Synthesis and characterization of Ni nanoparticles

GEETA NAIR[1], SMITA SURVASE[1]

[1] Department of Physics, K.J.Somaiya College of Science and Commerce, Mumbai-77.
e-mail: ngeets1@rediffmail.com

Abstract

The study focuses on synthesis and characterization of Ni nanoparticles. Ni nanoparticles have been successfully synthesized using a low cost and simple chemical route. The calcinations of poly vinyl pyrrolidone and nickel acetate led to the formation of Ni nanoparticles. The resulting nanoparticles were characterized by X-ray powder diffraction. The average size of the particles was found to be 30 nm. The dislocation density and the perpendicular strain were also estimated. Variation of refractive index with wavelength at various glancing angle was studied using ellipsometry. Ellipsometric studies show an increase in refractive index as compared to the bulk Ni. Further studies and characterization techniques will help in understanding the exact structure and band gap variation which will be useful in actual application of Ni nanoparticles in industry. Also, it would be interesting to study the capping effect of PVP to control the particle size.

Key words: nickel, nanoparticles

Introduction

Nanomaterials have attracted interest in the past decade and have been studied extensively because of their size and shape dependent physical-chemical and magnetic properties for applications in various useful technologies. In recent years, with growing interest in building advanced materials using nanoscale particles, there is a need for general approach to controlling the size and shape of nanocrystals [1, 2]. Nanoscale magnetic materials have attracted much attention owing to their promising potential in magnetic storage, magnetic fluid, medical diagnosis and catalysis. Small metal particle arrays have been used to build single-electron devices [2-4]. Metallic nanoparticles have interesting properties and applications because of which their synthesis has been recently receiving great attention. Metallic nanoparticles of Ni, Co and Fe are important due to their magnetic properties and application potential. For such crystallites, the physical and chemical properties depend sensitively on particle size and shape [2-11]. In the last few years, nickel nanomaterialhave been synthesized in various forms like nanotubes, nanorods, hollow spheres, nanobelts, nanoprisms, and hexagonal flakes [2-6].Magnetic nanoparticles are being widely used in rechargeable batteries [7],optoelectronics [8], chemical catalysts [9], conducting paints [10], magnetic recording media[11] ferro-fluids, magnetic resonance imaging contrast enhancement, drug delivery[12] and magnetic hyperthermia [13, 14]. Several methods have been developed to synthesize particles with controlled size and shape. These methods include photolytic

reduction [15], radiolytic reduction [16], sonochemical method [17], solvent extraction reduction [18], microemulsion technique [19], polyol process [20], and chemical route [21].

As an important transition metal, Ni nanoparticles have wide ranging applications in the fields of permanent magnets, magnetic fluids, magnetic recording media, solar energy absorption, fuel cell electrodes, catalysts etc. So the synthesis of Ni nanoparticles has attracted considerable attention.

The purpose of this study is to describe a simple way for preparing Ni nanoparticles. Pure Ni nanoparticles have been synthesized and characterized herein.

Material and Methods:

All chemicals used in the experiment were analytical reagent grade and were used without further purification. Ni nanoparticles were synthesized by dissolving nickel acetate in the solution of 1-proponal and distilled water. Palladium acetate was added as a catalyst. PVP was used as a capping agent and precussor. The solution was heated in a round bottom flask for about 6 hours at around 140°C to 160°C. Small grains of nickel start forming in the solution which was indicated by a change in colour of the solution. The heating was stopped and the solution was left overnight for cooling. The particles were then collected after centrifuging.

The samples were characterized by X-Ray Diffraction (XRD). X-ray powder diffraction was collected on a Phillips X-ray diffractometer X-ray Tube with monochromatiser CuKα (1.5406 Å) with a scan range of 5.0000 <-> 60.0000 degree and step size of 0.0500 degree. The average thickness of the sample was determined using the Debye-Scherrer formula.. Also the strain and dislocation density were estimated. The variation of refractive index with wavelength at various glancing angle was studied using ellipsometry (Model no: M-2000).

Results and discussion:

The XRD plot of intensity versus 2θof a representive sample is as shown in Fig.1.It clearly shows an intense peak at 39^0. Comparison with the standard database confirms the presence of Ni [010] hexagonal nanoparticles (CAS 7440-02-0). The particle size was estimated using the Debye Scherrer formula,

$$\text{Thickness } t = (K\lambda)/\beta \cos\theta$$

where β is the FWHM of the profile, K is a dimensionless shape factor, with a value close to unity. The shape factor K was taken as 0.9 for the present work.

The average size of the nanoparticles was around 20-30 nm. The perpendicular strain was estimated using the formula $\varepsilon = \beta/4\tan\theta$ and it was found to be 9.1×10^{-3}.

