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Synthesis, Characterization of Hybrid Nanomaterials of Yttrium-Nickel Doped with Cobalt Possessing Dielectric Characteristics

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Abstract: Objective: A set of different nanocomposites of yttrium-nickel has been prepared through co precipitation and surface reduction methods. The synthesized material of various compositional has been doped with cobalt (1-4 %), isolated by forming gelatinous network and obtained hybrid nanocomposite material. The material was investigated for their transistor properties .Method: Nanocompositional hybrid materials were prepared by co precipitation method with composition of Ni 0.9 Y 0.2 moles with 1-4 % of Co, the reduction is done using cetyl trimethyl ammonium bromide (CTAB), gelated precipitate of hybrid nanomaterials were calcinated at different temperatures. Nanocompositioinal hybrid derivatives were characterized by XRD, FT-IR, UV-Vis, SEM spectroscopic techniques. The VR characteristics and complex impedance constants of the pelletalized samples were examined at room temperature. The precursor material used for the synthesis is nickel chloride and yttrium oxide which are reduced in presence of CTAB and urea .The aqueous mixture of violet coloured precipitate was filtered, washed with octanol-triethyl alcohol mixture (1:1 volume %) to remove any impurities present with the precipitate, dried at 50-120 °C, heat treated at 650-750 °C and obtained pure nanocomposite. Findings: Initial spectroscopic studies showed that grain size of cobalt was 20-30 nm in diameter. XRD pattern demonstrated the formation of trigonal nickel and dopant addition considerably affect the crystal structure.
Keywords: Nanocomposite, yttrium oxide, CTAB, Co precipitation, Hybrid nanomaterials

I. INTRODUCTION

A novel nanocomposites [1-5] of yttrium-nickel doped with cobalt has been prepared by co-precipitation methods [6, 7]. Yttrium oxide is used as precursor and by using ammonium hydroxide as gelation agent (P^H more than 12) during the co precipitation high basicity is maintained [8,9]. The Y-Ni nanocomposites were obtained by using cetyl trimethyl ammonium bromide as surfactant as well as reducing agent in presence of urea and concentrated HCl at reflux condition in ethylene glycol as solvent. The reddish brown precipitate was calcinated at different temperatures doped with cobalt and studied with their transistor characteristics [10-15]. Literature reports [16-20] showed that Nanocomposites of Y-Ni possessing various optical, electrical and electronic properties [20-23]. It is envisaged that by doping appropriate amount of cobalt to the Y-Ni nanocomposite [23] would enhance the electronic and electrical properties [24]. Concentrated and dried, calcinated at 650 ^{0}C and obtained Y-Ni nanocomposite

II. EXPERIMENTAL

A. Synthesis of Chromium Nanocomposites

Nickel chloride is added with CTAB, little amount of TEA (triethanol amine) in presence of concentrated HCl and refluxed for 8 h in an RB flask to this RM yttrium oxide reduced in presence of urea and Conc. HCl was added and reflux was continued for 3h. The reduced Y-Ni nanocomposites were precipitated by adding NH_4OH solution drop wise after the formation of gelation in 36h the entire mass was concentrated and dried, calcinated at 650 ^{0}C and obtained Y-Ni nanocomposite

B. Purification and Isolation of Y-Ni Nanocomposites

The obtained Y-Ni nanocomposite was taken in a 25 ml Rb flask added with 10 % octanol water mixture and warmed in a water bath and reprecipitated by adding triethyl alcohol dropwise, the precipitate was filtered, the filtered solid was further given with THF solvent wash and calcinated at 600^0C to get the pure Y-Ni nanocomposite.

C. Doping of Yttrium Nickel to the Cobalt Nanocomposites

In a flask a cobalt chloride hexahydrate powder (appropriate amount) was added with concentrated HCl in presence of urea and TEA and refluxed for 2-3h. The reaction mixture was cooled and added with Y-Ni nanocomposite, made collapsing network with ammonium hydroxide and the precipitate was dried, the cobalt was doped with 1-4 % to the mixture of Y-Ni nanocomposites dissolved in TEA and processed to obtain the desired cobalt doped with yttrium and nickel nanocomposites.

