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Sparse recovery based compressive sensing algorithms for diffuse optical tomography

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HIGHLIGHTS

- The DOT reconstruction problem using CS framework.
- The compressive sensing algorithms have studied.
- Experimental validation of CS algorithms.
- Different metrics such as SSIM, MSE have studied.

ARTICLE INFO

Keywords:
Diffuse optical tomography (DOT)
Single measurement vector (SMV)
Greedy algorithms

ABSTRACT

The optical parameters of a tissue such as a highly turbid medium can be reconstructed by the diffuse optical tomography. It is well known that the inverse problem of DOT is nonlinear, unstable and ill posed due to the propagation of photons through the tissue in a zig-zag manner. Though conventional iterative methods have been employed to solve this problem, they seem to be unsuccessful, considering the complex geometries for study. Recently, the compressive sensing (CS) technique has emerged as recent trend in DOT because of its sparse reconstructions for biomedical applications. The main goal of this paper is to formulate the inverse problem as a single measurement vector (SMV) problem by employing the given CS framework. The greedy algorithms such as compressive sampling matching pursuit (CoSaMP), regularized orthogonal matching pursuit (ROMP), stagewise orthogonal matching pursuit (StOMP), and orthogonal matching pursuit (OMP) are extensively studied to reconstruct the 2D map of the absorption parameter change from the tissue boundary data. The conventional method such as least square technique is studied for comparison. The experimental validation of the greedy algorithms is done on a wax circular phantom through a DOT experimental setup. The performance metrics such as mean square error (MSE), structural similarity index (SSIM), and normalized mean square error (NMSE), are used to assess the performance of the DOT imaging in this paper. The extensive study of the simulation results confirm that the greedy algorithms specially, CoSaMP outperform the conventional methods in DOT.

1. Introduction

The diffuse optical tomography (DOT) has been considered as the prominent imaging modality [1–3] by the various research imaging groups in the recent years. In DOT, the tissue to be illuminated by the near infrared light from the various light sources and the boundary data is to be measured at the tissue boundary by the various detectors [4].

It is evident from the DOT imaging methods that the inverse problem of DOT is ill-posed, unstable, and nonlinear [5] because of the light propagated through the tissue follows a zig-zag path. The main focus in DOT is to solve this problem.

The optical parameters of DOT are absorption and scattering coefficients [6]. The reconstruction of the absorption coefficient is the main goal in the inverse problem of DOT. Here, the aim is to image the absorption parameter map by assuming that the scattering parameter is constant in the entire tissue [7].

Generally, the propagation of photons within the tissue undergoes a significant scattering and it is being modelled by using either diffusion

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Original research article

Evidence of Superparamagnetism in nano phased copper doped nickel zinc ferrites synthesized by Hydrothermal Method

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ARTICLE INFO

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Hydrothermal route
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ABSTRACT

Nanophased $Ni_{0.65}Zn_{0.35}Cu_xFe_{(2-2x/3)}O_4$, ferrites with lower dopant concentrations i.e., for x ranging from 0 to 0.05 in steps of 0.01 have been synthesized using hydrothermal route. Structural characterization is carried out by powder X-ray diffraction (XRD), Scanning Electron Microscopy (SEM) and far –IR spectroscopy (FTIR). XRD confirms the formation of pure spinel structure of Ni-Cu-Zn ferrites. Proposed cation distribution is able to explain properties of Cu^{2+} doped Ni-Zn ferrites. Variation of lattice constant **a** is explained through occupancy of dopant ions both in tetrahedral (A)-sites and octahedral (B)-sites. Crystallite size, determined for high intensity (3 1 1) peak using Debye-Scherrer method, W-H plots and Size-Strain plots, is found to exhibit an overall decreasing trend (62.75–31.56 nm) with x. Observed FTIR absorption bands at 400–600 cm^{-1} confirm the formation of ferrite structure. Vibrating Sample magnetometer (VSM) studies reflect upon improved magnetic properties mainly due to adopted hydrothermal synthesis route, replacement of Fe^{3+} ions with very low dopant concentrations of Cu^{2+} ions of the order of 0.01%. Non-linear variation of M_s with x is attributed to Y-K angles and crystallite size. Highest value of M_s of 73.25 emu/gm is obtained for x = 0.02. Relatively higher values of M_s coupled with lower values of H_c in nanophased Ni-Cu-Zn ferrites make them usable for high frequency and power applications. Lower values of coercivity (Hc) observed in the range of 32–80 Oe reveal the soft magnetic nature of these ferrites. Existence of single domain particles witnessed from variation of H_c with **D** indicate the superparamagnetic nature and confirms that these materials can be used for biomedical applications.

1. Introduction

Rapid growth of technology resulting in miniaturization of devices is a consequence of extensive research carried out in the field of material science. [1–3]. Ferrite's feasibility in preparing unfettered solid solutions and their capitative unique electromagnetic features are centric for their utilization in diversified technical applications [4,5], such as adsorbents of pollutants in wastewater treatment, for

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Structural, optical, magnetic and dielectric studies of SnO_2 nano particles in real time applications

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ARTICLE INFO

Keywords:
SnO_2 nano particles
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ABSTRACT

Pure and Aluminium doped (x = 0.01, 0.02, 0.03, 0.04) SnO_2 nano particles have been prepared by Sol Gel method. XRD studies confirm tetragonal structure of SnO_2 and second phase peaks are absent. The obtained crystallite size of undoped SnO_2 is 17.5 nm and with Al insertion Crystallite size reduced to 10 nm for $Sn_{0.96}Al_{0.04}O_2$. FTIR data in the range of 550 cm^{-1}–630 cm^{-1} confirms the vibration modes of Sn—O—Sn and Sn—O in SnO_2 molecules. UV spectrum shows red shift due to the trapping of exitons by oxygen vacancies. In contrast to quantum confinement energy gap decreases from 3.7 eV for undoped SnO_2 and to 2.91 eV for $Sn_{0.97}Al_{0.03}O_2$ due to the band bending, which is the result of particle size reduction and then increases to 3.19 eV. This variation has been explained based on Burstein-Moss effect for $Sn_{0.96}Al_{0.04}O_2$. Impedance studies of undoped and Al doped SnO_2 samples have been investigated at room temperature and found that $Sn_{0.97}Al_{0.03}O_2$ exhibits peculiar behaviour of having high dielectric constant, high A.C. conductivity, low dielectric loss and high theoretically calculated mobility among Al doped SnO_2 samples. The data obtained from Vibration Sample Magnetometer shows typical conversion of magnetic nature of undoped SnO_2 which is diamagnetic to paramagnetic in the case of $Sn_{0.99}Al_{0.01}O_2$ and $Sn_{0.98}Al_{0.02}O_2$ samples and to superparamagnetic nature for $Sn_{0.97}Al_{0.03}O_2$ and $Sn_{0.96}Al_{0.04}O_2$.

