observed with Ubbelohde viscometer. Around 90 minute, pH increased, viscosity decreased, and slight exothermic reaction was observed.

After spin-coating sols onto amorphous-SiO_2/Si substrates at 1600 rpm followed by drying at 300 ℃, we heat-treated dried films at various temperatures to see at which temperature

YIG thin films can be formed. To obtain distinguishable XRD peaks of films, we repeated drying and coating processes over 15 times. Thickness of 1-time coated films was about 300 Å, that was confirmed by cross-sectional SEM photographs of YIG thin films. YIG thin films could be formed by just 800 ℃ heat-treatment.

Table I. shows the results of the FMR measurements. Microwave losses are expressed in terms of the FMR linewidth(ΔH); low losses corresponding to small values of linewidth. ΔH(=362 Oe) of the 15 times coated film is larger than ΔH(=210 Oe) of the 5 times coated film. And ΔH of the 800 ℃ heat-treated film is smaller than ΔH(=410 Oe) of the 1000 ℃ heat-treated film. These facts mean that microwave losses of films which have poor morphology - morphology was become poorer as the thickness and heat-treatment temperatures are increasing - have a tendency to be larger.

Table I. The FMR linewidth of YIG thin films

sample	(a) 5 times coated film heat-treated at 800℃	(b) 15 times coated film heat-treated at 800℃	(c) 5 times coated film heat-treated at 1000℃
ΔH	210 Oe	362 Oe	410 Oe

4. Conclusions

YIG sols suitable for sol-gel coating were prepared by reacting for 120 minute to 150 minute at 80 ℃ YIG thin films can be fabricated by spin-coating sols onto amorphous-SiO_2/Si substrates followed by heat-treating above 800 ℃. As the thickness and heat-treatment temperatures increase, the morphology of the films are become poorer. With the worsening of the morphology of the film, microwave losses tend to be larger. In this experiment, 5 times coated YIG thin films which were heat-treated at 800 ℃ had the smallest value of the FMR linewidth of 210 Oe.

5. References

[1] G. P. Rodigue, Proceedings of the IEEE, Vol. 76, No. 2, 121, February(1988).

[2] Charles Kittel, Introductin to Solid State Physics, John Wiley and Sons Inc., New-York (1996), pp461

[3] T. Kasuya and R.C. Lecraw, Physical Review Letters, Vol. 6, No. 5, 223, March 1(1961).

[4] Jaekyoung Cho, Manabu Gomi and Masanori Abe, Japanese Journal of Applied Physics, Vol. 28, No. 9, 1593, September (1989).

[5] Koji Matsumoto, Satashi Sasaki, Yasunori Yamanobe, Kazuhiro Yamaguchi, Toshitaka Fujii and Yousuke Asahara, Journal of Applied Physics, 70(3), 1624, 1 August(1991).

[6] Charles Kittel, Physical Review, Vol. 72, No. 2, 155, January 15(1948).