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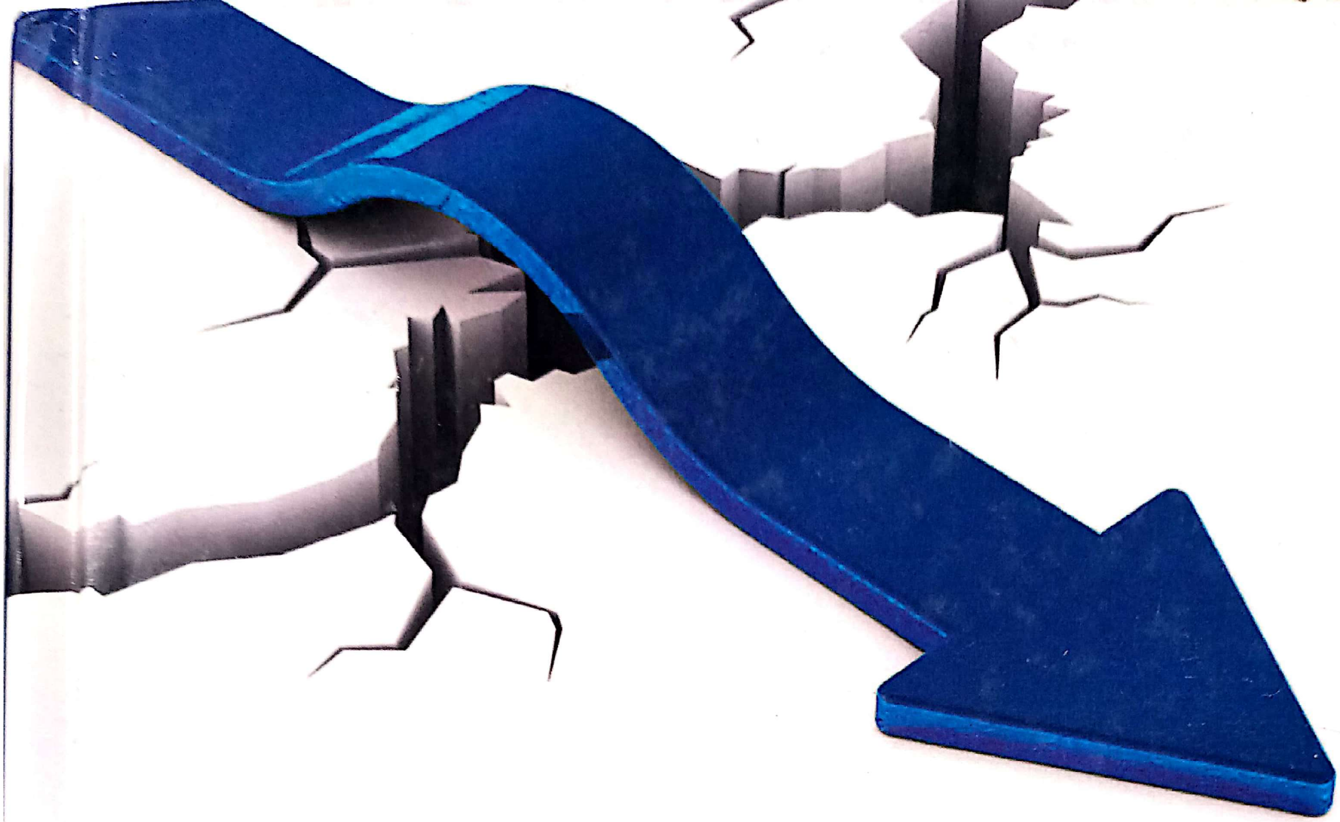

FAULT LINE IN HIGHER EDUCATION

AN INDIAN PERSPECTIVE

PREETI OZA
GURUDUTTA P. JAPEE

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An Indian Perspective

Editors

Preeti Oza

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Simulation for Brine Evaporation Parameters Acquired using Distributed Embedded System and Seepage Estimation

Rameshchandra Makavana
Department of Physics
Veer Narmad South Gujarat University
Surat, India
dhyeymakwana@yahoo.co.in

Vibhutikumar Joshi
Department of Physics
Veer Narmad South Gujarat University
Surat, India
joshi_vibhuti@yahoo.com

Hiteshkumar Lad
M,Sc.IT Programme
Veer Narmad South Gujarat University
Surat, India
hiteshlad.msc@gmail.com

***Abstract*—Natural water evaporation is a physical phenomenon that is useful in many industrial applications. Many researchers have worked to monitor the parameters affecting the brine evaporation rate. Many different criteria have been determined by researchers to obtain data for the parameters. This paper presents a simulation based on modified Penman equation. Objective of this work is to acquire the parameters experimentally in a different way using distributed embedded system. Finally evaporation rate for series of condensers prepared for natural evaporation type salt manufacturing process has been compared with experimental values. The result shows that the parameter acquisition method performs well in the environment of salt manufacturing unit and also helps estimating seepage component of brine.**