III. CHARACTERIZATION

SEM images were obtained and the experiment was performed using electron field emission in a field microscope at 50 Kilo Volt. The obtained linear peaks were identified by cubic crystalline phase of the image. The perovskite nanocomposites were characterized by using a TGA (TGA Q500). The peak determination were achieved using 15 mg of the sample which was initially heated at 850 °C, the heating rate was maintained at 10 °C/min under standard temperature. The hybrid nanocomposites whose initial conductivity was calculated using probe technique assays. The probes were prepared by compressing the hybrid nano composites at room temperature. A standard electrode cell is used in order to investigate the electro chemical reactions the platinum foil consists of cross sectional are of 0.75 cm^2 and silver and silver chloride used as a secondary reference electrode. The electrolyte used is a 0.1M sulphuric acid. The SEM analysis using scan rate of 50 milivolt/s against Ag/AgCl reference electrode. The reading electrode was a made from graphite or carbon which consists of 5 mg of the coated nanocomposite. Magnetic experimental determination was done at room temperature using a standard magnetometer (Versalab Crio Free VSM) with maximum applied field *Hmax*= 30Kiloelctron volt.

A. Morphology

The SEM (scanning electron microscopic) images of the pure hybrid nanocomposites were obtained and consists of nano sized semi-spherical structures the different grain sized nanocomposites. Fig. 2 shows that observed as the grey line consists of the yttrium doped nanocomposite having 20nm nanoparticles. In the SEM image grain interaction between doped and undoped materials were observed. The interaction between different polymeric grain planes were explained in terms of the continuous surface activity of the different surfactants. The surfactants get adsorbed to the hybrid composites, which develops the crystalline inter phase of the hybrid nano material which intern reduces reagglomeration. Fig. 3 shows magnetic interaction of the hybrid nano composites of yttrium particles. Average particle size was 17.7 nm. Considering the standard deviation the 68 % of the hybrid nanoparticles are close to the surface and the particle size was 22.5 nm.

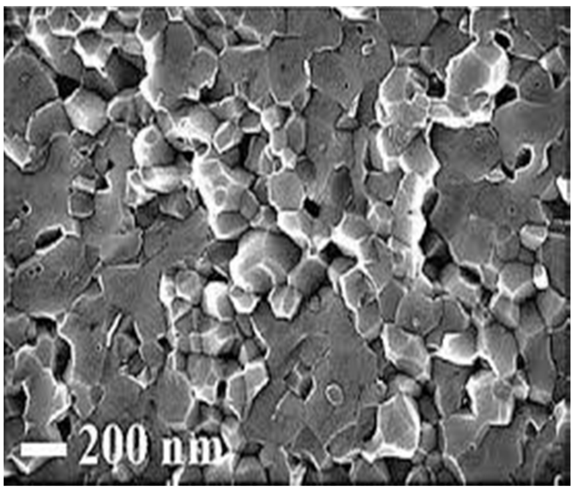

Fig. 1: Scanning electron microscope image of Y-Ni nanocomposite 2 % doped with cobalt. The particle size distribution in the 5% doped yttrium nanocomposite is almost 200 nm in the SEM image at 600 ^{0}C.