1. Introduction

Nano particles exhibit different properties when compared to their bulk counterparts because of high surface to volume ratio and quantum confinement effect. An extensive work his being carried out from decades to hours on the method of synthesis and characterization of nano materials prepared in the form of quantum dots, films, particles, ribbons, wires and tubes. Innumerable applications are found in various electric, electronics and biomedical fields like gas sensors, energy storage devices, solar cells, photovoltaic applications, super capacitors, spintronics, magneto optical and tissue engineering applications [1].

Stannic oxide, popularly known as Tin dioxide (SnO_2), is one of the best materials among transparent conducting oxides. High transparency in visible region and reflectivity in infrared region [2], low electrical resistivity, and high chemical, mechanical and thermal stability [3] are some of the desirable properties of SnO_2. These properties made the compound to be the most essential for many applications in spintronics [4] and magneto optic devices [5], gas sensors [6], photo catalysts [7], solar cells [8] and for lithium-ion batteries (LIBs) and super capacitors [9]. SnO_2 is an n type semiconductor possessing wide, direct band gap of energy 3.6 eV at room temperature [10]. Generally, it exists in Tetragonal (rutile) structure with lattice parameters a = b = 4.737 Å, c = 3.186 Å [11] and belongs to $P4_2/mnm$ space group. The SnO_2 unit cell consists of two Sn^{4+} and four o^{2-} ions. Each of Sn^{4+} is surrounded by six O^{2-} ions occupying the corners of regular octahedron and O^{2-} ions are surrounded by three Sn^{4+} which occupy the three corners of equilateral triangle [12]. Dual valence of Tin (+2 in SnO and +4 in SnO_2) generates compositional variation in oxygen at the surface. This has become the origin for many chemical properties of the material. In order to improve the performance of TCOs of high energy band gap and to explore the unique properties great efforts have been rendered since few decades by doping suitable elements.

Energy band gap of a semi conductor is an important factor, which affect its optical and electrical properties. Doping with an apt impurity material in the host (SnO_2) lattice modifies energy band structure of semi conductor. The various parameters such as temperature, pressure

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PAPER

Dielectric properties of superparamagnetic titanium doped nanophased Mn–Zn ferrites for high frequency applications

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Keywords: nanophased ferrites, dopant concentration, hydrothermal synthesis, dielectric properties, superparamagnetism

Abstract

Effect of Ti^{4+} ions on Structural, Dielectric and Magnetic properties of nanophased $Mn_{0.5}Zn_{0.5}Ti_xFe_{2-4x/3}$($x = 0.0, 0.01, 0.02, 0.03, 0.04$ and 0.05) ferrites synthesized by hydrothermal method is studied. XRD peaks reveal pure spinel phase without extra peaks. Lattice parameter (**a**) is found to vary non-linearly with dopant concentration (x). An overall decrease in Crystallite Size (**D**) (varying from 78 nm–41 nm) with x is witnessed. Values of dielectric constant (ε') and loss factor ($\tan\delta$) of Ti^{4+} doped Mn–Zn ferrites are lower than that of the undoped sample. Increase of AC resistivity (ρ) by an order of 10 in Ti^{4+} doped Mn–Zn ferrites is ensued due to locking of Ti^{4+}–Fe^{2+} pairs. Lowered values of M_s is attributed to spin canting due to growth of nanosized grains, weakening of exchange interactions by non-magnetic Ti^{4+} doping and lower values of x-ray density. Transition from single to multi- domain region of Mn–Zn–Ti ferrites is clearly evinced from the plot of Coercivity (H_c) with D. Reduced value of coercivity to zero upto a critical size of ~49 nm indicates the existence of superparamagnetism in these ferrites. Superparamagnetismis first ever reported in the present caseof Ti^{4+} doped Mn–Zn ferritessynthesized by hydrothermal method. Relatively lowered values of ε' (29–18), $\tan\delta$ (of the order of 10^{-2}–10^{-3}), higher values of ρ (10^6 Ω—cm) and lowered values of H_c obtained with Ti^{4+} doping improve the eddy current losses and direct these materials for high frequency applications.

1. Introduction

Mn–Zn ferrites are an important class of soft ceramic magnetic materials, with relatively low cost, lower core losses, high electrical resistivity and high initial permeability and have a wide range of applications [1] in electronic or electrical peripherals. Rapid development in power electronic devices towards miniaturization tends to increase the operating frequency of the Mn–Zn ferrites to relatively higher values resulting in dramatic increase in power losses. One of the key strategies to improve the electromagnetic properties is to synthesize [2] the nanoferrites from their bulk counterparts. Occurrence of new physical phenomena like quantum confinement and larger surface to volume ratio in the nano regime along with improved power losses and enhanced electrical resistivity are reported [3, 4] in nanophased Mn–Zn ferrites. Owing to these phenomena, they have enormous technological and biomedical applications in ferrofluids, magnetocaloric refrigeration, Magnetic Resonance Imaging (MRI)and guided drug delivery. Although nanoparticles of pure metals like Fe, Co and Ni are found [5, 6] to exhibit superparamagnetism, they have limited applications due to their chemical unstability and relatively lower sizes of few nanometers. On the other hand, magnetic metal oxides such as spinel ferrites have a great potential for applications as they are relatively inert and their properties can be improved [7] by addition of dopants. Single domain particles are formed for critical size varying from 10–40 nm resulting in an increase of coercivity with increase in crystallite size. In this single domain region, reduced coercivity to nearly

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Study of the Structural, Optical, Dielectric and Magnetic Properties of Copper-Doped SnO_2 Nanoparticles