Keywords—Brine, Distributed Embedded System, parameter Acquisition, Simulation

I. Introduction

The relationship between salt and human exists since time immemorial. Initially rock-salt was used for domestic purpose, but after the industrial revolution, extraction of the salt from brine/seawater made available. With the highest number of primary consumers on the globe, salt is an essential commodity for human with any type of food cooking habits. Apart from serving to add taste to food, salt is an important raw material for production of range of chemicals [1]. In the salt manufacturing process, inland brine or seawater has been used as raw material. Salinity of the brine or seawater plays an important role during the salt production process. Brine to be exposed for evaporation has different salt concentration will show different evaporation rate. Common salt NaCl has been produced through natural solar evaporation technique. Evaporation is the phenomenon in which state of liquid changes to the vapor. The evaporation rate from brine resources depends mostly on the amount of saturated vapor pressure above its surface. The saturated vapor pressure is affected by the ion activity coefficient, which stems from the salt concentration of water, which is also known as salinity of the brine. Thus, increase in concentration results in reduction of saturated vapor pressure. To acquire actual evaporation rate a uniform set of evaporation pans under same meteorological condition with different salt concentration are used [2]. Solar ponds are simple pools of saltwater where it acts as a large scale solar energy collection system which absorbs solar radiation and stores it as thermal energy [3]. Such solar ponds have been used to increase the salinity of brine are known as condensers. A series of various condensers have been prepared in order to evaporate content of the water from the brine. Information on the evaporation rate is crucial when designing saltwater ponds [4]. If evaporation rate has been known, planning and scheduling to feed fresh brine has to be determined. Brine flow control between two successive condensers also depends on the rate of evaporation. The last pond after the series of condensers is the main pond where crystallization of sodium chloride takes place.

In natural evaporation salt manufacturing process, a gradual salinity increment in successive condensers play an important role. Brine salinity level must be reached at certain level before filling the brine in the main salt pan followed by a series of condensers. Operation of this task requires close monitoring by the saltpan workers for brine flow control in the process. This paper presents a real-time concept for the development of the system replacing traditional method and in order to help saltpan workers to monitor the salinity of successive condensers in the series and system is also helpful to operate the pump/ actuator.

II. THEORETICAL BASE FOR SIMULATION

A. The Equation

In natural solar evaporation, the main source for the energy is the sun. The air above the brine surface of the condenser becomes saturated with vapor of water and In order to remain continue the evaporation process, this humid air must be removed by natural wind. Many field testing methods and few equations are used till today for the determination of evaporation rate. In order to determine evaporation rate from open water source the Penman equation, which was proposed in 1948, has generally be used by hydrologist in that era. This equation is acceptable for natural water resources with relatively very lower salinity levels. The Penman equation was modified to reflect the reduced vapor pressure of a saline solution of higher TDS levels (Akridge, 2008). The modified Penman equation is presented as [4] [5]:

$$\lambda E=\frac{\Delta}{\Delta+\gamma}R_n + \frac{\Delta}{\Delta+\gamma}f(u)(e_s-e)\ldots\ldots\ldots\ldots(1)$$

Where: E= evaporation

λ=latent heat of vaporization ($MJKg^{-1}$)

Δ=gradient of the vapor pressure-temperature curve.

Υ=psychometric constant (location specific)

R_n=net solar radiation ($MJm^{-2}day^{-1}$)

f(u)=function of wind speed (m/s)

e_s=saturation vapour pressure (function of temperature and salinity

$e_s=0.6108a_w\exp\frac{17.27T}{237.3+T}\frac{17.27T}{237.3+T}$, T=mean temperature

Where $a_w=-0.0011m^2-0.0319m+1$, m is salinity of brine in mole per liter)

e= ambient water vapor pressure (function of relative humidity $=H_r e_s/100$, where H_r=relative humidity) [6]

In order to calculate latent heat of evaporation mean of daily maximum and minimum temperature is required and for this purpose we input maximum temperature and minimum temperature of the day in simulation. In order to calculate gradient of vapor pressure- temperature curve, saturation vapor pressure and mean temperature are required and saturation vapor pressure is a function of concentration of sodium chloride and mean temperature. Mean temperature will be obtained from maximum and minimum values of the daily temperatures and concentration of sodium chloride for brine (salinity) has been taken as an input parameter. Psychometric constant is a function of the atmospheric pressure, which is dependent only on the height of the site from the sea level. Net solar radiation can be calculated from latitude of the place, number of the day of the year, from the sunshine duration of the day and albedo of the surface. Ambient water vapor pressure is calculated from average relative humidity of the day.

B. The Simulation

The simulation of above equation is possible using so many packages of software. Different researchers use different kind of software. In this paper trial version of MATLAB has been used for simulation work. Following parameters have been taken as inputs for the simulation.

1. Maximum temperature of the day in °C.
2. Minimum temperature of the day in °C.
3. Concentration of sodium chloride in mole/liter
4. Height of the site above sea-level in meters
5. Latitude of the experimental site in decimal degree
6. Number of the day of the year
7. Sunshine duration in hours
8. Albedo of the surface.
9. Wind speed in m/s
10. Average relative humidity of the day in rh%

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Values of above mentioned parameters are necessary in simulation method, to find out evaporation rate for the particular salt condenser. Method for acquiring values of these parameters is explained in the next section of the paper. Distributed embedded system is used for this purpose. There are two types of distributed embedded system can be employed in this application (1) Wired distributed embedded system and (2) wireless distributed embedded system, the later one is most suitable for acquiring the parameter in conventional salt manufacturing industries.

