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DEVELOPMENT OF MgZn-BASED FERRITE MATERIALS FOR DEFLECTION YOKES

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Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of requirements for the degree of Master of Science

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Faculty : Faculty of Science and Environmental Studies

Ferrite materials in the form of the deflection yokes constitute a very significant portion of the entire world production of soft ferrites. The main applications are in TV sets and computer display monitors. Thus, this work was initiated to develop soft ferrite materials of the MgZn type suitable for use as deflection yoke materials. As cost plays a very important role in production, the initial part of the project was to develop the required material by manipulating the composition through production grade raw material. Various additives such as CaO, CuO, TiO_2 and La_2O_3 were added to assist in attaining the required properties. Green compacts with a sintering temperature of 1150°C and only air atmosphere were needed to achieve the magnetic and electrical properties close to those of SAMHWA's YL-5 material. A compositional design technique capable of producing deflection yokes material was

successfully developed to cater for the television and computer industry in Malaysia.

Abstrak tesis yang dikemukan kepada Senat Universiti Putra Malaysia bagi memenuhi keperluan Ijazah Master Sains.

PENGHASILAN BAHAN FERIT MgZn UNTUK "DEFLECTION YOKES"

Oleh

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Jun 2000

Pengerusi : Professor Madya Dr. Mansor Hashim

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Bahan ferit dalam bentuk "deflection yokes" merupakan sebahagian besar daripada pengeluaran ferit lembut dunia ini. Kegunaan utamanya ialah dalam peti TV dan monitor komputer. Maka, kerja ini dijalankan semata-mata untuk menghasilkan bahan ferit lembut jenis MgZn yang sesuai digunakan sebagai bahan "deflection yokes". Disebabkan, kos memainkan suatu peranan yang penting dalam pengeluaran, penyelidikan ini dimulakan dengan tujuan untuk menghasilkan bahan tersebut melalui manipulasi komposisi dengan menggunakan bahan mentah gred pengeluaran. Berbagai jenis bahan penambah seperti CaO, CuO, TiO_2 dan La_2O_3 telah digunakan untuk membantu dalam mendapatkan ciri-ciri yang dikehendaki. "Kompak hijau" dengan suhu persinteran setinggi 1150°C dan hanya udara atmosphera diperlukan untuk mencapai ciri-ciri magnet dan elektrik yang hampir dengan bahan ferit lembut SAMHWA YL-5. Suatu teknik rekabentuk komposisi yang berupaya

menghasilkan bahan ferit "deflection yokes", yang mampu memenuhi keperluan industri televisyen dan komputer di Malaysia, telah berjaya dihasilkan.

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LIST OF SYMBOLS AND ABBREVIATIONS

A	cross sectional area
H	applied field
H_C	coercive force
μ_B	Bohr magneton
T_C	Curie temperature
ρ	resistivity
f	frequency
μ'	real of permeability or magnetic loss
μ''	imaginary part of permeability or magnetic loss
B	induction
L	inductance
μ_i	initial permeability
μ_0	magnetic constant
D_i	inner diameter
σ	internal stress
l	length
tan δ	loss tangent
N	number of wire turns
D_0	outer diameter
PVA	polyvinyl alcohol
Q	quality factor
RLF	relative loss factor

B_r	remanence induction
B_s	saturated induction
M_s	saturation magnetisation
T	temperature
t	thickness
K_1	first anisotropy constant
W	weight
SEM	scanning electron microscope

CHAPTER I

INTRODUCTION

General

Ferrimagnetism is the term proposed by Neel to describe the magnetism of ferrites whereby the material possesses unequal, anti parallel ionic magnetic moments resulting in a net moment due to incomplete compensation. This spontaneous magnetization is temperature dependent and vanishes at the Curie temperature.

Ferrites are generally divided into two major classes, the soft and the hard ferrites which are further classified according to their specific crystal structure; cubic spinel, garnet and magnetoplumbite (Goldman, 1990).

Soft magnetic materials are generally developed with technical applications in view as they become magnetized in relatively weak fields and return to a state of relatively low residual magnetism when the field is removed. Besides, the remarkably high electrical resistivity of these materials, depending on composition, has given ferrites a distinct advantage as magnetic materials of choice in most technological applications covering antennas,

transformer cores, deflection yokes and others. In addition, the spinel crystal structure of ferrites is tolerant to numerous variations in their chemical composition, giving the technologist access to a wide range of properties.

Application As Magnetic Deflection Yoke

Through the years, the demand in terms of tonnage has steadily increased but also the specific applications of ferrite have changed remarkably and kept pace with the developments in electronic technologies. At this time, the TV industry still remains the largest user of ferrites with approximately 1 kg of ferrites per TV set (Ghate, 1981) with deflection yokes contributing about 20% of applications.