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This work explores the structural, optical and dielectric properties and the magnetic behaviour of copper (Cu) (0–4%)-doped tin dioxide (SnO_2) nanoparticles, synthesized by the sol–gel method using methanol as solvent. X-ray diffraction (XRD) analysis confirmed the tetragonal structure of SnO_2. The inclusion of Cu in the SnO_2 lattice enhanced the crystallite size of the Cu-doped SnO_2 nanoparticles, as determined by the Scherrer method, and crystallite sizes were found to be consistent with the Williamson–Hall method. The morphology, observed by field emission scanning electron microscopy (FESEM) and transmission electron microscopy (TEM), revealed the formation of uniformly distributed nanoparticles of spherical shape. The formation of a characteristic peak in the range of 480–750 cm^{-1} was associated with an antisymmetric O-Sn-O bridge functional group of SnO_2. The reduced band gap is in accordance with the quantum confinement effect in synthesized samples. Strain-influenced dielectric studies conducted at room temperature within a frequency range of 1 Hz to 7 MHz revealed a relatively high dielectric constant, AC conductivity and low dielectric loss. Here, for the first time, electric modulus formalism is adapted to analyse the relaxation mechanism in Cu-doped SnO_2 nanoparticles. The relaxation peak shift towards lower frequency ($\approx$ 1 kHz) in the investigated samples indicates the short-range mobility of ions and longer relaxation times. The transition from a diamagnetic to a paramagnetic state is confirmed by the addition of Cu content in the SnO_2 lattice. The observed paramagnetism of the Cu-doped SnO_2 nanoparticles is correlated with lattice strain. Cu doping led to an increase in magnetic moment on the order of 10^{-1} emu/g. The synthesized samples with high dielectric constant, low dielectric loss and paramagnetic behaviour are found to be efficient candidates for high-frequency devices and biomedical applications. The longer relaxation times may make them suitable for future memory materials.

Key words: Lattice parameter, nanoparticles, sol–gel, porosity, dielectric constant, coercivity

INTRODUCTION

Wide-band-gap transparent conducting oxides (TCOs) have been enriching the class of nanomaterials for decades. Researchers of the twenty-first century have shown an intense interest in nano-

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Full Length Article

Studies on nano crystalline copper doped Nickel Zinc ferrites for optoelectronic applications

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ABSTRACT

Investigation of optical and dielectric properties of nanocrystalline $Ni_{0.65}Zn_{0.35}$ Cu $_x$ $Fe_{(2-2x/3)}$ O_4 (for x = 0.00–0.05 in steps of 0.01) ferrites synthesized using hydrothermal route is successfully carried out. Two distinct analytical spectroscopic methods with Dichloro – 5,6-Dicyano – 1,4-Benzo quinone (DDQ) and Bromo Phenol Blue (BPB) are adopted to observe the UV–visible absorption spectroscopy in the dispersed solutions of all samples. The formation of ion pair complex in the presence of BPB results in two distinct absorption edges in the visible region, around 440 nm and 580 nm in the present ferrite samples. Application of Tauc's formalism gives rise to two optical band gap values E_{g1} and E_{g2} in the range of 2.12–2.40 eV and 3.583–3.674 eV, respectively. The formation of charge transfer complex with all sample solutions in presence of DDQ reagent results in sharp absorption edges in the UV-region around 306 nm wavelength. An initial rise followed by continuous drop in band gap values ranging from 3.814 to 3.824 eV is observed from Tauc's plots. The optimum refractive index (n) values calculated for the three types of band gap values using empirical relations display the optical absorption potentiality of Ni–Cu–Zn nano ferrites in both Visible and UV – regions. Variation of band gap values is ascribed to the lattice strain effect, quantum confinement and narrowing band gap effects. Real part of dielectric constant (ε'), dielectric loss factor (tanδ) and ac-conductivity(σ_{ac}) are studied for all samples at room temperature with in the frequency range of 42 Hz to 5 MHz. The values of ε' and tanδ are observed to decrease with increase in frequency, while that of σ_{ac} are found to increase with increase in frequency. Improved dielectric properties, existence of optical band-gap values observed in the present Ni–Cu–Zn ferrites promote these materials for their utility in optoelectronic devices and high frequency applications.

1. Introduction

Unique features and a wide range of applications of spinel ferrites in various fields have led to great interest of researchers worldwide. Quantum confinement and increase in surface to volume ratio of nano particles improve the intentness of exploration of nano ferrites in multifarious dimensions. Spinel ferrites with general formula, MFe_2O_4, where M is a divalent transition metal ion (Ni, Zn, Fe, Co, Cr, Mn, Mg, Al, etc.) or a combination of two or more metal ions, have revealed their good bio-compatibility, low toxicity, and innovative electromagnetic functionalities depending upon their composition and microstructure [1]. Among them, it is well known that Ni–Zn ferrites are a class of soft ferrites with prevalent usage in high frequency applications and electronic industry owing to their relatively larger values of magnetization, permeability, curie temperature, resistivity, quality factor and lower values of power loss at high frequency [2]. Ni–Zn ferrites render them a fortified optimal system for power transformer cores, high frequency electronic and telecommunication gadgets, in designing good quality microwave devices such as isolators and switches [3]. The structural, electrical, dielectric, optical and magnetic properties of Ni–Zn spinel ferrites are regulated by the cation distribution among the tetrahedral (A-site) and octahedral (B-site) positions in the crystal structure and so as the method of synthesis, sintering temperature, sintering time, chemical composition and dopant ions. Studies on manipulating optical

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Adsorptive removal of toxic Methylene Blue and Acid Orange 7 dyes from aqueous medium using cobalt-zinc ferrite nanoadsorbents

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ABSTRACT

Cobalt-zinc ferrite nanoparticles of general formula $Co_{1-x}Zn_xFe_2O_4$ ($0.0 \leqslant x \leqslant 1.0$) were synthesized by means of chemical co-precipitation method. Impedance analysis was used to study the grain and inter-grain conductivities. The changing of complex conductivity with composition confirmed the semiconducting behavior. A significant influence of Zn concentration on dielectric properties was observed. The obtained Co-Zn ferrites were examined as magnetic adsorbents using both cationic and anionic dyes as model pollutants. Substitution of zinc ions with cobalt ones resulted in changes in sorption characteristics. The efficiency of Methylene Blue (MB) dye removal was increased with increasing Co content. On contrary, efficiency of Acid Orange 7 dye removal was increased with increasing Zn content. The adsorption of the both anionic and cationic dyes onto ferrite nanoparticles agreed well with the Langmuir isotherms. The maximum adsorption capacity for the Acid Orange 7 dye was reached up to 31 mg/g using $ZnFe_2O_4$, while the maximum adsorption capacity for the cationic Methylene Blue dye was found to be 3.4 mg/g on $Co_{0.9}Zn_{0.1}Fe_2O_4$. The relation of adsorption efficiency with ionic-covalent and acid-basic parameters of the ferrite surface was also discussed.