III. PARAMETERS ACQUISITION METHODOLOGY

A number of researchers have worked in modeling and simulation of solar evaporation process, but a very rare has touched the parameter acquisition side. As all the solar evaporation type salt manufacturing units do not have nearby meteorological stations, demand of in-situ parameter acquisition has been increased. Day by day new methods are invented for the determination of parameters affecting the solar evaporation process.

Parameters described in above simulation can be acquired by so many different methods. One of these, using distributed embedded system is illustrated. In the study the site has been selected near Desert Island of Vachchharaj Bet, little runn of Kutch in the Gujarat state of India. The latitude of the site is 23.38575 and longitude of the site is 71.51788. In the extracted brine from this site, the prevailing dissolved salt in water is sodium chloride.

A. Method Discription

Temperature has been monitored at regular interval of the day by using temperature sensor DHT22. The sensor DHT22 is available with digital output. A complete set of the temperature data has been acquired and stored in Excel sheet through the specially designed data logger. Using data shorting method, maximum and minimum temperature of the day have been obtained easily. Concentration of sodium chloride in the brine is obtained by electrical conductivity measurement and temperature of solution. Sensors DFR0300 and DS18B20 are used for the measurement of conductivity of brine and temperature of the solution respectively. Data of these sensors are useful for the calculation of the concentration of NaCl in the conversion of mole per liter. Sensor DFR0300 is based on principal of temperature dependant electrical conductivity with analog output. This conductivity meter is specially designed for Arduino based microcontrollers. Conductivity is reciprocal of resistivity, and it describes the ability of the material to carry the current. In liquid we often use conductance rather than resistance. The measurement unit for the solution conductivity is either milli-Siemens (mS) or micro-Siemens (µS), salinity of the brine has been decided through this measurement. How much electrolytes are present in the water, if concentration of the electrolytes differs, conductivity of the solution differs. In order to measure temperature dependent salinity, DS18B20 is used as temperature sensor for the temperature measurement of the brine. This sensor provides configurable 9 to 12 bit, 1-wire interface digital output. The sensor electrode design has been kept waterproof as this sensor is used for different types of liquid solutions.

Height above sea-level can be obtained from internet site www.mapcoordinates.net simply adjusting latitude and longitude data of the place where experiment has been performed [7]. Latitude of the experimental place has been obtained from GPS coordinates or from the internet sites or by mobile phone application [8]. Number of the day of the year can directly be calculated and entered. In order to calculate sunshine duration of the day, light intensity sensor GY30 has been configured. Output of this sensor is in lux. According to World Meteorological Organization sunshine duration has been defined as the period during which direct solar irradiance exceeds a threshold value of 120 W/m^2. This threshold value is equivalent to 15190 lux. So in this research work calculated hours of the day during which the irradiance of the sun exceeds 15190 lux, in the experiment the value is 7 hours, this is easy to find out from irradiance data obtained from the installed embedded system. During solar evaporation process of the brine, salt crystal will begin to form, thus in reflectivity is increased. In such case appropriate albedo value found by Rife et al. (2002) is 0.3 [6]. This reference value has been used in this research work. In order to obtained wind speed data, Adafruit industries make wind speed sensor 1733 has been configured. This anemometer measures wind speed directly in meters/seconds. This sensor is RoHS (Restriction of Hazardous Substances) compliant. RoHS compliant means that the electronics or electrical component or device does not contain hazardous substances namely: lead, mercury, cadmium, PBB and PBDE. This well made wind speed sensor is designed to install outside and measure wind speed with ease. The sensor is rugged and easy to mount. The sensor gives analog voltage output which is proportional to the wind speed. The voltage ranges from 0.4V DC (for wind speed of 0 m/s) up to 2.0V DC (for wind speed of 32.4 m/s). At regular interval humidity data in rh% has been recorded using the sensor DHT22, Which is earlier mentioned for temperature monitoring. This sensor is dual purpose sensor. Humidity sensors works on either capacitive principle or resistive principle. In capacitive sensor, a thin film of metal oxide or polymer is deposited between two conductive plates. The change in dielectric constant of the sandwiched material is directly proportional to the humidity of surrounding environment. In resistive humidity sensors, electrical resistivity of medium, like conductive polymer or salt exhibits, change with the change in humidity. DHT22 is capacitive type, high precision humidity sensor. It is preferred in this work because it gives calibrated digital signal with low power consumption and no extra components required to configure it. It is available in fully interchangeable package with 4-pins. Full range temperature compensation and outstanding long-term stability are additional features of this sensor. Sensors DHT22, DFR0300, DS18B20, GY30, 1733 are configured with appropriate input pins of Arduino Uno microcontroller kit. All data regarding air temperature, salinity, brine (solution) temperature, solar irradiance and wind speed are displayed on LCD display by designing suitable program in IDE Arduino 1.8.5. The system is expandable as required by number of condensers in the series. Zigbee wireless modules are used in order to transfer the data wirelessly from one node to another node and to the base station. Zigbee is a standard IEEE 802.15.4 based wireless protocol. It is a high level communication protocol used to create personal area networks built from small, low power digital radios [9]. The parameters acquired by this methodology for the experimental site has been summarized in table: 1.