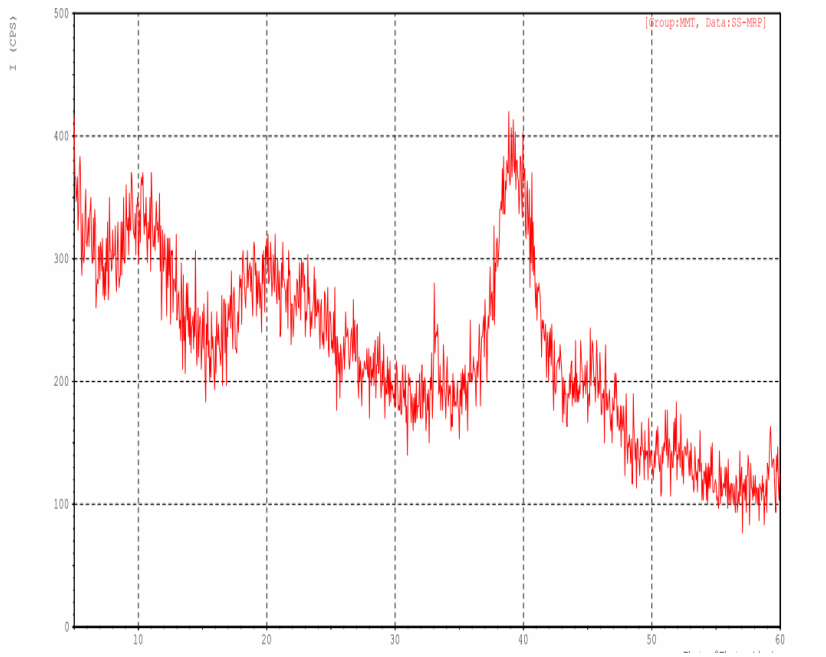

Figure 1 XRD profile of the synthesized nanoparticle

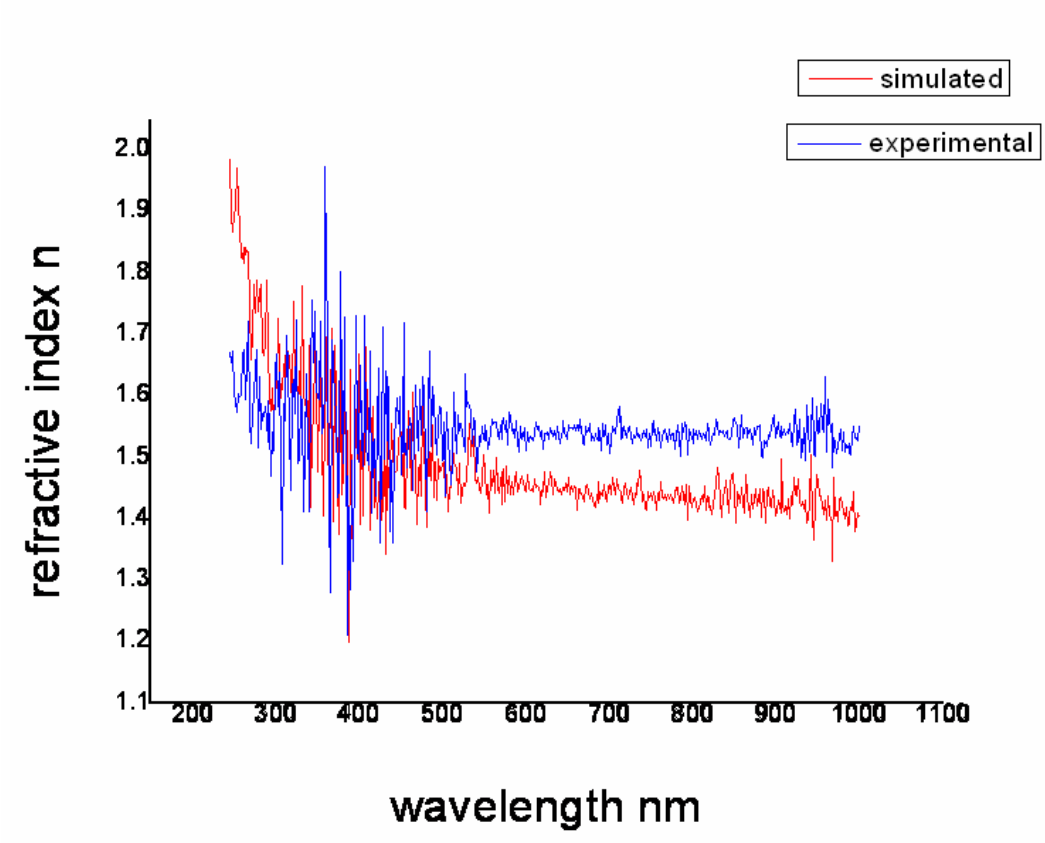

Figure 2 Variation of refractive index with wavelength

Fig.2 shows the result of ellipsometry at various glancing angle. Ellipsometric measurement helps in direct evaluation of both real and imaginary parts of complex dielectric function. This can be related to refractive index and extinction coefficient [22].It is seen that the experimental data shows a good agreement with the theoretical fit. The graph shows dispersion in the refractive index with a peak near 400 nm. Also the maximum refractive index is around 1.9, which suggests that it is quite different from the refractive index of bulk Ni which is 1.08. Such variation in refractive index with particle size has been reported.[23].

Conclusions

Ni nanoparticles have been successfully synthesized using a low cost and simple chemical route. The XRD pattern clearly shows the presence of Ni nanoparticles with average size of about 30nm. It shows the variation of refractive index with wavelength and indicates an increase in refractive index. Further studies are necessary to understand the exact structure and band gap variation which will be useful in actual application of Ni nanoparticles in industry. Also, it would be interesting to study the capping effect of PVP to control the particle size.

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