Keywords: Ferrite nanoparticles; Magnetic sorbents; Dyes; Surface

1. Introduction

Adsorption is well known as affordable and efficient method of water purification. A huge number of sorbents based on diverse materials such as activated carbon, clay minerals, waste biomass, agricultural by-products etc. have been proposed for the removal of various types of pollutants from aqueous medium [1–4]. In the recent decades, literature reports the information about the sorbents with magnetic properties possessing the advantage of after-use separation by means of external magnetic field. Among the magnetic sorbents, the most promising materials are ferrite spinels possessing adjustable crystalline structure [5,6]. Year-to year, spinel ferrite sorbents attract ever increasing attention of

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Development of graphene oxide based hybrid metal oxide nanocomposites of GO-SnO_2/ZnO/Fe_3O_4, GO- SiO_2/ZnO/Fe_3O_4 for energy applications

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ABSTRACT

The research paper aimed at the development of multifunctional hybrid metal oxide nanocomposites with Graphene oxide (GO) as active surface framework. The hybrid metal oxide nanocomposites (SnO_2/ZnO/Fe_3O_4, SiO_2/ZnO/Fe_3O_4) were achieved by the simple chemical double co-precipitation technique. The GO layers were achieved by modified hummer's method with a thickness of 5.42 nm. The GO integrated composites (GO-SnO_2/ZnO/Fe_3O_4, GO-SiO_2/ZnO/Fe_3O_4) were developed by the *ex-situ* technique through sonication. The nanocomposites were structurally confirmed by the powder X-ray diffraction (PXRD), Transmission Electron Microscopy (TEM), Selected Area Electron Diffraction (SAED), elemental mapping and EDAX studies. These results confirmed the formation of composites. Furthermore, the application of these GO based nanocomposites were examined for dielectric applications. These results were compared with the bare composites, the addition of GO a better ϵ' with temperature was observed at lower frequency region.

1. Introduction

Presently, researchers focused on the multifunctional hybrid nanomaterials by integrating two or more nanomaterials (semi conductive, carbon based, inorganic and polymeric materials) to address different challenges in energy systems, stability, high efficiency and low-cost processes. The integration of nanostructure materials can generate superior multifunctional properties to exhibit a variety of applications in chemical, biological sensing, heterogeneous catalysis, energy conversion and storage, environment and human health. In the recent times, Graphene-based nanocomposites have attracted considerable attention due to their unique properties and variety of applications in sensing, energy storage, catalysis [1–6]. These enormous applications of GO are due to high specific area [7], chemical inertness [8], great mechanical strength [9], excellent thermal and electrical conductivities [10] etc and therefore GO as an active surface framework for functional nanoparticles for opening of different research areas. GO possesses sp-3 hybridized carbon atoms which are covalently decorated with oxygen containing functional groups of hydroxyl, epoxy at basal planets of carbon sheets and carbonyl and carboxylic groups at the edges which provides GO with a remarkable hydrophilic character and chemical reactivity. Also, the oxygen containing functionalities can act as active sites for adsorbing different metal oxide nanoparticles [3,7,11]. However Graphene showed better properties but its effective usage was hindered by restacking. This might be avoided by integrating with inorganic materials. It was reported in the literature that Go-and its derivatives when combined with inorganic nanoparticles such as SnO_2 [12–14], ZnO [15,16], TiO_2 [17,18], ZrO_2 [19,20], Fe_3O_4 [21] [–] [23], Fe_3O_4@ZrO_2 [24], Ag@TiO_2@SiO_2 [25], MnO_2 [26,27], Ta@GO@MgO [28],V_2O_5 [29,30] exhibited prominent properties. Based on the previous work on the mixed metal oxide hybrid nanostructures for improved energy applications [31,32] and the present work is aimed at the development of Graphene oxide supported hybrid nanostructures of SnO_2/ZnO/Fe_3O_4 and SiO_2/ZnO/Fe_3O_4 through ex-situ mixing method. The developed nanocomposites were examined for dielectric applications by comparing the individual SnO_2/ZnO/Fe_3O_4 and SiO_2/ZnO/-Fe_3O_4 with the GO structures.

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Investigation of structural, magnetic, and electrical properties of Ru doped brownmillerite oxide: $KBiFe_2O_5$

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HIGHLIGHTS

- Ruthenium (Ru) doped $KBiFe_2O_5$ brownmillerite nanomultiferroic nanoparticles were prepared by coprecipitation route.
- Ru influence the magnetic and electrical properties of $KBiFe_2O_5$.
- Facile route resulted uniform grain with dense microstructure formation.
- Ru dopant influence the optical and electrical bandgap.

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ABSTRACT

We studied and reported the Ruthenium (Ru) doped KBF ($KBiFe_2O_5$) multiferroic nanoparticles on structurl, magneitc and electrical properites as a function of dopant and temperature, synthesized through coprecipitation route. X-ray Diffraction spectra of all the samples were indexed with orthorhombic structure (space group P_{21am}) at room temperature and lattice constant decreased with Ru substition. The structural parameters including bond lengths and angles were refined using a standard Rietveld program. Average crystallite measured from schereer method increases with increasing annelaing temperature. Morphology from TEM confirms control over uniform distribution of particle size and shape. Zero field-cooled (ZFC)-Field-Cooled (FC) magnetic measurements reveals superparamagnetic behaviour above room temperature. Magnetic hysteresis loops (M − H) measured at 5 K and 300 K shows improvement with Ru substitution. An insginificant decrease in optical band gap 2.35 to 2.23 eV observed from UV–Vis spectroscopy with Ru substitution. Ferroelectric loops resembling lossy dielectric nature of unpoled samples. Activation energy estimated from DC electrical resistivity was found to be 0.6 eV. Room temperature Dielectric data revelas Maxwell-Wanger type dielectric dispersion and analyzed based on the intrinsic and extrinsic parameters.