Fig.1. Experimental Set-up to acquire data of the parameters affecting evaporation rate

B. *Acquired parameters*

TABLE I. PARAMETERS USING DISTRIBUTED EMBEDDED SYSTEM

Parameter	Condenser 1	Condenser 2	Condenser 3	Condenser 4
Maximum temperature of the day in degree Celsius	8	8	8	8
Maximum temperature of the day in degree Celsius	32	32	32	32
Concentration of Sodium Chloride in mol/liter	5.6	7.1	10.2	12.8
Site height above mean sea level (in meters)	07	07	07	07
Number of the day of the year	26	26	26	26
Latitude of the site (in degree North)	23.3857	23.3857	23.3857	23.3857
Actual duration of sunshine hours of the day	7	7	7	7
Albedo	0.3	0.3	0.3	0.3
Average relative humidity (RH%)	42	42	42	42
Wind speed (meter/second)	2.22	2.22	2.22	2.22

IV. RESULTS AND CONCLUSION

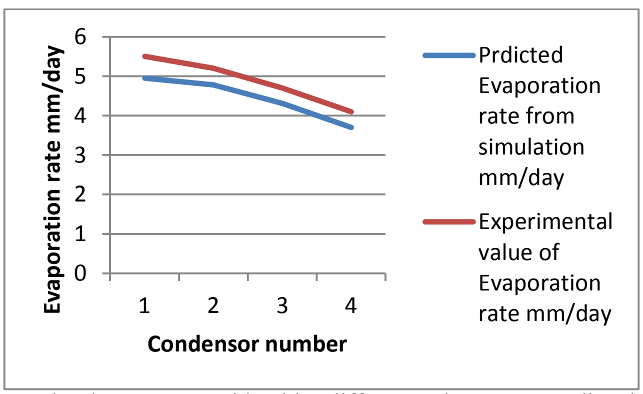
In an industrial operation several condensers (ponds) are used for salt crystallization. A salt-worker has to plan the feeding flow to each of the solar ponds, the manipulation of the brine solution between ponds, brine and solids inventories in the pond that maximizes the salt production [10]. The production unit has four successive condensers followed by a main salt-pan. The data obtained by simulation model and experimental values of the parameters obtained by above mentioned wireless distributed embedded system have been compared in table: 2.

A. Results and Discussion

TABLE II. COMPARISION OF SIMULATED AND EXPERIMENTAL VALUES

Condenser Number	Salinity Level (mol/lit.)	Evaporation rate predicted from Simulation model mm/day	Actual Evaporation rate (water lost) mm/day
1	5.6	4.9492	5.5
2	7.1	4.7807	5.2
3	10.2	4.3078	4.7
4	12.8	3.7053	4.1

Fig.2. Graphical representations of the results



Result shows a considerable difference between predicted evaporation rate from simulation and experimentally measured values. This kind of almost constant difference between simulated and experimental values of the evaporation might be seen because of the simulation considers only evaporation component and it does not consist the seepage component of the brine loss. Seepage is the slowly soaking of brine in porous soil. Seepage contributes as a function of brine level filled in the salt pan. The soil of the desert always consists of porous sand material that's why the seepage effect cannot be neglected. After crystallization at the bottom of the condenser, seepage doesn't show a major effect. Dikes and bottom of the salt pond/condenser employ porous sandy material mixed with minor partial loam and clay. Analysis of the soil of experimental site shows the seepage of approximately 0.5 to 1 mm/day after five weeks of filling the salt pan in these conditions. After the consideration of evaporation and seepage components, above results are justified as summarized in table-3.

TABLE III. CONSIDERATION OF SEEPAGE RATE

Condenser Number	Evaporation rate predicted from Simulation model mm/day	Actual Brine loss mm/day	Seepage rate after five weeks of salt production stage mm/day	Net Evaporation rate (Experimental values) mm/day
1	4.9492	5.5	0.5	5.0
2	4.7807	5.2	0.5	4.7
3	4.3078	4.7	0.5	4.2
4	3.7053	4.1	0.5	3.6

B. Conclusion

Theoretical evaporation rate in mm/day from simulation model are very close to the values obtained by practically measured values of evaporation in mm/day after considering the estimated seepage effect of 0.5 mm/day. Actual brine loss in the condenser includes the major factor of evaporation as well as the minor factor of seepage also. Thus parameters acquired through distributed embedded system showed an acceptable compatibility with predicted evaporation rate. System can be developed for more numbers of condensers and feeding flow of brine can be decided according to this database. Brine flow in each condenser can be managed using the data of the evaporation rate and seepage rate.

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Structural characterization of nanocrystalline cadmium sulphide powder prepared by solvent evaporation technique

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Samir G Pandya
Gujarat Arts and Science College, Ahmedabad, Gujarat, INDIA. (Government College, Pincode - 380006.)

