Effect of Firing Temperature to Surface Morphology of Nanosized YIG Based Thick Film with Linseed Oil as Organic Vehicle

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Abstract: This paper presents results of morphological study on nanosized yttrium iron garnet (YIG) thick film using linseed oil as organic vehicle and nanosized YIG powder. First, YIG nanopowder is mixed with organic vehicle which consists of linseed oil, m-xylene and α-terpineol. Paste samples were screen printed onto alumina as substrate, dried and fired at different temperatures of 100°C, 200°C, and 300°C respectively. Microscopic images of the samples and elemental analysis were observed to determine good dispersion of the active powder with the organic vehicle. Based on the results, the nanoparticles were uniformly dispersed, with images of thick films fired at 200°C and 300°C have showed clearly visible particles, indicating that at these temperatures, the organic vehicle has started to evaporate on the surface, revealing nanoparticles of the active powders. Elemental analysis confirmed this theory, of which carbon element of the organic vehicle gradually decreased with increasing temperature.

***Keywords*:** Yttrium iron garnet, Thick film, linseed oil, organic vehicle, nanopowders.

INTRODUCTION

Thick film technology is the most commonly used technology for producing electronic devices due to its inexpensive production and simple method by using thick film paste. One of the ingredients in the paste is organic vehicle which serves as a binder of the active powder to the substrate while maintaining the suitable rheological properties for screen printing process. Ethyl cellulose mixed with α-terpineol solvent is commonly used in preparing thick film paste [1], [2]. In conventional pastes, glass frit is normally used to bind the particles to each other and improve the properties of the paste [3]. However, the use of glass frit will increase the firing temperature needed to improve film characteristics. This paper investigates the effect of firing temperature with the use of linseed oil as organic vehicle of which in theory can help reduce the firing temperature without using glass frit with its high viscosity and capability of polymerization in lower temperature than using ethyl cellulose.

MATERIALS AND METHODS

Thick film paste was prepared by mixing YIG powder with organic vehicle using magnetic stirrer at 150rpm for 3 hours at 40°C in order to obtain homogenous paste. The paste samples were then screen printed onto alumina substrate, dried and later fired in box furnace at 100°C, 200°C, and 300°C for 30 minutes. Sample was then investigated using field emission scanning electron microscope (FESEM) to observe morphology of the paste, and elemental analysis was performed to investigate any changes in ratio of elements on the surface of the thick film.

RESULTS AND DISCUSSION

Fig. 1 shows the microscopic images of the screen printed paste samples after firing process at 100°C, 200°C, and 300°C for 30 minutes. As can be observed from the image, the YIG nanoparticles were dispersed uniformly in the paste and the good dispersion could improve the permittivity of the thick

film, which is important for magnetic materials if to be used in high frequency application such as antenna and magnetic sensor. Increased visibility of the nanoparticles on the surface indicated that the organic vehicle has mostly evaporated, leaving only nanoparticles on the surface of the thick film. Fig. 2 shows the elemental analysis of the thick films with linseed oil as the binder. As can be observed from the figures, analysis of all samples also confirmed the effect of firing temperature, of which the carbon element found in the organic vehicle decreased, while other elements associated YIG started to increase with the increase of the firing temperature.

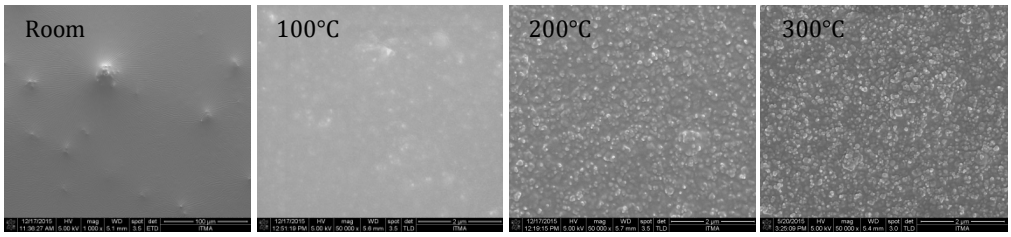

Fig. 1. FESEM images of YIG thick film with different firing temperatures

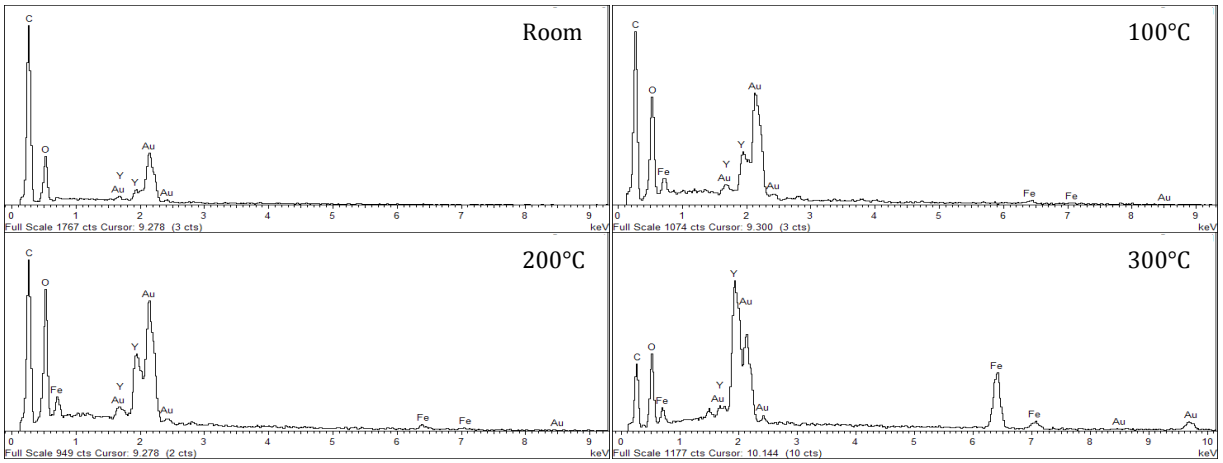

Fig. 2. EDX analysis of YIG thick film (YIG 30 wt.%) with different firing temperatures

CONCLUSIONS

This project investigated the printability of thick film paste using linseed oil as organic and found that the sample has good dispersion of the nanopowders and decreasing of organic vehicle with increasing temperatures. This proved that linseed oil can be used as organic vehicle to produce thick film paste and can reduce firing temperature while omitting glass frit as binder.

ACKNOWLEDGMENT: This work is sponsored under MOSTI Sciencefund grant 03-01-04-SF1860.

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