International Journal of Advanced Science and Research
ISSN: 2455-4227
Impact Factor: RJIF 5.12
www.allsciencejournal.com
Volume 3; Issue 2; March 2018; Page No. 139-143

Synthesis and characterization of transition metal oxides (Nano Material)

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Abstract
The main study of Nanomaterial's is to assemble self-fueled Nano systems that are ultra-little in estimate, display super affectability, unprecedented multi usefulness, and amazingly low power consumption. As we as a whole realize that 21st century has brought two most critical difficulties for us. One is energy shortage and the other is a worldwide temperature alteration. Presently to beat these difficulties, it is exceedingly alluring to develop nanotechnology that harvests vitality from the environment to create self-power and low-carbon Nano devices. Along these lines a self-control Nano system that gathers its working vitality from the environment is an alluring recommendation. This is likewise practical for Nano devices attributable to their to a great degree low power consumption. One worthwhile approach towards collecting energy from the environment is the usage of semiconducting piezoelectric materials, which encourage the change of mechanical energy into electrical energy. Among numerous piezoelectric materials ZnO has the uncommon trait of having both piezoelectric and semiconducting properties. Be that as it may, most uses of ZnO use either the semiconducting or piezoelectric property, and now it's a great opportunity to completely utilize the coupled semiconducting-piezoelectric properties to frame the reason for electromechanically coupled Nano devices. Since quartzite zinc oxide (ZnO) is basically non-midway symmetric and has the most astounding piezoelectric tensor among tetrahedral reinforced semiconductors, along these lines it turns into a promising possibility for vitality reaping applications. ZnO is generally bio sheltered and biocompatible too, so it can be utilized everywhere scales with no damage to the living condition. The synthesis of another progress metal oxide known as Co3O4 is additionally imperative because of its potential use in the material science, material science and science fields. Co3O4 has been contemplated broadly because of minimal effort, low poisonous quality, the most normally bounteous, high surface territory, great redox, effortlessly tunable surface and auxiliary properties. These huge properties empower Co3O4 productive for creating assortment of Nano devices. Co3O4 nanostructures have been centered extensively in the previous decade because of their high electro-concoction execution, which is basic for growing profoundly delicate sensor devices.

Keywords: nanomaterial's, nano systems, challenges, important, nano devices, nanotechnology

Introduction

The 21st century economy improvement firmly relies upon the supply of energy and in this manner causes an environmental effect on the worldwide atmosphere because of the burning of petroleum derivatives. These non-renewable energy sources with high percentages of carbon include coal (27%), oil (36%) and natural gas (23.4%) adding up to 86.4% offer for petroleum derivatives. The consuming of these petroleum derivatives creates around 21.3 billion tons of carbon dioxide (CO2) every year [1]. CO2 is one of the ozone harming substances that improves radioactive constraining and adds to a worldwide temperature alteration. Since these natural resources on earth are constrained and couldn't be recovered over a brief timeframe, subsequently human beings when all is said in done and researchers/ scientists specifically should have the capacity to confront these severe energy and environmental problems starting from the customary energy consumption. For the improvement of clean alternative energies, an extensive variety of methodologies have been investigated by researchers both everywhere and little scale. On the bigger scale, other than the outstanding energy resources that power the world today, for example, oil, hydroelectric, natural gas, and atomic, dynamic innovative work are occurring so as to investigate alternative energy assets like solar, geothermal, biomass, wind, and hydrogen. But on littler scale, it is exceptionally attractive to investigate novel advancements to build up a self-fueled Nano system that harvests energy from the environment so it works remotely, remotely, and autonomously with a continuous energy supply. Subsequently the objective of nanotechnology is to manufacture self-fueled Nano systems that are ultra-little in size, and show super affectability, phenomenal multi usefulness, and to great degree low power utilization. Building self-fueled Nano systems is a future course of nanotechnology and there are three conceivable routes for accomplishing these self-controlled Nano systems.