Structural characterization of nanocrystalline cadmium sulphide powder prepared by solvent evaporation technique

Samir Pandya, Digisha Tandel, and Nisarg Chodavadiya

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Structural Characterization of Nanocrystalline Cadmium Sulphide Powder Prepared by Solvent Evaporation Technique

Samir Pandya[1,a)], Digisha Tandel[2], Nisarg Chodavadiya[2]

[1] *P.G. Department of Electronics, Gujarat Arts and Science College, Ellisbridge, Ahmedabad, Gujarat 380006, India*

[2] *Department of Physics, Uka Tarsadia University, Bardoli, Dist. Surat, Gujarat 394120, India*

[a)]Corresponding author: sp16574@gmail.com, Phone no.:+91 9825380476

Abstract. CdS is one of the most important compounds in the II-VI group of semiconductor. There are numerous applications of CdS in the form of nanoparticles and nanocrystalline. Semiconductors nanoparticles (also known as quantum dots), belong to state of matter in the transition region between molecules and solids, have attracted a great deal of attention because of their unique electrical and optical properties, compared to bulk materials. In the field of optoelectronic, nanocrystalline form utilizes mostly in the field of catalysis and fluid technology. Considering these observations, presented work had been carried out, i.e. based on the nanocrystalline material preparation. In the present work CdS nanocrystalline powder was synthesized by a simple and cost effective chemical technique to grow cadmium sulphide (CdS) nanoparticles at 200 °C with different concentrations of cadmium. The synthesis parameters were optimized. The synthesized powder was structurally characterized by X-ray diffraction and particle size analyzer. In the XRD analysis, Micro-structural parameters such as lattice strain, dislocation density and crystallite size were analysed. The broadened diffraction peaks indicated nanocrystalline particles of the film material. In addition to that the size of the prepared particles was analyzed by particle size analyzer. The results show the average size of CdS particles ranging from 80 to 100 nm. The overall conclusion of the work can be very useful in the synthesis of nanocrystalline CdS powder.

INTRODUCTION

Cadmium sulphide (CdS) is an wide band gap chalcogenide semiconductor, that have direct band gap transition with band-gap energy at room temperature of 2.4 eV, [1,4,7,9,11] high photoconductivity, high electron affinity and electronic band gap tunability [5]. By changing size and shape one can play with their optical and electrical properties and overall functionality. Therefore the control over size and shape of the nanocrystals plays vital role for their implementation in proposed applications [5]. CdS consists of two types of crystal geometry one is cubic zinc blend and other is hexagonal wurtzite. Out of these wurtzite is thermodynamically stable structure.

Both chemical and physical methods were well reported in the literatures by controlling the deposition parameters. It has emerged as important material for the solar photovoltaic multilayer light emitting diodes, optical filters, thin film field effect transistors, transparent conducting semiconductor for Optoelectronic devices, gas sensors, light detectors, etc [1-19].

The general observation from the literature is the formation of non-stoichiometric CdS film (with less sulphur) may be more favorable than stoichiometric films [4]. CdS itself is a combination of the light and heavy elements. The present era has the large number of the studies on the high purity CdS thin films by controlling the various deposition parameters such as temperature, deposition time, concentrations of various reagents. Xiang hui Zhao [3], Koigala subba ramaiah [4], Fouad Ouachtari [7-8], C. Gopinathan [14], studied CdS thin films prepared by chemical bath deposition, Jin Hyeok Kim [5] on photo-electrochemical performance, Anbarasi M [6] by spray pyrolysis technique, changing S/Cd molar ratios. In the present case we had used solvent evaporation technique to prepare Cadmium Sulphide Powder.

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EXPERIMENTAL

CdS thin Powder Prepared by Solvent Evaporation Technique. Before preparation of solution the glass wares were Organic cleaned using Methanol, Acetone, Trichloroethylene and deionized (DI) water. Precursor solution was prepared by dissolving 0.1 M each of Cadmium Acetate Dihydrate and Thiourea in methanol. The solution was stirred for 20 minutes for homogeneous mixture of the chemicals. Then after the precursor solution was kept 24 hour at 80 °C for evaporation of solvent. Remaining white colored salt then after heated at 200 °C for the thermolysis purpose. The white powder turns in to yellow color as shown in Figure 1. The prepared powder was characterized by XRD with Cu Kα radiation [λ = 1.54056 Å] and having SSD160 or LYNXEYETM detectors (D2 Phaser, Bruker Make) and the particle size analyzer on the basic of dynamic light scattering measurement (Malvern Instruments).

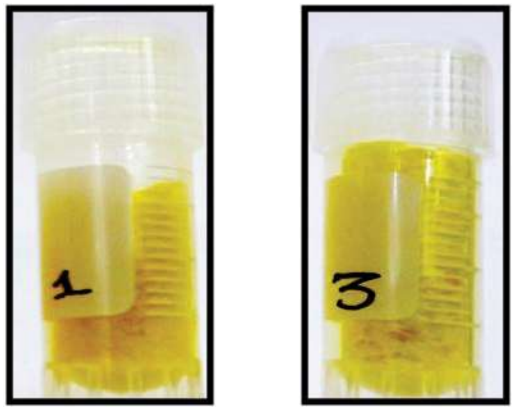

FIGURE 1. Prepared CdS powder using solvent evaporation method

RESULTS AND DISCUSSIONS

Optical Characterization

On the basis of the Color of the powder one can say that the prepared material can be CdS, as the bulk color of CdS is yellow. The detail structural characterization and the conformation of material XRD has been carried out. The XRD pattern of prepared CdS film is shown in Figure 2. Diffractogram of the thin film shows sharp peaks at 2θ values of about 26.5°, 43.9° and 52.1° which are identified as the diffractions from (111), (220) and (311) planes by comparing with the d-values of standard cubic Cadmium Sulphide phase.