A television picture tube uses magnetic fields that are produced by external coils placed around the neck of the picture tube for deflecting the beam vertically and horizontally. The combination of the vertical and horizontal deflection coils plus the core is called the yoke. These coils have flowing through them a sawtooth current and the magnetic field generated by this flow of energy through the coil will influence the beam and deflect it accordingly. The horizontal deflection coil that sweeps the beam across the face of the tube from left to right is split into 2 sections and mounted above and below the tube neck. The vertical deflection coil is also split into 2 sections and mounted on each side of the tube neck in order to pull the beam

gradually downward as the horizontal coils sweep the beam across the tube face.

Historical Overview

The existence of magnetite, a typical ferrimagnetic ferrite called lodestone, has been known since more than 2000 years ago. Nevertheless, there was hardly any progress in scientific research concerning ferrites until the 19th century (Ishino, 1987). Ferrites came into prominence at the end of the Second World War (Goldman, 1990).

In 1930, Y. Kato and T. Takei discovered soft ferrite from the solid solution of zinc ferrite. Based on their research, Snoek (1936) and his coworkers at the Philips Research Laboratories in the Netherlands developed the first soft magnetic spinel ferrites for commercial applications under the trade name Ferroxcube. In 1948, the first explanatory theories on the origin of magnetism (theory of ferrimagnetism) in ferrites was published by Neel. This has brought about a great advance in the magnetic investigation of ferrites.

The real breakthrough, however, of ferrites as important materials for electrotechnical applications took place in the early 1950s due to the large-scale introduction of the television (Owens, 1956). From 1955 to 1965, when ferrites were first applied to electron beam deflection, Mn-Zn or Ni-Zn ferrites

were used. Providing lower resistance, Mn-Zn ferrites were used with saddle toroidal winding. But due to ringing problems, they were gradually replaced by Ni-Zn ferrites, which featured higher resistance. Currently, Japanese, Korean and Taiwanese makers mainly select Mg-Zn ferrites for their low material costs.

Significance of the Study

Today, there is a growing need for ferrite materials in the form of the deflection yokes as the main applications are in TV sets and computer display monitors, both being in the upper part of the technology and having a huge market. However, production of deflection yokes is dominated by only a few big manufacturers such as TDK and SAMWHA. Therefore the aim of this project is to produce deflection yoke materials which are not only superior in qualities but also lower in cost. It is hoped that the results of this research development work will be a significant contribution to the television and computer industry in Malaysia.

Statement of Objective

The objective of this project is to develop soft ferrite materials of the MgZn type suitable for use as deflection yoke cores with specific characteristic and properties similar to those of SAMHWA deflection yoke cores.

The ultimate objective is to obtain a relatively large saturation magnetization, $B_{sat,}$ as it provides a large excursion of flux and thus it is able to handle faster raster rate. Besides, since TVs operate with a large amount of electric power, it is necessary to produce a low-loss ferrite at high flux densities to reduce heat generation and to ensure greater safety. Therefore, high electrical resistivity plays an important role as it minimizes the eddy current losses and also eliminates the need for taped insulation between yoke and winding.

Future Technology Of Ferrites

If the trends in magnetic materials is examined as a whole, ferrites will continue to play a unique role by virtue of their high electrical resisitvity, ease of fabrication into a multitude of shapes having widely divergent properties, light weight and cost effectiveness. It is expected that development of future process technologies will be evolutionary as the technological developments in ferrites have been basically evolutionary rather than revolutionary. Material science and technology has been steadily applied to improve properties as well as new products. However, the highly capital intensive nature of ferrite processing makes it that much more difficult to readily implement changes, especially in products used in large quantities or requiring a large volume of material.

Ferrites will make a remarkable progress towards the future as an advanced ceramics as it still has promising opportunities for dramatic developments in the fundamental studies, search for new materials, improvements in manufacturing technology and the search for new applications (Sugitomo, 1985).

CHAPTER II

LITERATURE REVIEW

Introduction

Despite of the utilisation of ferrite core decades ago, commercialisation of MgZn based ferrite replacing MnZn and NiZn ferrite has been very recent. Hence, the scarcity of publications exist. Besides, due to the great competition in the ferrite market, reputable manufacturers such as TDK, SAMHWA and Philips tend to conceal the compositional and processing details that contribute to high quality ferrite products. Fortunately, there still exists a wide availability of open publications on fundamental science and applied aspects in this field. Thus, these perhaps would be the only source of knowledge to researchers in fabricating high-quality ferrite materials and products comparable with those available on the world market.

Although not much has been studied on MgZn ferrite, the ample literature particularly on NiZn and MnZn ferrites available may be helpful in understanding the properties of ferrites in this project. In general, the literature review is divided into two sections based on the chemical and microstructural aspects of ferrites.