One is to utilize a battery as power source, however the main challenges in such manner are the size, weight, poisonous quality of the utilized material and lifetime of the battery. The other approach is to harvest energy from the environment by changing over mechanical, chemical, or thermal energy into electricity [2]. The resultant vitality collected from the environment ought to be adequate to power the system. A self-fueling Nano system that gathers its operating energy from the environment is an appealing recommendation. This can upgrade the flexibility of the gadgets as well as incredibly diminish the size and weight of the framework. This is on a basic level attainable for Nano devices inferable from there to a great degree low power consumption. The third approach, which relies upon creating nanomaterial enabled innovations for energy harvesting has pulled in a great deal of enthusiasm for late years [3, 4]. One preferred standpoint that makes this approach productive for harvesting energy is the use of minimal effort semiconducting piezoelectric materials [5], which encourage the transformation of mechanical energy into electrical energy. Age of electric energy from transformation of mechanical energy through this approach is of extraordinary enthusiasm inferable from its plenitude and one of a kind fit for a few applications. This approach is a basic advance towards creating self-fueled Nano systems by using piezoelectric materials.

Review of literature

Nanomaterial's, for example, ZnO, GaN, CdS, and perhaps ZnS can assume a critical part in managing the difficulties with respect to new manageable and renewable energy resources. Particularly, oxide nanostructures with interminable assortment of basic themes and complex morphological highlights display basic surface properties for energy harvesting, transformation, and storage devices. By utilizing the piezoelectricity of these semi conductive materials, Nano scale mechanical-electrical energy conversion gadgets known as the Nano generators (NGs) have been shown lately [6-10], in which the electric current in an outer circuit is driven by the piezoelectric potential made by the bent nanowires (NWs)/Nano belts (NBs)/Nanorods (NRs) [10]. Keep in mind that NWs/NBs/NRs are natural cantilevers that can be effectively twisted to make a huge disfigurement. The essential rule is to utilize piezoelectric and semiconducting coupled materials, such as ZnO, to change over mechanical energy into power [10, 11]. Based on the coupled conduct amongst piezoelectric and semiconducting properties, piezotronic impact [12] has been uncovered, which uses the piezoelectric potential to tweak the bearer transport process in the NWs/NBs/NRs. The mechanical adaptability of piezoelectric compound NWs/NBs/NRs gives a more flexible stage to use the material science of piezoelectricity in semiconductors, as one finds in NGs and in nanopiezotronics. Piezoelectric NGs utilizing NWs/NRs are a technique for changing over mechanical energy into power [13, 14]. The idea of the NG was first presented by inspecting the piezoelectric properties of ZnO NWs with an atomic force microscope (AFM) [10]. The system of the NG depends on the coupling of piezoelectric and semiconducting double properties of piezoelectric materials and also the rich correcting capacity of the Schottky boundary shaped between the metal tip and the NW/NR. The improvement of a NG to change over the accessible type of mechanical energy into electric energy would not just encourage the advancement of Nano devices in fields like therapeutic science, resistance innovation, detecting and even individual gadgets; yet can likewise be valuable for building up a battery-less framework for future applications.

Zinc Oxide (ZnO)

ZnO as mineral zin-refer to is available in the world's covering [1] and has been broadly utilized as an added substance in various items, for example, elastic, earthenware production, colors, bond, sealants, plastic and paint [2]. ZnO is additionally an alluring material for biomedical applications, since it is a bio-safe material [3, 4]. With the progression of time ZnO turned out to be an adaptable material as a result of its direct/wide band hole (3.37 eV) and high exciton restricting vitality (60 meV) [1, 5, 6]. The highlights identified with wide band hole, for example, least electronic commotion, capacity to keep up high breakdown voltages, capacity to keep running at high power and capacity to adjust immense measure of natural deformities are basic for some electronic/ optoelectronic gadgets. Then again the bigger exciton restricting vitality (60 meV) than thermal energy (25 meV) at encompassing temperature is in charge of stable electron-gap match recombination, which makes ready for good radiance conduct of ZnO [7]. Close to these there are some different properties that make ZnO more best material than other II-VI semiconductors. For instance close UV outflow and straightforward conductivity, piezoelectricity and pyro power, biocompatibility, moderately bio safe/condition neighborly, irrelevant danger, expanded affectability, basic union and ease.