1. Introduction

Multiferroics (MFs) consolidate the macroscopic and microscopic properties of structure and crystallinity of the material in terms of their ferroic (Ferroelasticity, Ferromagnetic and Ferroelectricity) orders. The dynamical magnetoelectric (ME) coupling between dielectric and magnetic orders of MF materials is the fundamental building block of spintronics and hybrid memory systems [1–3]. Furthermore, MF orders demonstrate the establishment of magnetic point group in which the magnetic field control of electric polarization is employed [4–6]. This integrates the ME, optical, magnetic, and dielectric studies on single crystals and single domains. Switching the direction of ferroic order and the existence of spontaneous macroscopic property with/without the influence of external field are most focused for future commercial application [2]. A careful study of magnetoelectricity with semiconducting properties in a single structure at room temperature (RT) can advance the spintronics.

$BiFeO_3$ (BFO) is widely considered Type-I MF possessing feeble G-

Abbreviations: PPMS, physical property measurement system.

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Mn Modified Mesoporous TiO_2 Particles: Synthesis, Characterization and Photovoltaic Application

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In this work, manganese (Mn) modified mesoporous titanium dioxide (Mn-MT) particles were synthesized by a hydrothermal process using an impregnation method and cetyltrimethylammonium bromide as a template. This method enables synthesis at relatively low temperatures, with good surface modification resulting in ordered spherical particles. To verify the modifications in structural properties, x-ray diffraction (XRD) studies were carried out. A pure anatase phase was exhibited by both MT and Mn-MT particles. XRD patterns showed no evidence of secondary phase formation after surface modification with Mn. Optical studies of these particles were analysed by band gap studies. Both the optical and electron spin resonance studies revealed the presence of Mn in the 2^+ state. Finally, these particles were coated on Si solar cells and exhibited an overall increase in efficiency of 15% when compared with bare cells, which can be attributed to better surface passivation.

Key words: Mesoporous, titanium dioxide, x-ray diffraction, photovoltaic, electron spin resonance

INTRODUCTION

Since its discovery, titanium dioxide (TiO_2) has been extensively studied, and has been used for a wide range of applications. This is mainly because TiO_2 is chemically stable and environmentally friendly.[1–3] Various research groups have shown applications of titanium dioxide materials in photocatalysis and for renewable energy.[4–8] Among all the phases which TiO_2 can exhibit, the anatase phase of TiO_2 is often preferred because it offers high structural stability and high discharge voltage.[2] It is often used as a negative electrode, as in the case of Li-ion batteries. There are also reports that photo-conversion efficiency has been improved by using differently shaped TiO_2 nanoparticles (NPs) in dye-sensitized solar cells as a photo anode material.[3,9–11] TiO_2 in its anatase phase has a band gap of 3.3 eV, which indicates that under ultraviolet light it exhibits high reactivity and chemical stability. This limits the usage of the material in the visible region.[1] In order to extend the usage of this material over the visible region, many research groups have tried to reduce the band gap by doping, surface modification or by photosensitizing the surface of TiO_2.[4,5] Over the past few decades various methods have been proposed to synthesize anatase TiO_2 in various forms. Because of the readiness of chemicals and low cost with a good reproducibility, the hydrothermal process has emerged as preferred among all the methods.[6–15]

Synthesis of meso, micro and nanostructures with different morphologies has been studied extensively to observe their structural effects on photo-catalytic

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ORIGINAL PAPER

Correlation Between Structural, Magnetic and Dielectric Properties of Microwave Sintered Ni-Zn-Al Nanoferrites

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Abstract
A series of diamagnetic aluminum (Al^{3+}) substituted Ni-Zn Nanoferrites have been synthesized using sol-gel auto combustion route. Structural, magnetic, and dielectric properties were systematically studied and reported with respect to Al^{3+} substitution in host Fe^{3+} ions. X-ray diffraction (XRD) and infrared spectroscopy (IR) measurements confirm the presence of Al^{3+} ions at both A and B sites. Cation distribution proposed from XRD and IR correlates with magnetic and dielectric results. It is observed that Al^{3+} ions are distributed in to tetrahedral and octahedral sub-lattices. The saturation magnetization varies between 58.5 and 44.2 emu/g with increasing Al^{3+} substitution. This decrease in magnetization is ascribed to presence of the non-collinear spin (canted spin) structure in octahedral sub-lattice. Dielectric constant decreased and a significant improvement in AC resistivity is observed with Al^{3+} substitution. The observed variations are accounted on the basis of cation distribution in spinel ferrite.

Keywords Ni-Zn ferrite · Microwave sintering · Al^{3+} substituted ferrites · FT-IR spectra · Magnetic and dielectric properties

1 Introduction

Research in nanocrystalline ferrites has increased dramatically in recent years, due to their viability to serve in wide range of applications like sensors, phase shifters, amplitude modulators, and optical wave devices and in devices from microwave to radio frequencies [1–5]. Due to the miniaturization, devices with small size and exhibit high performance are necessary not only to reduce the cost but also to improve efficiency of the system. Among the many available ferrite systems, Ni-Zn ferrite is a promising ceramic magnetic spinel and used in low- and high-frequency transformer cores, antenna rods, and microwave devices because of its inherent properties like high resistivity high saturation magnetization, high Curie temperature, low dielectric losses, relatively high permeability, and chemical stability [6–8]. However, ionic radii, particle size, grain size, grain structure, porosity, and cation distribution among the crystallographic lattice sites play a major role to use Ni-Zn ferrite for a specific device application [9–12].

It is established that doping of various magnetic or non-magnetic elements in spinel ferrite results in cation disorder/redistribution and frustration at tetrahedral (A) and octahedral (B) sub lattice, which further tailors the electrical and magnetic properties [13–15]. In particular, when a diamagnetic Al^{3+} ions are introduced at lower proportion in the spinel ferrite, it dilutes the net magnetic nature of the system and shows a significant control over magnetic and electric properties, which further allow to tune for a specific application [16–20]. These reports infer that Al^{3+}-substituted ferrites enhance resistivity and posses low coercive field and thus good core materials for power transformers in communication applications. Apart from the dopant substitution, preparation, and sintering method, temperatures are also key factors, which dramatically influence the properties. In general, conventional ceramic method is widely used for the synthesis of ferrites, which produces non-stoichiometry product due to prolonged heating at elevated temperatures [21]. To address this wet

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Structural, electrical and magnetic properties of cobalt ferrite with Nd^{3+} doping

