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Studying Dielectric and Magnetic Properties of Nano Ferrite Functionally Graded Materials

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Abstract

Functionally graded materials (FGMs), with ceramic –ceramic constituents are fabricated using powder technology techniques. In this work three different sets of FGMs sample were designed in to 3 layers, 5 layers and 7 layers. The ceramic constituents were represented by hard ferrite (Barium ferrite) and soft ferrite (lithium ferrite). All samples sintered at constant temperature at 1100oC for 2 hr. The magnetic properties showed an increase in coercive force (Hc) with increased number of layers. The dielectric properties measured at room temperature with constant frequency 1 MHZ. The results showed the dielectric constant increase with the increase the number of layers from (1.39×10-2) to (2.83×10-2).

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Keywords: Functionally graded materials; hard ferrite; Soft ferrite and ceramic

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1. Introduction

In the past few years, the use of ceramic materials has significantly increased in various applications due to the unique characteristics of these materials in comparison with metals and polymers. The advantageous properties of ceramic materials are hardness, rigidity, abrasive toughness and low density. Ceramics are a class of materials broadly defined as "inorganic, nonmetallic solids". They have the largest range of functions of all known Material. The last decades have seen the development of the enormous potential of functional ceramics based on unique dielectric, ferroelectric, piezoelectric, pyroelectric, Ferromagnetic, magneto resistive, ironical , electrical,

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superconducting , electro optical and gas- sensing properties[1].Ferrites are classified mainly into three groups with different crystal types. They are spinel, Garnets and magneto-plumbite. Spinel ferrites have a cubic structure with general formula MO Fe_2O_3, where M is a divalent metal ion like Mn , Ni , Fe , Co, Mg etc. Garnets have a complex cubic structure having a general formula $M_3Fe_5O_{12}$. The third type,"magneto-plumbite" is having a hexagonal structure with general formula MO $Fe_{12}O_{18}$. The most important in the group of magneto plumbite is barium ferrite $BaOFe_{12}O_{18}$, which is a hard ferrite [2].The fast evolution of new high technology requires new materials with various special properties or functions. Under some severe environment such as super high temperature, conventional materials may not service. A new material concept functionally graded materials (FGMs) has been proposed to meet the need which usually contain various material constituents such as ceramics and metal. FGMs have received considerable attention in many engineering applications since they were first reported in 1980s. FGMs are composite materials, microscopically inhomogeneous, in which the mechanical properties vary smoothly and continuously from one surface to the other. Compared with classical laminated composite materials, FGMs provide superior thermo-mechanical performances under given loading circumstances. FGMs can be used to improve creep behavior, fracture toughness of machine tools, wear resistance, oxidation resistance of high temperature aerospace and automotive components and so on [3]. Mortensen and Suresh, 1995 [4] Reviewed two parts of the processing, mechanical analysis and performance of functionally graded materials containing a metallic phase. The first class, termed 'constructive processes', produces gradients by stacking selectively two or more starting materials, allowing full and potentially automated control of compositional gradients. The second class is termed 'transport based processes' and utilises natural transport phenomena to create compositional and microstructural gradients during production of a component. Fadhil, et.al.2016 [5] studied the microstructure and characterization of nickel ferrite Nano fibers. The nanonickel-zinc ferrite ($Ni_{1-x}Zn_xFe_2O_4$), with (x=0, 0.25, 0.5, 0.75), was prepared by electrospinning technique. Zinc nitrate hexahydrate, nickel nitrate hexhydrate, iron nitrate nonahydrate, Polyvinylpyrrolidone PVP and N, Ndimethylformamide (DMF) were used as precursor materials. The result showed that the electrospinning method leads to obtain nanofibers of nickel zinc ferrite with good controllable stoichiometry at low temperature. The morphology and diameters of the fibers are largely affected by the calcination temperature, increasing calcination temperature, the morphology of the calcined fibbers gradually transforms from a porous structure to a necklace-like nanostructure. The $Ni_{1-x}Zn_xFe_2O_4$ fibers are mainly necklace- like Nano fibers. Put, et.al.2003 [6] investigated functionally graded ceramic and ceramic-metal composites shaped by electrophoretic deposition the mechanisms of deposition and the relation between the evolutions of the current, yield and the electric field strength are evaluated. The investigated materials comprise alumina, zirconia and their composites as well as various formulations of hard metals. The fabrication of homogeneous as well as continuously graded plate-shaped components is highlighted. Special attention is given to the electrophoretic characteristics of the constituent powders, such as the point of zero charge, the natural pH, the electrophoretic mobility, the effective particle charge and the resistance of the suspension the main feature of a functionally graded material (FGM) is the position-dependant composition and related mechanical properties. Jaworska, et.al.2006 [7] Studied functionally graded cermets. Materials were obtained using free sintering at vacuum and the high temperature-high pressure sintering method. Functionally graded cermets have more amount of hard phase in the surface layer and lower participation of this phase in the body frame. FGMs were prepared by the layers pressing method and the centrifugal deposition method. Material with 55 wt.% of TiC and 45 wt.% of (Ni,Mo) was prepared. The phase's composition of this material was analysed. Shabana,et.al.2006 [8] Modeling the evolution of stress due to differential shrinkage in powder-processed functionally graded metal–ceramic composites during pressureless sintering .This model can be used to determine appropriate shrinkage rates and gradient architectures for a given component geometry that will prevent the component from cracking during pressureless sintering by balancing the evolution of strength, which is assumed to be a power law function of the porosity, with the evolution of stress. To develop this model, the powder mixture is considered as a three-phase material consisting of voids, metal particles, and ceramic particles. A micromechanical thermal elastic–viscoplastic constitutive model is then proposed to describe the thermo mechanical behavior of the composite microstructure. Shahrjerdi, et.al.2011 [9] demonstrated the functionally graded metal-ceramic composite fabricated via pressure-less sintering. The pure metallic and ceramic components are Titanium (Ti) and Hydroxyapatite (HA), which were located at the ends of a cylindrical specimen. FG samples are prepared with mixing ratios of 100:0, 75:25, 50:50, 25:75, 0:100. The cylindrical samples had a thickness of 6 mm in size and 20 mm radius. Samples are created by using carbon cylindrical die. The optimum thermal load mapping is obtained