Property	Value
Molecular Mass	81.37 g/mol
Crystal Structure	Wurtzite
Density	5.606 g/cm^3
Melting Point	1975°C
Boiling Point	2360°C
Solubility in water	0.16 g/100 mL
Thermal Conductivity	0.6 ; 1-1.2
Energy gap	3.37 eV
Exciton binding energy	60 mV
Intrinsic carrier concentration	< 10^6 cm^3
Electron effective mass	$0.24m_0$
Hole effective mass	$0.59m_0$
Electron Hall mobility	200 cm^2/V.s
Hole Hall mobility	5-50 cm^2/V.s
Static dielectric constant	8.656
Bulk effective piezoelectric constant	9.9pm/V
Bulk hardness; H(GPa)	5.0±0.1

All the more essentially ZnO is remarkable in a way that it holds both semiconducting and piezoelectric properties, which make ready for number of utilizations in vitality gathering gadgets. In this way ZnO has an essential part in creating carbon dioxide (CO2) discharge free vitality. A portion of the essential qualities of ZnO have additionally been highlighted in Table 1.

Following is a short exchange on precious stone structure and those properties of ZnO which are specifically identified with the introduced work, for example, piezoelectric, mechanical, optical, and electrical characteristics of ZnO.

Crystal structure

ZnO has three sorts of gem structures in particular wurtzite (B4), zinc blende (B3) and shake salt (B1). Among these, the thermodynamically stable stage at room temperature is wurtzite and all the exchange canvassed in this paper depends on wurtzite gem structure. The wurtzite structure of ZnO involve a hexagonal unit cell as shown in figure 1.

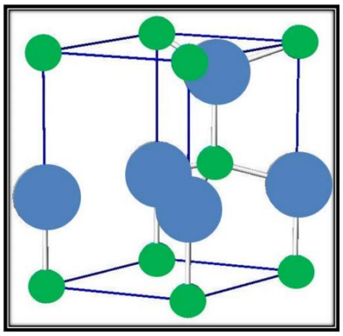

Fig 1: Wurtzite structure of ZnO unit cell, in which green balls are Zn^{+2} ions and blue balls are O^{-2} ions showing tetrahedral coordination

It has two lattice parameters in particular and c and its space aggregate recognized as C4 6v or P63mc at surrounding conditions. As indicated in figure 1 wurtzite ZnO has four face terminations, two are polar and other two are non-polar. The polar countenances incorporate Zn ended (0 1) and O ended (0 1) (c-pivot arranged), while the nonpolar appearances incorporate (1 2 0) (a-hub) and (1 0 1 0). Both polar and non-polar appearances have meet number of Zn and O molecules, however the concoction and physical properties of polar countenances are unique in relation to non-polar countenances. Both the polar surfaces are steady, while among non-polar surfaces (1 0 1 0) surface is steady and (1 2 0) confront is generally less steady and has moderately substantially higher surface unpleasantness. These highlights of polar and non-polar countenances have enter part in becoming distinctive ZnO nanostructures. It is imperative to bring up that three speediest development headings of ZnO are along (0 1), (0 1 0) and (2 11 0). Another critical element of ZnO is its holding nature. The bond amongst zinc and oxygen has firm ionic character, while the tetrahedral coordination of the ZnO precious stone structure additionally brings up the sp3 covalent holding. That is the reason ZnO dealt with as covalent and additionally ionic compound. It is outstanding that among every one of the semiconductors, which have tetrahedral bond; ZnO holds the most elevated piezoelectric tensor. Because of these highlights ZnO turn out to be more imperative than others in applications where electromechanical coupling plays a role.