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Abstract A systematic study on the influence of Nd^{3+} substitution on structural, magnetic and electrical properties of cobalt ferrite nanopowders obtained by sol–gel auto-combustion route was reported. The formation of spinel phase was confirmed by X-ray diffraction (XRD) data, and percolation limit of Nd^{3+} into the spinel lattice was also observed. Fourier transform infrared spectroscopy (FTIR) bands observed $\approx$ 580 and $\approx$ 390 cm^{-1} support the presence of Fe^{3+} at A and B sites in the spinel lattice. The variation in microstructure was investigated by scanning electron microscopy (SEM), and the average grain size varies from 5.3 to 3.3 μm. The substitution of Nd^{3+} significantly affects the formation of pores and grain size of cobalt ferrite. Room-temperature saturation magnetization and coercivity decrease from 60 to 30 $mA \cdot m^2 \cdot g^{-1}$ and 19.9–17.8 mT, respectively, with Nd^{3+} substitution increasing. These decreases in magnetic properties are explained based on the presence of non-magnetic nature of Nd^{3+} concentration and the dilution of super-exchange interaction in the spinel lattice. The room-temperature direct-current electrical resistivity increases with Nd^{3+} concentration increasing, which is due to the unavailability of Fe^{2+} at octahedral B sites.

Keywords Co-Nd ferrite; Saturation magnetization; DC resistivity

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1 Introduction

In recent years, among the family of spinel ferrites, cobalt ferrite has been rigorously investigated due to its tremendous applications in high-density magnetic recording media, microwave devices, high-sensitivity sensor and biomedical industries [1–4]. Apart from the promising electronic applications, they are also suitable and widely used in environmental remediation applications due to their excellent physical and chemical properties like high saturation magnetization, low cost, size- and shape-dependent and catalytic properties [5, 6].

The structural, electrical, magnetic and dielectric properties of cobalt ferrite are governed by the factors like method of preparation, sintering time and temperature, chemical composition, type and concentration of dopant. The spinel unit cell consists of cubic closed-pack arrangement of oxygen ions with 64 tetrahedral (A) and 32 octahedral interstitial sites (B). Out of these 96 interstitial

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Enhanced humidity sensing and magnetic properties of bismuth doped copper ferrites for humidity sensor applications

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ABSTRACT

In present investigation, the $CuFe_{(2-x)}Bi_xO_4$ (where, x = 0.00, 0.01, 0.02, 0.03) nanoparticles synthesized by solution combustion technique using mixture of fuels as glucose and carbamide. The refined XRD (X-ray diffraction) patterns of the samples confirms the spinel cubic structure having space group *Fd3m*. The average crystallite size was found to be in nanometer. The lattice parameter, volume, strain and hopping lengths were estimated. TEM (Transmission Electron Microscopy) micrographs confirm the particles are agglomeration. SAED (Selected Area Electron Diffraction) pattern reveals the polycrystalline nature of the material. The magnetic nature of spinel ferrite can be explained by Neel's two sub-lattice model. In the present work, the observed decrease in magnetization can be ascribed to occupancy and migration of cations at/from B sites by the substitution of Bi^{3+} ions. The magnetic parameters such as saturation magnetization, remanent magnetization (M_r), coercivity field (H_c), remanence (S), uniaxial anisotropy (K_u) and cubic anisotropy (K_c) were estimated. The resistance and humidity sensing responses increases with increase of the Bi^{3+} concentration. The hysteresis curves reveal the desorption process is somewhat slower than the adsorption process. The sensing response time 73 s was recorded when sample was moved from 11% RH to 97% RH and the recovery time 36 s was recorded when sample was moved from 97% RH to 11% RH. The humidity sample shows exceptionally stable response at relative humidity 99% RH and 33% RH.

1. Introduction

Copper ferrite nanoparticles have pulled in significant consideration due to their specific properties [1–4]. Thus, copper ferrite nanoparticles are intensively studied and developed for industry application such as transformer, information storage, ferrofluid and high frequency devices [1,5].The difference in the properties of the nanoparticles are mainly ascribed to crystallite size because of the fraction of atoms on the surface compared to the bulk [6]. The $CuFe_2O_4$ (copper ferrite) nanoparticles having the inverse spinel cubic structure [7,8]. The $CuFe_2O_4$ is in the form of AB_2O_4 structure where, Cu^{2+} ions occupying tetrahedral site (A-site) and Fe^{3+} ions occupying octahedral site [6]. In recent years, Spinel ferrites are attention turned towards their use in biomedical applications as drug carriers [9], contrast agents [10] and in cancer treatment by magnetic hyperthermia [11,12]. Now a days, the science and technology mainly depend on sensing materials and devices. Humidity sensor devices could be used in great potential applications such as chemical gas purification, food packaging, textile for industries field, and also in agriculture and medical fields [13,14]. The humidity sensor materials can be fabricate based on ceramics, polymers and organic compounds. The humidity sensing materials are improving their sensing response, response and recovery time with

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Original research article

Hybrid Unscented Kalman Filter with Rare features for Underwater Target tracking using Passive Sonar Measurements

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ABSTRACT

A Novel estimator called as Hybrid Unscented Kalman Filter(HUKF) is developed in the paper to tackle the issue of passive target tracking in underwater scenarios using bearing-only measurements (captured by a towed array). As the name indicates the algorithm is a hybrid one obtained by combining three existing algorithms namely UKF, Integration technique and Pre-processing mechanism to yield much better performance than any of them individually. The sensor noise reduction in spatial measurements caused by integration technique together with noise reduction in time measurements caused by Pre-processing mechanism in successive time iterations cumulatively contribute to the improvement in performance. Moreover the montecarlo simulations in Matlab(R2009a) provide evidence that, HUKF also display attractive features like Optimal Performance(produce less estimation errors at less computational complexity), Efficient Tracking in critical conditions(long ranges/severe noise) and Non-Divergence even with nasty initialization. Lastly the algorithm can be helpful in promoting TA usage on regular basis despite of the associated maneuvering issues.