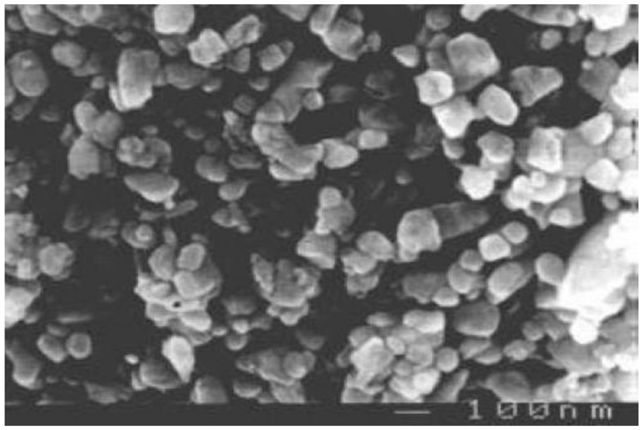

Fig. 2: Scanning electron microscope image of Y-Ni nanocomposites 4 % doped with cobalt at 450 ^{0}C. In the 4 % doped nanocomposite shows particle distribution is uniform and in the range of 100 nm and the nanocomposite of this category exhibits wide range of electronic properties.

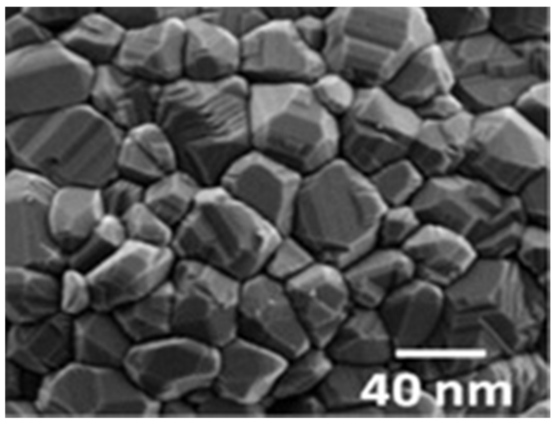

Fig. 3: Scanning electron microscope image of Y-Ni nanocomposite with cobalt. The particle size distribution is 40 nm.

IV. DIELECTRIC PROPERTIES

The electrical conductivity of the different grain sized particles were examined and found to be much (μ) higher than that of nanoparticles present in grain boundaries. For SM/SC the numerical values of μg at room temperature was found to be $2.09*10^6$/Ω/cm.Which is about 20 times higher than μgb ($0.09*10^{-6}$ Ω/cm). The dielectric constants μg&μgb were found to increase with increase in temperature. The dielectric properties of the hybrid nanomaterials were examined in the frequency range from 10^{-1} to 10^6 Hz at 300K and 320K temperature. The each sample having the error in the measurements is maintained within 3%. Impedance Spectroscopy (IS) is used to determine the total current gain of the hybrid nanomaterials and also employed to calculate the total electric behavior of the hybrid nanomaterials. Impendence spectra and the correlation diagrams were directly related to the grain boundary structure of the nanoparticles and can affect the total conductivity of the doped nanomaterials. The grain of the nanocomposite contribution to the complex impedance was higher than that of the grain boundary. In this research dielectric conductivity was described at two different temperatures.

A. Electrical Properties

The Electrical conductivity of the yttrium doped and chromium and gadolinium undoped hybrid nanocomposites were found to be 6.67 and $0.08*10^{-8}$ respectively. The literature reports the common behavior of the reduction of electrical conductivity at elevated magnetite content of the hybrid nanocomposite. This behavior has been related to the charge transport mechanism. Fig. 4 shows the grain size of the doped hybrid nanocomposite was 15 nm. As expected, magnetite loadings of the different ratio of the composite showed no electrochemical response. Furthermore, the negative range was swept from half-doped to the doped material state to fully doped state, they are non-conducting in nature, and offer high resistance.

TABLE I
Dielectric Constant Parameters Of The Y-Ni Nanocomposites With Dopant Cobalt

Serial No	Sample	W g(1*10^4 radius/s)	Cgb (PF)	Temperature	R gb(K ohm) ohm/cm/)	[1]µ (10^{-6} *g(*10^6)
1	S1	1.23	0.09	300K	1232.00	0.09
2	S2	2.34	2.45	300K	985.00	1.87
3	S3	3.45	4.56	300K	640.00	2.67
4	S4	0.97	0.08	300K	76.00	0.87
5	S5	2.45	2.10	300K	198.00	5.67
6	**Y-Ni (U)**	1.22	8.87	300K	789.00	0.98