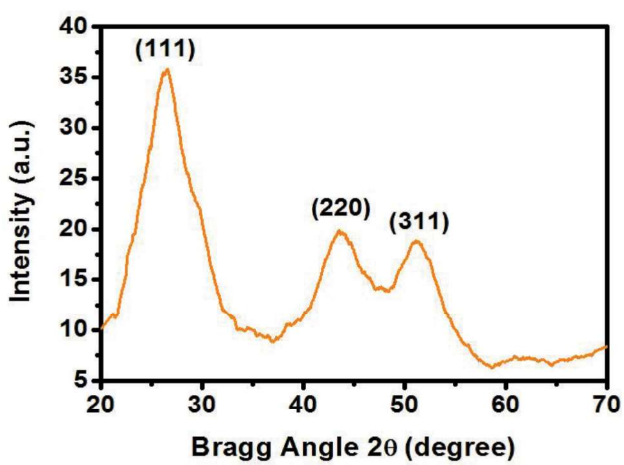

FIGURE 2.XRD pattern of CdS Powder obtained with Cd/S molar ratio 1.

Here, the d-spacing for all samples can be evaluated from the position of the major peak at about 26.5° & by the Bragg condition [19],

$$n\lambda = 2d\sin\theta \;\; or \;\; d = \frac{n\lambda}{2\,\sin\theta} \tag{1}$$

where,

n is the order of diffraction,

λ is the wavelength of the incident X-ray,

θ is the diffraction angle

d is the distance between the planes parallel to the axis of incident beam.

The XRD profile clearly reveals the cubic CdS phase formation in the films. The lattice constant "a" is calculated by using the following formula,

$$\frac{1}{d^2} = \frac{(h^2+k^2+l^2}{a^2} \tag{2}$$

where,

h, k and l denote Miller Indices.

The "Crystallite Size" of the crystallites was calculated using Scherrer's equation,

$$D = \frac{k\lambda}{\beta\cos\theta} \tag{3}$$

where,

D is the mean size of Crystallites;

k is a dimensionless shape factor usually = 0.94;

λ is the wavelength of X-Ray;

β is FWHM (full-width at half maximum) of the peak, in radians. This quantity is also sometimes denoted as $\Delta\,(2\theta)$;

θ is the angle of diffraction called Bragg angle (in degrees).

The dislocation density can be found using size of crystallites,

$$\delta = \frac{1}{D^2} \tag{4}$$

The lattice (micro) strain in the film can be found by,

$$\varepsilon = \frac{\beta\cos\theta}{4} \tag{5}$$

The observed value for the peak about 26.5° is mentioned in the Table 1.

The average crystallite size was found to be 1.55 nm. Further the strain present in the film is 0.1021, indicates the stability of the crystal structure in the prepared powder.

TABLE 1.XRD Table of CdS thin powder

Sample Code	Cadmium salt concentration (M)	Thiourea concentration (M)	Cd/S molar ratio	FWHM 'β' peak width (°)	Crystallite size (nm) 'D'	Dislocation density 'δ' 10^{15} (lines/m^2)	Lattice strain
1	0.1	0.1	1	5.514	1.55	0.4162	0.1021

Particle Size Analyzer

XRD results suggest the formation of the CdS material in the nanocrystalline form. To further identification of the size of the particle, Particle size analyzer was used at room temperature. We had prepared the samples having a different dilution percentage in the methanol solvent. The best results were obtained at the 0.53 mPa.s viscous solution. Figure 3 shows the particle size distribution of CdS by volume as well as the size in nm.

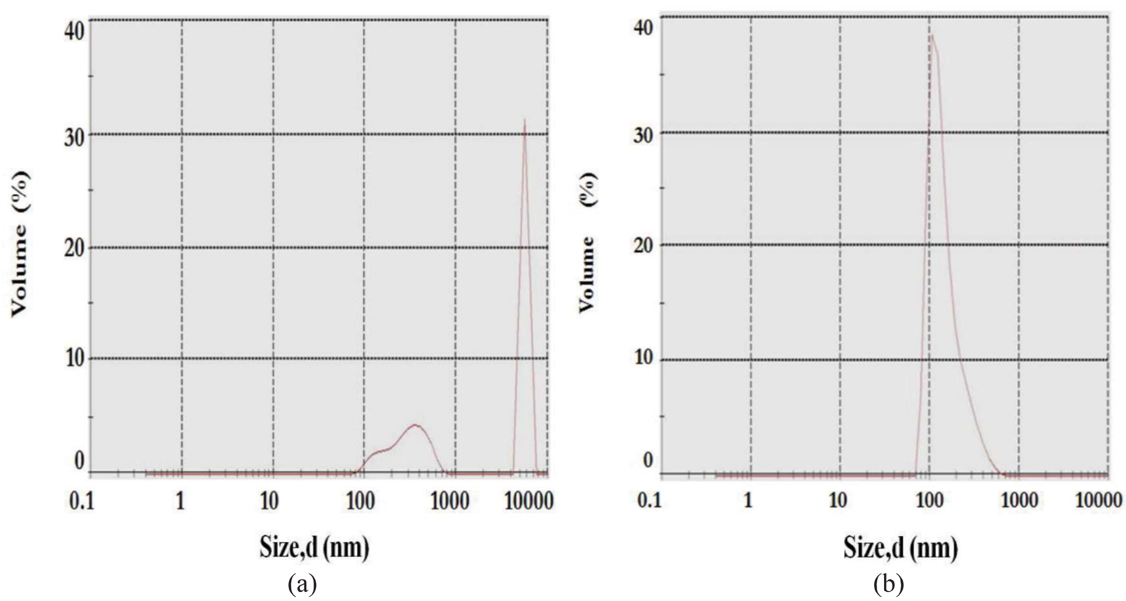

FIGURE 3. Particle Size Distribution of CdS powder by Volume (a) and by Number (b)

Figure 3(a) indicates the particle size distribution by volume. In that case 5% volume of the CdS particle was clearly observed. Figure 3(b) indicates the size of the particles which are in the range of 80-700 nm. The peak intensity observed at 100 nm. This indicates the average particle size is around 100 nm. These each particle contains nearly 2 nm crystals, which are observed from XRD.