1. Introduction

War conditions mainly demand two technical things one is the defensive approach of hiding called as stealth technology while the second one is the aggressive approach called attacking. Attacking primarily concentrates on the detecting, tracking and blasting the enemy with a torpedo. The paper concentrates on developing the tracking technology used in the process of attacking the enemy. Tracking deals with localization of the enemy which involves estimation of the current as well as the future location of the target with the help of measurements mixed with troubling intensity of noise. Targets wandering in air and water are tracked by radar and sonar respectively. Tracking targets using sonar is possible by using active or passive measurements. Active mode measurements are generated by releasing, capturing the echo and processing them while the passive mode measurements are collected by listening to the propeller sound produced by the enemy's vehicle. In the current research the underwater moving vehicle is tracked by using passive mode sonar which is assisted by a set of sensors called Towed array(sensor Array towed/dragged by the observer).

Different estimators and their variants were designed to deal with the issue of target tracking in the course of time. In this queue the first one to be discussed is the Kalman filter [1]. This three step algorithm first starts with a blind guess(step called initialization) of the estimate then improves it with target dynamic properties (step called prediction) and then refines it with the measurements provided by the sensor(step called updation). The iterative process converges the estimation error towards zero as time progress. This basic design was used in the earlier stages for active tracing problem but incompatible(linear) nature of the KF limits its usage for passive

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Conditioned measurement fused estimate Unscented Kalman filter for underwater target tracking using acoustic signals captured by Towed array

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ABSTRACT

In the paper, an algorithm named Robust Unscented Kalman filter (R-UKF) is proposed to handle the popular ocean issue called underwater passive object/target tracking in a more efficient manner than the conventional algorithms. This R-UKF algorithm using acoustic signals supplied by a Towed array is developed when two novel Techniques named as Estimate Fusion (EF) Method and Measurement Conditioning (MC) Method are applied simultaneously to the existing Unscented kalman filter (UKF). Estimate Fusion method and Measurement Conditioning methods operate on the principles of weighted averaging of measurements in space and time respectively. EF Method contributed to the improvement by believing that the collective opinion about state estimation is much better than the individual opinions. This is accomplished by relying on Multiple sensors of TA and Multiple Intermediate estimators instead of single one. On the other hand MC method contributed to the improvements by application of the soothed measurements instead of traditional ones. The soothing is possible by weighted averaging of the current and track of past sensor data. Montecarlo simulations in Matlab(R2009a) shows that, R-UKF display better performance that its base algorithm UKF. Moreover, Optimal Performance (produce low estimation errors without demanding complex processors) of R-UKF makes it even more attractive.

1. Introduction

Tracking is a sophisticated signal processing concept used for computation of the current location of the target. It also deals with anticipation of target's future location (in proximity to the true position), with the assistance of the noisy sensor measurements. Tracking is only possible with the support of Radar/Sonar. Targets moving on land or in air can be tracked with Radar while underwater moving targets can be tracked with Sonar. Sonar inturn can be operated in two modes namely Active/Passive mode. Active mode sonar provides information related to distance and angle (Range and Bearing) of the target, while passive mode sonar is only capable of capturing angle (Bearing information). The sonar while operating in passive mode can be assisted by a single sensor or Multi-sensor array. The Multi sensor array can be of two types namely Hull Mounted array sensors type (HMA) and Towed array sensors type (TA). The authors performed target tracking in the context of the underwater scenarios with the help of a passive mode Sonar. The Sonar in turn collects data from a Multi-sensor array of TA type.

In the older generation of the target tracking, stochastic algorithms like Least Squares estimator (LSE), Weighted LSE (WLSE), and weiner filter (WF) served the purpose. However the new generation of the target tracking started with the proposal of R.E. Kalman [1]. The algorithm was named as Kalman filter (KF) later, was the most advanced stochastic algorithm at that time. The KF operates in three vital steps namely initialization, forecasting and updation. The initialization of the algorithm parameters like the estimate and covariance is performed only once at the beginning of the algorithm. On the other hand forecasting step is performed before the reception of the measurements using the state equation while updation is done after the measurements are received in such a manner that the associated mean square error is minimized.

After the inception of the basic form of KF, attempts were made to fit it to the issue of tracking targets with the active sonar measurements. But this didn't happen in a smooth manner because of the linear nature of KF (KF is linear while the problem is nonlinear). In order to deal with the situations, the hydrophone measurements which are available in the angular (polar) form are transferred to the rectangular form to make the issue look like a linear one and

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A novel estimation algorithm for torpedo tracking in undersea environment

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Abstract: A novel estimation algorithm is introduced to handle the popular undersea problem called torpedo tracking with angle-only measurements with a better approach compared to the existing filters. The new algorithm produces a better estimate from the outputs produced by the traditional nonlinear approaches with the assistance of simple noise minimizers like maximum likelihood filter or any other algorithm which belongs to their family. The introduced method is extended to the higher version in two ways. The first approach extracts a better estimate and covariance by enhancing the count of the intermediate filters, while the second approach accepts more inputs so as to attain improved performance without enhancement of the intermediate filter count. The ideal choice of the placement of towed array sensors to improve the performance of the proposed method further is suggested as the one where the line of sight and the towed array are perpendicular. The results could get even better by moving the ownship in the direction of reducing range. All the results are verified in the MATLAB environment.

Key words: estimation algorithm; torpedo tracking; angle-only measurements; line of sight; maximum likelihood filter

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1 Introduction

Tracking is a process of computing the present position of the target. It also involves estimation or anticipation of the future position of the target as close to the true position as possible with the help of the available noisy measurements. The tracking is done with the help of the radar and sonar. Radar stands for radio detection and ranging and it is used to track targets in the air and on land, while the sonar stands for sound navigation and ranging and it is used to track targets in the underwater scenarios. In our paper we are dealing with underwater torpedo tracking so, we are concerned with only the sonar measurements. The sonar can again operate in two modes namely active and passive modes. In active mode of operation of sonar, the principle of operation is that a sound signal will be transmitted towards the target and after some time an echo is heard. Based on the time taken by the signal to travel toward the target and back to us we can find the range of the target and based on the direction from which the echo is received we can find the azimuth at which the target is present. So in active mode of operation of sonar we get both the range and bearing information of the target. The alternate approach is the passive tracking [1, 2] where no signal will be released by us and we will only collect the information from the enemy which is produced by the propellers of the enemy vehicle. Because of this advantage we are concerned only

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GPS Receiver Position Augmentation Using Correntropy Kalman Filter in Low Latitude Terrain

