Thermal and Electrical Characterization of Zn-Cu Ferrites Thin Films

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**Abstract.** The effects of Zn and Cu on the thermoelectric properties of ferrite thin films were studied in this paper. The Zn-Cu ferrite thin film was fabricated using ink-jet printing method. A minimum of 50 print cycles was required to obtain continuous film with approximately 9 µm thick thin films. The thickness of Zn-Cu ferrite thin films was decreased with increasing sintering temperature from 200 ºC (9.21 µm) to 400 ºC (5.48 µm). The XRD traces of Zn\textsubscript{x}Cu\textsubscript{1-x}Fe\textsubscript{2}O\textsubscript{4} exhibit as plane reflection for cubic spinel phase of Zn\textsubscript{x}Cu\textsubscript{1-x}Fe\textsubscript{2}O\textsubscript{4} and there were no impurity peaks detected with increasing Zn content and sintering temperature. The electrical conductivity of Zn\textsubscript{x}Cu\textsubscript{1-x}Fe\textsubscript{2}O\textsubscript{4} thin film decreased from 1.18x10\textsuperscript{-3} S/cm (x=0.0) to 0.48x10\textsuperscript{-3} S/cm (x=1.0) with increasing Zn content. Positive Seebeck values were observed for all the samples, which indicated the samples were p-type. The Seebeck coefficient of Zn\textsubscript{x}Cu\textsubscript{1-x}Fe\textsubscript{2}O\textsubscript{4} thin film increased from 6.36 µV/K (x=0.0) to 17.46 µV/K (x=1.0) with increasing Zn content.

**Introduction**

The downsizing electronic components have leads to the growth of thin film developments for various applications such as coatings, solar devices, electronic and optical devices [1,2]. Thin film has the advantage of faster response time, lower power draw, and smaller dimension compared to the bulk materials [2]. Thin films have been fabricated by different deposition methods such as thermal evaporation [3], pulsed laser deposition [4], spin spray plating [5] and electron beam evaporation [6]. Among these methods, the ink-jet printing is the simple and inexpensive deposition method compared to others methods that required costly equipment or laboratory setups [7]. The inkjet printing process is a contactless technique of printing and had been applied as an alternative way for producing microcircuits and metallization of the solar cell due to the low cost of fabrication [8,9]. The ink-jet printing method has the advantages of low cost, easy operation, simple equipment and the ability to pattern directly [10].

Mixed ferrites are widely used in various applications such as transformers, inductors, information storage system and high frequency microwave devices due to its electrical and magnetic properties [11,12]. The structural, magnetic and optical properties of Zn-Cu ferrites widely reported [13,14,15]. However, there is no much information regarding the thermoelectric properties of Zn-Cu ferrite. Thermoelectric materials have the ability to convert heat into electrical energy and vice versa. Materials that possess the properties of high Seebeck coefficient, high electrical conductivity and low thermal conductivity considered to be good thermoelectric materials [16]. The physical and chemical properties of the ferrites depend on many factors such as sintering temperature, sintering time, rates of heating and cooling [17]. The desired electrical and magnetic properties of ferrites can be incorporated with different substitution [18]. In this study, the effects of Zn and Cu on the thermoelectric of ferrite thin films fabricated through ink-jet printing method were investigated.