Table II
Dielectric Constant Parameters Of The Y-Ni Nanocomposites With Dopant Cobalt

Serial No	Sample	W g(1*10^4 radius/s)	Cgb (PF)	Temperature	R gb (K ohm) ohm/cm/)	[1]µ (10^{-6} *g (*10^6)
1	S1	2.23	2.10	320K	1232.00	1.09
2	S2	3.34	1.45	320K	985.00	3.87
3	S3	0.45	2.96	320K	640.00	0.67
4	S4	2.70	1.88	320K	76.00	3.87
5	S5	2.70	2.33	320K	198.00	5.07
6	**Y-Ni (U)**	2.30	6.87	320K	789.00	0.09

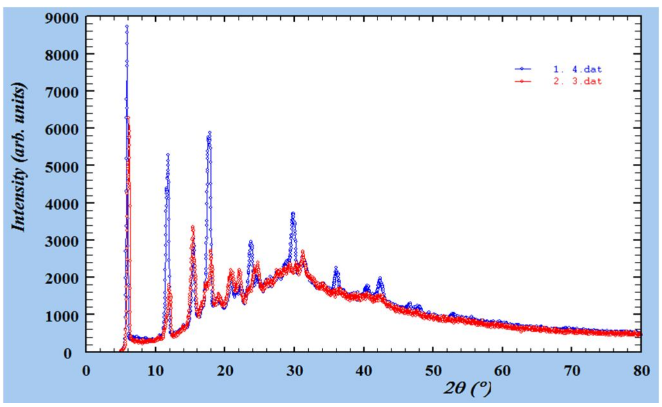

Fig. 4: XRD Pattern of Y-Ni hybrid nanocomposites doped with cobalt showing the different hexagonal crystal pattern.

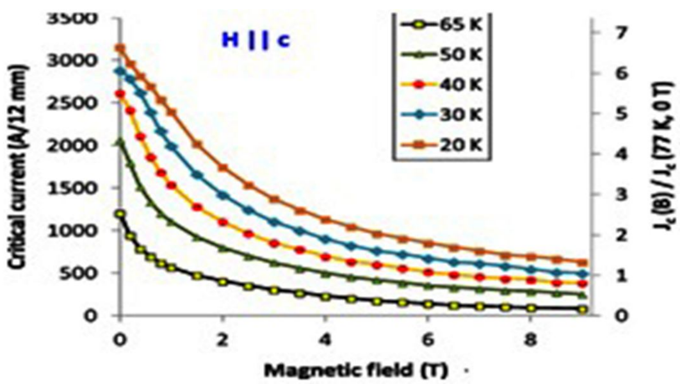

Fig. 5: Show the variation of critical current density of the Cobalt doped Y-Ni nanocomposite with undoped nanocomposite at different magnetic field.

V. RESULTS AND DISCUSSIONS

In this research work we have synthesized Y-Ni nanocomposites doped with different concentrations of cobalt and studied for their transistor related properties. The composites are synthesized by co precipitation methods, isolated, purified and obtained the SEM images of doped assembly of Y-Ni nanocomposites. XRD absorption intensity studies were carried out for the doped nanocomposite as initial level in which it is found that the particle size is less than 50nm exhibited increased intensity various absorption bands in the spectrum. Further studies are in progress.

VI. CONCLUSIONS

The composites are synthesized by co precipitation methods, isolated, purified and obtained the SEM images of doped assembly of Y-Ni nanocomposites. XRD absorption intensity studies were carried out for the doped nanocomposite as initial level in which it is found that the particle size is less than 50 nm exhibited increased intensity. The Electrical conductivity of the cobalt doped and yttrium and nickel undoped hybrid nanocomposites were found to be 6.67 and $0.08*10^{-8}$ respectively. XRD absorption intensity studies were carried out for the doped nanocomposite as initial level in which it is found that the particle size is less than 50 nm exhibited increased intensity various absorption bands in the spectrum. Further studies are in progress.