CONCLUSION

Solvent evaporation method used for the preparation of nanocrystalline CdS powder at 200 °C temperatures. In the XRD analysis, crystalline size, dislocation density, lattice strain were analyzed. In addition to that the particle size analyzer shows the average size of the prepared CdS particles. The overall conclusion of the work can be very useful in the synthesis of nanocrystalline CdS powder.

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5 authors, including:


Jaymin Ray
Uka Tarsadia University


Samir G Pandya
Gujarat Arts and Science College, Ahmedabad, Gujarat, INDIA. (Government College, …

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Nisarg Chodavadiya, Amisha Chapanari, Jignesh Zinzala, Jaymin Ray, and Samir Pandya

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Synthesis and Characterization of Cadmium Sulphide Thin Films Prepared by Spin Coating

Nisarg Chodavadiya[1], Amisha Chapanari[1], Jignesh Zinzala[1], Jaymin Ray,[1,a)] and Samir Pandya[2]

[1] *Department of Physics, Uka Tarsadia University, Bardoli, Dist. Surat, Guajrat 394120, India*
[2] *P. G. Department of Electronics, Gujarat Arts and Science College, Ellisbridge, Ahmedabad, Gujarat, India*

[a)]Corresponding author: jayminray@gmail.com, Phone no.: +91 9904829289

Abstract. An II-VI group semiconductor is Wide band gap materials and has been widely studied due to their fundamental optical, structural, and electrical properties. Cadmium sulphide (CdS) is one of the most emerged materials in II-VI group. It has many applications such as buffer later in photovoltaic cell, multilayer light emitting diodes, optical filters, thin film field effect transistors, gas sensors, light detectors etc. It is fundamentally an n-type material with an optical band gap of 2.4 eV. Owing to these properties we had studied CdS thin films synthesis and characterized by Raman, Ultraviolet – Visible spectroscopy (UV-VIS) and Hot probe method. CdS thin films were prepared by spin coating of the Cadmium-thiourea precursor solution. Visual inspection after 20 minute thermolysis time the films were looks uniform and shiny pale yellow in color. Raman confirms the A1 vibration of pure CdS. UV-VIS gives the band gap about 2.52 eV, which confirms the formation of nanocrystalline form of CdS. Finally, hot probe signifies the n-type conductivity of the CdS film.

INTRODUCTION

Majority of metal sulphides and selenides thin film semiconductors such as CdS, ZnS, CdSe, ZnSe, are deposited by chemical routes on to the variety of substrates like glass, polymers metal etc [1]. Cadmium sulphide (CdS) is one of the most emerged materials in II-VI group and has good optical transmittance, direct wide band gap and electrical properties suitable for their application to solar cell fabrication, multilayer light emitting diodes, optical filters, thin film field effect transistors, gas sensors, light detectors, [2-6] etc. Various reports available in the literature on the properties of polycrystalline thick or thin film CdS deposited by several techniques such as chemical vapour, deposition, chemical bath deposition, spin coating, thermal evaporation, Spray pyrolysis, thermal evaporation etc. In spite of it there is always a need of uniform CdS thin film over a large area and stoichiometry control. In the chemical route, depending on the deposition conditions such as solution temperature, stirring time and deposition time decides the quality of the film and hence their optoelectronics properties [7]. Addition to that the deposition route can be low-cost and relatively simple for particularly ease of large area deposition.

A Polycrystalline CdS has the metastable cubic structure and the stable hexagonal structure. Depending on to the application one of these two transitions can be utilized. Obtaining the stable structure need to go for many adjustment in the process of chemical route. H. Metin et.al. [8] reported that the thermal annealing in a controlled Ar + S_2 atmosphere responsible for the structural transition of CdS films from cubic to hexagonal. That also caused the variation in the band gap. R. Ram´ırez-Bon et.al. report said that. CdS film annealed at 200 °C shows the cubic and above 400 °C it is a hexagonal [9]. Addition to that Newmann et. al also observed the order–disorder transition of CdS films [10]. In the present study we report the preparation and characterization of CdS thin films by simple spin coating method. A possible explanation to these results will be discussed in brief.