Cobalt (II, III) oxide (Co_3O_4)

In various fields of science and innovation cobalt based oxide materials have caught a great deal of enthusiasm among investigate group in view of their potential applications. Cobalt has two stable oxide states known as CoO and Co3O4. At room temperature the two mixes are observed to be actively steady. In the present work the exchange will be centered around Co3O4 and NiCo2O4. Cobalt (II, III) oxide is an inorganic compound and as a blended valence intensifies, its equation is composed as CoIICoIII2O4 or CoO.Co2O3 or Co3O4. It receives the typical spinel structure, with Co2+ particles involve the tetrahedral 8a destinations and Co3+ particles in the octahedral 16d locales in light of the cubic close-pressed varieties of oxide anions as shown in figure 2.

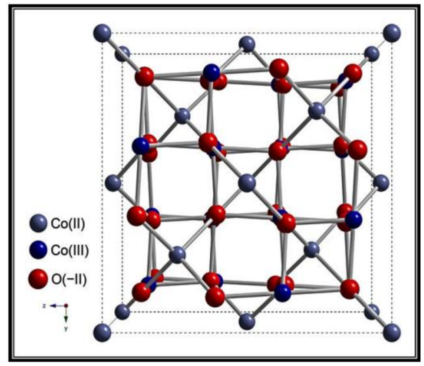

Fig 2: The unit cell structure of Co_3O_4.

Co3O4 is an imperative attractive p-type semiconductor having direct optical band holes as 1.48 and 2.19 eV, yet 1.6 eV is additionally announced in the writing. It is trusted that change metal oxides are great hopefuls as terminal materials, since they have variety in oxide states which is appropriate for viable redox charge exchange. That is the reason as the most dynamic change metals, Co3O4 has been utilized broadly as heterogeneous impetuses, strong state sensors and in color, magnet also. In a decade ago specialists have invested a great deal of energy in Co3O4 nanostructures because of their high electro-compound execution; on the grounds that the highlights like high surface region, short way length for particle transport and effectively tunable surface have made Co3O4 a promising material for electrochemical gadgets. Hence with a specific end goal to get most extreme preferred standpoint of these properties a sparing, steady, quick and touchy H2O2 sensor has been set up in the exhibited work.

Aqueous chemical growth (ACG) method

Throughout the years various types of synthesis techniques/methods have been created. These can be ordered as gas stage methodologies and arrangement stage approaches. In gas stage approaches high vacuum as well as lifted temperature, long response time, expensive gear and utilization of lethal segments (now and again) are regularly required. While the arrangement eliminate methodologies can be conveyed at low temperature and pressure. The arrangement based methodologies have numerous different focal points like minimal effort, high efficiency, low vitality utilization, conceivable in-situ doping, adaptability in hardware and similarity for both organic and inorganic materials. Because of these highlights low temperature solution based methodologies have discovered their place in various branches of science and technology and this has driven the establishment for some other techniques strongly in view of arrangement stage approach. These methodologies can additionally be partitioned in three classifications specifically hydrothermal, chemical shower statement or fluid chemical growth and electrochemical testimony technique. Among these, aqueous chemical development is one of the strategies that have been widely utilized for synthesis. The term fluid compound stands for the heterogeneous responses happened within the sight of watery solvents/minerals. Presently for a long time fluid chemical growth method has been vigorously utilized for the combination of metal oxide nanostructures. Considering distinctive parts of synthesis process, we infer that watery chemical growth method is the most straightforward, modest and compelling strategy to synthesize different metal oxide nanostructures. A portion of the preferences related with watery chemical growth technique are low temperature, low assembling cost, basic gear, predominant throughput, in-situ doping and condition inviting.