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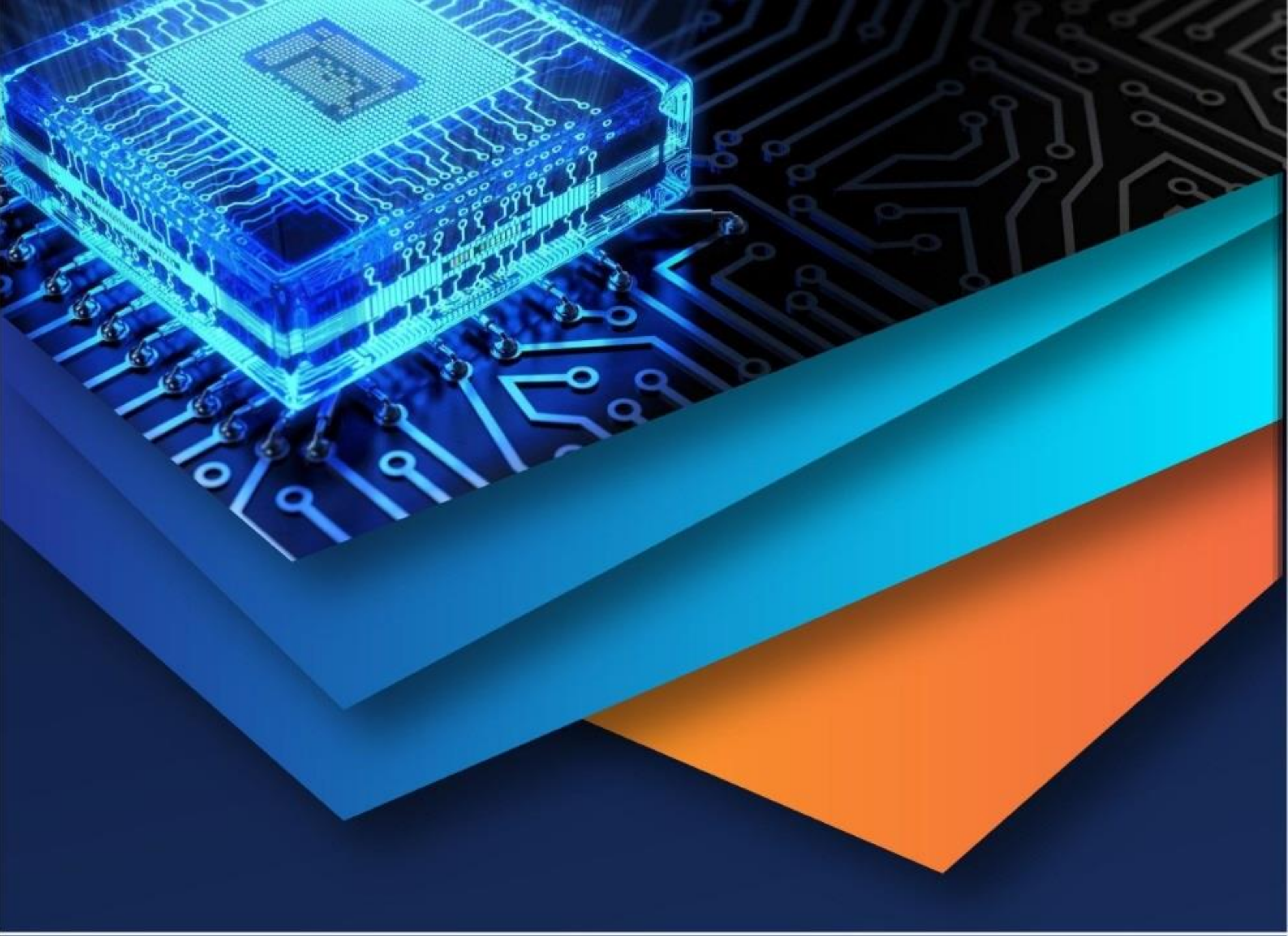

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