Synthesis of Neodymium Doped in Nickel Oxide for Nano-Compound

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Abstract - *In era of digital world with fast generation up gradation in field of electronics and reduction in power consumption with same application and properties cross all boundaries with significant development in nanotechnology with working at nanoscale. Working on such small scale has its own level of difficulty and effort to produce it without having physical changes. The increase in application of nanotechnology is changing the way of thinking such as nano-wire, nano-tube and many more. These trends tend us to move forward in direction of nanotechnology to educate and investigate our research. Moving forward in this direction, help us to focus on one of important material selection for my research in this field is that neodymium doped nickel oxide to synthesis a nano-compound using sol-gel method.*

Key Words: nanoparticles, ferromagnetic, Nickel oxide and nano-compound

1. INTRODUCTION

"Nanoparticles lying less than size of a 100nm between intermediate molecular state and bulk state are represented under the region of material science. It is expected that the particle with such small size will show two different properties one is physical property and another is chemical properties, which could be utilized in many important applications. Especially, a magnetic nanoparticle is used as an active component of magnetic recording devices, solar energy transformation and chemical catalyst. A millionth of millimeter is defined as nanometer which is thin than human hair [1]. The unique properties in the ground of electrical, optical and magnetic properties possess by nano developed nanomaterial have shown great interest for emerging technology.

Some of the nonmaterial occurs naturally. Some of the example in our life of nanotechnology is sunscreens, cosmetics, sporting goods, stain-resistant clothing, tires, electronics, as well as many other everyday items, and in medical application such as diagnosis, imaging processing and drug delivery [2]. Nonmaterial can be classified as 1 dimensional, 2 dimensional, 3 dimensional nonmaterial as they have very small size. Quantum dots, nanotubes, dendrimers and fullerene are some common type of nonmaterial.

1.1 NiO nanostructures:

Endowing properties of physical and chemical into metal oxide exhibit properties like metallic, semiconductor and insulator with adaptation of required structural geometries within into electronic structure. NiO nanostructures: Metal oxides can take up a great range of structural geometries by means of an electronic structure through the objective to show metallic, semiconductor, or insulator character, when endow them with unlike chemical. Therefore, functional materials of metal oxide in chemical, biological and transduction will be very important [3].

The application in electronics and optoelectronics is possible due to unique and tunable physical characteristics by nonmaterial. The new horizon opens in nanostructure in field of scientific investigation and potential window for its application. From transition metal oxides, nickel oxide (NiO) bulk and nanosize have received consideration due to their broad choice of applications in diverse fields, such as: catalysis, fuel cells, electrodes, gas sensors, electro chromic film, battery cathodes, magnetic materials and photovoltaic devices [4]. For instance smart windows are one of its applications.

Nio have a cubic lattice structure. Nio oxide have an outstanding magnetic, electrical, electronic along with catalytic properties and that are different from bulk sized Nio nanoparticles. The feasible technique with low cost for preparation of NiO nanoparticles is sol-gel method. A various techniques are used to fabricate nickel nanoparticles such as sol-gel process, sonochemical, laser chemical method, flame spray pyrolysis etc [5].

Different characteristics technique are used to differentiate Nio nanoparticles are

1. X-ray diffraction technique (XRD)
2. Scanning electron microscopy(SEM),Transmission electron microscopy (TEM)
3. Fourier transform infrared spectroscopy (FTIR)
4. UV–Vis absorption spectroscopy

The new technique of spry pyrolysis becomes important for metal oxide, composite powder, non-oxide and various metals. The properties of nickel oxide (especially optical) can be characterized by photoluminescence (PL) method. Nickel oxide is a significant transition method. Semiconductor of Nio becomes a rousing subject in the research field [6]. It posses characteristics like durability, electrochemical stability and large spin optical density made it more suitable for manufacturing.

Hence numerous new methods have been used for preparing nanosized nickel oxides. As a result of selecting proper precursors Nio nanoparticles with uniform shape and sizes can be obtained. Nio has also have application in biological sensors but not so many. NiO nanostructures are p-type semiconductors with particular magnetic behaviors such as super paramagnetic, super anti-ferromagnetic, and ferromagnetic [5], [6], [7]. This all depends upon size of particle, shape way of synthesis but bulk sie NiO has anti-ferromagnetic insulator characteristics. The properties of Nio nanoparticles changes with size in addition to morphology.