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Abstract: *If any Global Positioning System (GPS) receiver is operated in low latitude regions or urban canyons, the visibility further reduces. These system constraints lead to many challenges in providing precise GPS position accuracy over the Indian subcontinent. As a result, the standalone GPS accuracy does not meet the aircraft landing requirements, such as Category I (CAT-I) Precision Approaches. However, the required accuracy can be achieved by augmenting the GPS. Among all these issues, the predominant factors that significantly influence the receiver position accuracy are selecting a user/receiver position estimation algorithm. In this article, a novel method is proposed based on correntropy and designated as Correntropy Kalman Filter (CKF) for precise GPS applications and GPS Aided Geosynchronous equatorial orbit Augmented Navigation (GAGAN) based aircraft landings over the low latitude Indian subcontinent. The real-world GPS data collected from a dual-frequency GPS receiver located in the southern region of the Indian subcontinent (IISc), Bangalore with Lat/Long: 13.021°N/ 77.5°E) is used for the performance evaluation of the proposed algorithm. Results prove that the proposed CKF algorithm exhibits significant improvement (up to 34%) in position estimation compared to the traditional Kalman Filter.*

Keywords: *Accuracy, correntropy, correntropy kalman filter, global positioning system, kalman filter.*

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1. Introduction

The generic term preferred for the satellite-based navigation system is the Global Navigation Satellite System (GNSS), which covers global satellite constellation such as Global Positioning System (GPS), Global Orbiting Navigation Satellite System (GLONASS), BeiDou, Galileo, etc., Currently, GPS is the only full-fledged global satellite constellation system in GNSS; it has 32 satellites more significant than the nominal figure of 24 satellites. All over this globe, a minimum of 14 to 18 satellite signal systems are available andoperating fully for various sources since 1995 in both civilian and military fields. For continuous worldwide coverage, the arrangement of GPS satellites is such that four satellites are arranged in each of 6 orbits [19].

The estimation problem has been a significant issue in industrial application and research areas covering the processing of signals, optimization, and navigational decisions; many marked fields requiring estimation, identification of system, tracking of the target, and localization. In linear dynamics and systematic applications, Kalman Filter (KF) is used to solve estimation. In general, KF and its modifications [12, 13, 15, 20, 23] have excellent performance in Gaussian variety noises. However, their operations get degraded when non-Gaussian situations are predominantly in a system with disturbance of impulsive noises. Aforementioned, KF and Extended Kalman Filter (EKF) [12, 13, 20] are not suitable for systems that are disturbed by heavy-tailed impulsive noises. Thus, modifications in the KF are necessary to overcome this difficulty. In this paper, KF has been modified based on the correntropy criterion [17] to improve the accuracy of GPS receiver position in low latitude regions like India. The proposed Correntropy Kalman Filter (CKF) adopts the robust correntropy criterion as the optimality criterion instead of using the well-known Minimum Mean Square Error (MMSE). Unless mentioned in this article, correntropy of error may be utilized as a cost function for adaptive training of the system. It perceives that correntropy, having the advantage of being local, can be useful for the situations in which the measurement noise has a non-zero mean, non-Gaussian pattern with large outliers. Like the traditional KF, the state mean vector and covariance matrix propagation equations give prior estimations of the state and covariance matrix in CKF. A novel Fixed-point algorithm is then used to update

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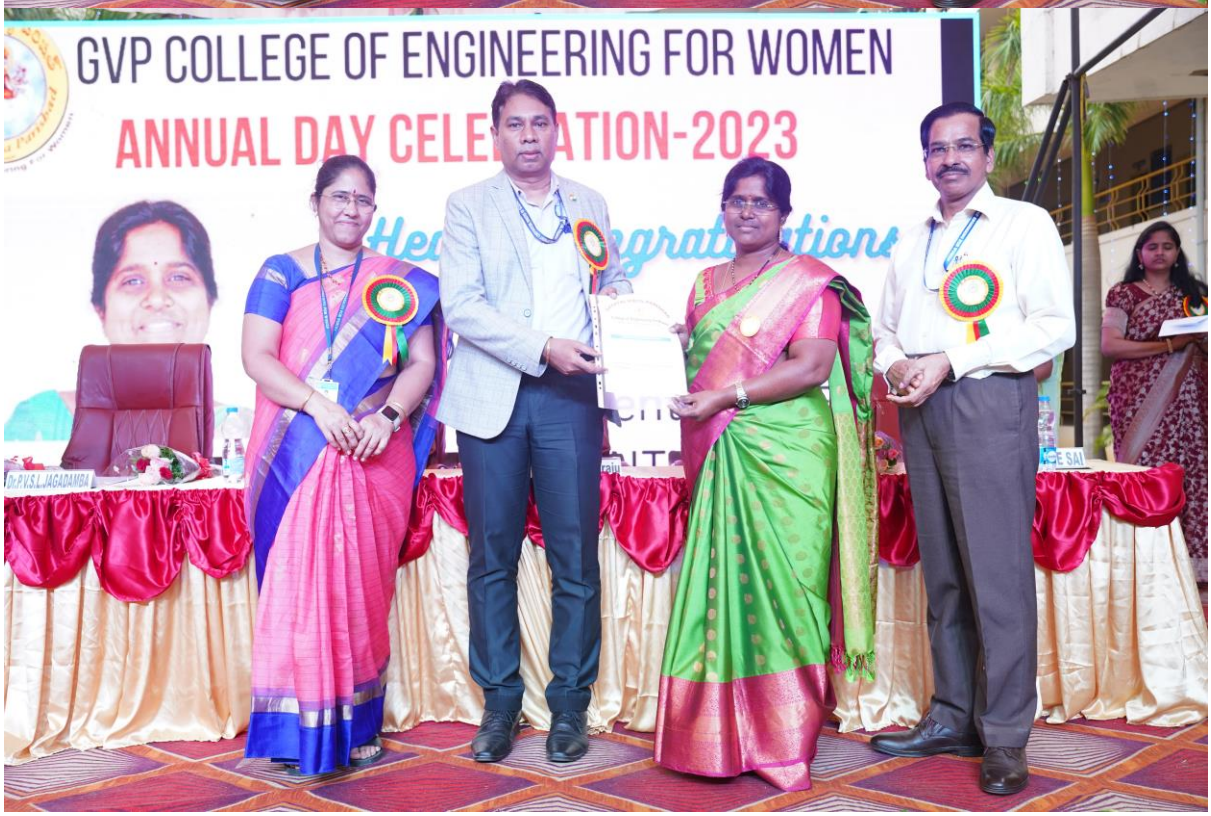

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