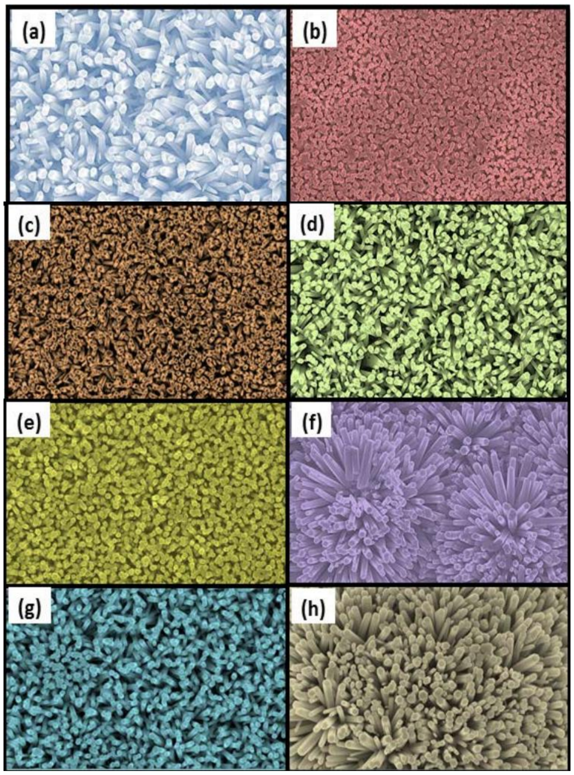

Fig 3: Aqueous Chemical Growth of ZnO NRs on different substrates

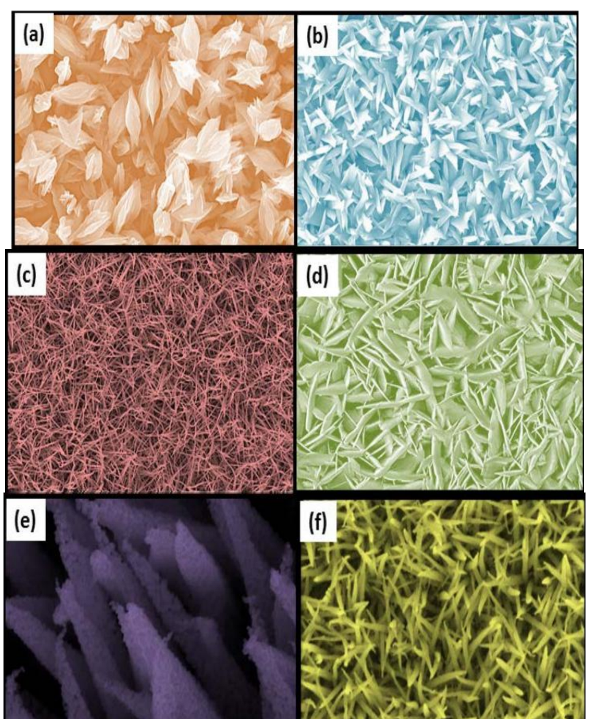

Fig 4: Aqueous Chemical Growth of different oxide materials

Above all by utilizing watery chemical growth strategy assortment of metal oxide nanostructures can effectively be developed on various substrates like metal surface, semiconductors, glass, plastic, common paper, aluminum thwart, graphene, cotton textile, etc. In the exhibited work, we examined three writes of nanostructures, i.e. ZnO Nano-bars, Co3O4 nanostructures using diverse salts and NiCo2O4 nanostructures by utilizing the aqueous chemical growth method.

Conclusion

The growth of metal oxide nanostructures by using low temperature aqueous chemical growth method. Their characterization by employing different kinds of techniques such as SEM, TEM, XRD, AFM, XPS, CL etc. Then influence of oxygen plasma treated ZnO nanorods, effect of different flexible substrate and effect of ZnO nanorods grown AFM tip on the amount of harvested energy have been discussed in detail. Transition metal oxides were synthesized inside the pore system of mesoporous carbon. By a wet impregnation, drying and calcination procedure iron, copper, nickel, cobalt, manganese and zinc oxides were formed almost exclusively within the mesoporous. A reduction into the metal forms with regard to structural array in the case of zinc oxide and a reduction to manganese oxide for manganese oxide were accomplished by hydrogen. The formation of nanosized metal oxides inside the mesopore system was confirmed with PXRD and TEM. Nitrogen physisorption measurements still revealed micro- and mesoporosity for the host/guest compounds. A reduction of the surface areas and pore sizes in contrast to the host structure being an indication of the coating of the inner surfaces of the carbon walls is shown as well. After that the effect of anion on the morphology of Co_3O_4 nanostructures is presented along with the development of a pH sensor.

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