1.2 structure and properties of Nd -doped NiO:

NiO had been widely studied material for the past decades; the renewed interests are paying attention on the modifications in various physical properties by rare earth dopants. It has been shown that doping rare -earth ions enable NiO as a multifunctional system.

In this element Neodymium (Nd) is doped with nickel oxide (NiO) element. Neodymium is very rare on earth. Due to presence of Nd^{3+}ion present reddish-purple color and varies with change in lighting. Its application in laser infrared for 1047 and 1062 nanometers wavelength neodymium doped glass is used and for this reason also it is used in high power optical application. Neodymium is moreover used with an assortment of further substrate crystals, such as yttrium aluminum garnet in application of Nd:YAG laser in metal cutting with operating wavelength of 1064 nm in addition to it is one of most commonly used in solid state laser. It's another application of magnet used in our daily life headphones, speakers and microphone by making it by neodymium magnet which has high strength.

I. Structure of nickel oxide:

Nio has a NaCl structure, with octahedral Ni (II) with O_2- sites. The Nio structure is also called as rock salt structure. As compared with further binary metal oxides, NiO is non-stoichiometric it means so as to the Ni: O ratio deviate from 1:1. The non- stoichiometry of nickel oxide is accompanied with a shade change. With the stoichiometrically acceptable- NiO is being green and the non-stoichiometric NiO being black.

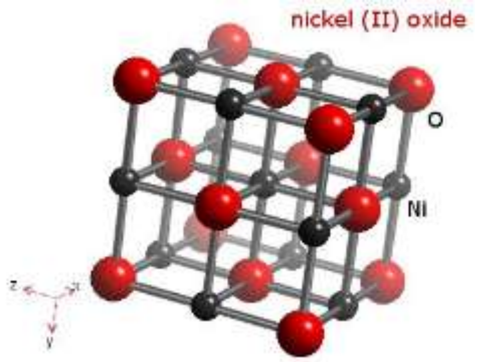

Fig. 2 NICKLE (II) OXIDE

It is a solid state structure of nickel (II) oxide .The geometry of nickel oxide is octahedral with 6 coordinates. Nickel oxide (NiO) is a versatile ample band gap semiconductor material. Nickle oxide has a face-centered cubic (FCC) structure. It is green in color. Experimental outcome contain optical properties of glucose solution that can be altered by the addition of nickel oxide nanoparticles [7]. This result is important for optical glucose sensors.

II. Experimental Part: Implemented Synthesis Technique

(A) Sol-gel synthesis Method:

In sol-gel process the process of polycondensation reaction help in formation of oxide network in liquid in molecular precursor. A sol is a colloidal particle in solvent with stable dispersion. The crystalline and amorphous may be its particle. Gas phase is posses by aerosol while sol in fluid. A gel enclosed in liquid phase has three dimension continuous networks. Hydrogen bonds or van-der Waal forces interacted in sol particle. It is created by connecting the chain of polymer.

The synthesis of dissolve compound in liquid is done to obtain it reverse as solid to have controlled process in sol-gel synthesis. Its advantage is that co-precipitation is a problem due to heterogeneous. It also enables mixing of a compound at an atomic level and hence results in small particles. A xerogel [8] is produced when gel is dried out using evaporation technique; if capillary force fails result in shrinkage then its network gets collapse.

In several steps sol-gel is synthesized:

1. Hydrolysis and condensation of molecules (Formation of a sol).
2. Gelation (sol-gel transformation)
3. Ageing

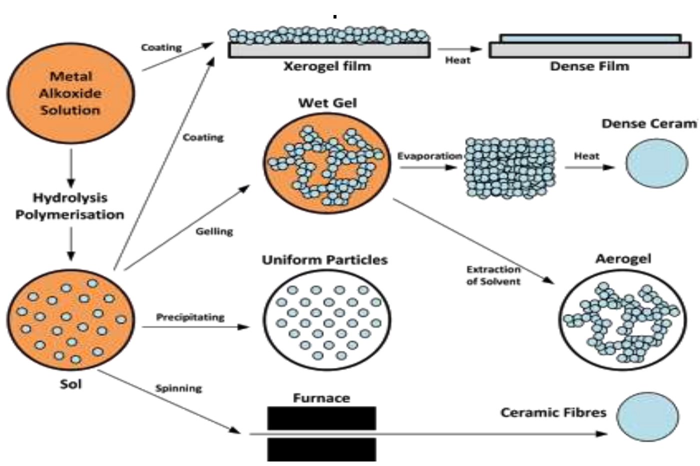

Fig. 3 sol gel processing

III. Experimental Work:

(A) sol-gel synthesis of undoped NiO nanoparticles:

Sol-gel production of undoped NiO nanoparticles: Nanocrystalline NiO skinny films have been synthesized by a sol-gel technique using Nickel Nitrate Ni (NO3)2.6H20 as a source of Ni [9]. In this experiment 2.79 gm of nickel nitrate was added in 50 ml of distilled water (H_2O) and stirred for 30 minutes at normal room temperature leading to the development of light green colored powder. After this 1ml of ethylene glycol (EG) was added and then once more the resulting solution was stirred normal room temperature for 1 hour. Different crystallite structure of NiO fine particles is created at various different range of temperature between 400-700°C and sintered at every hour in normal air condition.

(B) Sol-gel synthesis of Nd doped with NiO nanoparticles:

First of all 48 ml distilled of H_2O is taken in which 2ml of ethylene glycol is mix into it. At this moment 2.79 gm nickel nitrate is pour into it with 3.75 gm of tartaric acid. Now permit to stir the solution with the help of magnetic stirrer for 30 minute plus add 2ml ethylene glycol and then again stir for 60 minute. Following these 48 hours of continuous heating is required at furnace temperature of 1700 °C, so it can be well dried and converted into powder. This powder is particle of NiO (Nickel Oxide) [10].

IV. RESULTS AND DISCUSSION

The XRD pattern of Neodymium doped Nickel oxide is as obtained:

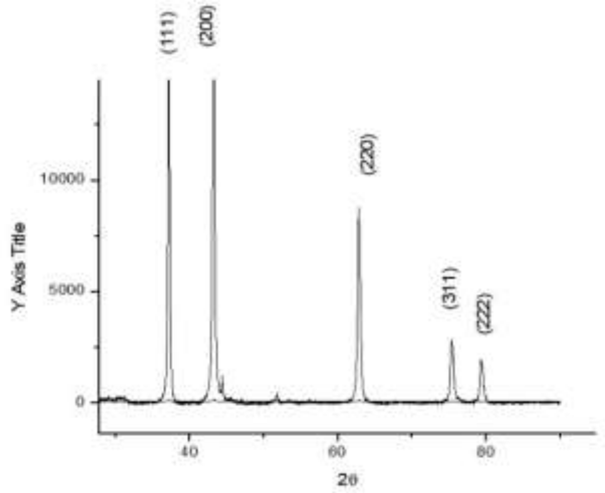

Fig. 9 XRD spectra of neodymium doped nickel oxide

Fig.9 shows the XRD graph of the precursor Ni (OH)2 and NiO nanoparticles products after doped with neodymium element. The highest value achieved by hydroxide precursor seems to be substantially wide-ranging which indicates that the crystallites of the hydroxide can be in the nanosized range. The dissimilarity in peak broadening related to crystallite shape, defects, and they change in crystal symmetry. The XRD sample result has indicated the growth of crystalline structure of NiO with sharp peaks. The peak value of 2θ during peak position is 37.101, 43.301, 62.871, 76.501 and 79.22. Bulk NiO are indexed as (111), (200), (220), (311), and (222) in crystalline planes respectively. All the reflections of face-centered cubic (FCC) can be indexed with NiO phase through lattice constant 4.175 Å (space group Fm3hm (225).

Table 1: Reading of Sample A

sample	Grain size(nm)	2θ (Deg.)	FWHM (degree)	d values(A°)		Miller plane (hkl)	Phase assignment
				Standard	observed		
	35nm	37.45	0.24	2.41	2		Cubic
		43.34		2.08	2.0	(200)	Cubic
		44.63		2.03	2.03	(200)	Cubic
A		51.81		1.75	1.75		Cubic
		62.76		1.47	1.47	(220)	Cubic
		75.61		1.29	1.29	(311)	Cubic
		79.37		1.20	1.20	(222)	Cubic

To calculate crystal size based on X-ray peak broadening corresponded to X-ray spectral, we have to use Debye–Scherrer's formula

$D = k\lambda / \beta \cos \theta$

Where,

K=0.9 (empirical constant)

λ=1.5405 (wavelength of the X-ray source)

β = full width at half maximum of the diffraction peak and θ is the angular position of the peak.

Therefore, the crystallite sizes of NiO samples are 37.5 nm.

IV. Acknowledgment

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