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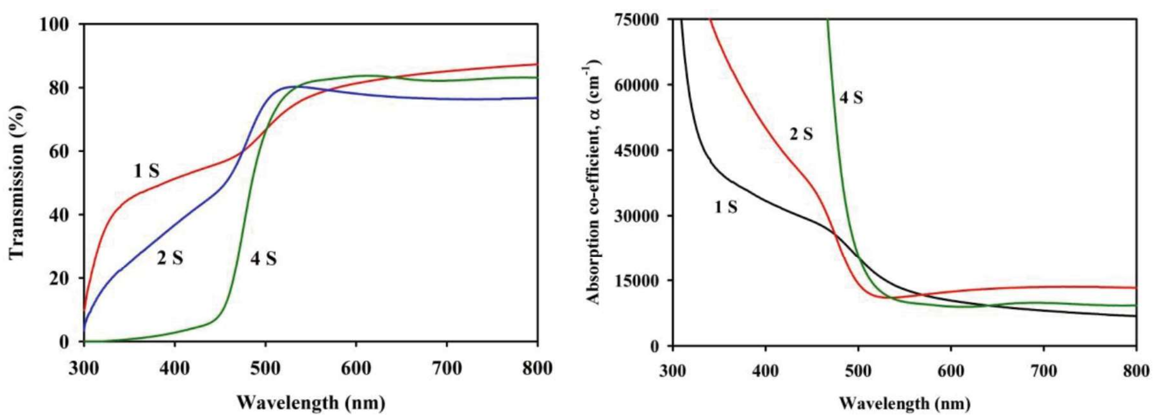
EXPERIMENTAL

CdS thin films have been prepared on organically cleaned glass substrate, 25 mm × 25 mm, by spin coating. Precursor solution contains the 0.1 M Cadmium acetate, 0.1 M Thiourea and methanol as a solvent. Glass substrate was held on the spin coating chuck at room temperature for the deposition of CdS films. Typical rpm was set to 1000 to obtain device quality films. After spinning the precursor films were heated at 200 °C for 20 minutes. We had prepared three sets of CdS films i.e. one time spin (1S), two time spin (2S) and four time spin (4S). In the other words we can say that as the Number of spin increases, thickness of the films increases. Ultraviolet – Visible (UV-VIS) spectroscopy (UV 1600, Shimartzu make), in the range of 300 to 800 nm, used to study the optical properties such as transmission absorption and band gap. Raman analysis was used to identify the vibration modes so the characteristic of the basic material. Hot probe method used to confirms the type of the conductivity of the prepared material.

RESULTS AND DISCUSSION

Optical Characterization

As prepared films were pale yellow in color and its transmission was measured at room temperature by UV-VIS spectroscopy. The transmission and the absorption spectrum of CdS films are shown in Fig. 1 (a) and (b).



(a) (b)

Fig.1 (a) Transmission and (b) absorption spectra of CdS films

Looking towards the both transmission and the absorption behavior of the CdS films one can certainly observer the influence of number of spins so the thickness of the film. In the case of 1S film the transmission edge does not seems to be sharp enough. As the thickness increase i.e. going from 1S to 4S, the transmission edge was become sharpen. Similar kind of behavior can be seen from the absorption spectra. Lower thickness film shows the multiple absorption edge while higher thickness shows the sharp and clear absorption edge. Approximate value of the absorption edge is about 500 nm, that is in well accordance with the reported literature [11,12]. Using the data of transmission and absorption the band gap can be calculated using the relation,

$$\alpha h\nu = \left[k\left(h\nu - E_g\right)^{\frac{1}{2}} \right], \quad (1)$$

Where, k is constant, α is the absorption co-efficient, E_g is the band gap, and hν is the photon energy.

The plot of band gap is shown in fig. 2, which signifies the significant variation in the band gap value as the thickness of the films varies.

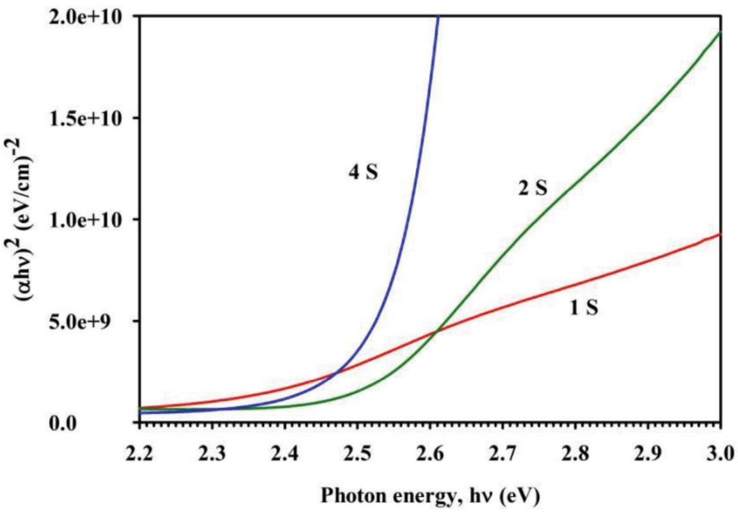


Fig. 2. Variation of energy band gap with the thickness of CdS thin films

Lower thickness (1S) films exhibit slightly uneven behavior of the absorption, compare to the higher thickness film, so it is very difficult to determine the value of band gap. As the thickness increases, i.e. from 2s to 4S, the band gap values decreases from 2.54 to 2.52 eV. There is no significant change observed in the band gap but the absorption value differs. Observed band gap, 2.52 eV is much higher than the bulk value; this signifies that the CdS films consists of very small sized grains [13]. That conduces to the electrical isolation of individual grains, and so the increase in the electrical resistivity can be observed.

Raman Spectra

Typical Raman spectra of the 4S CdS thin film is shown in Fig. 3.

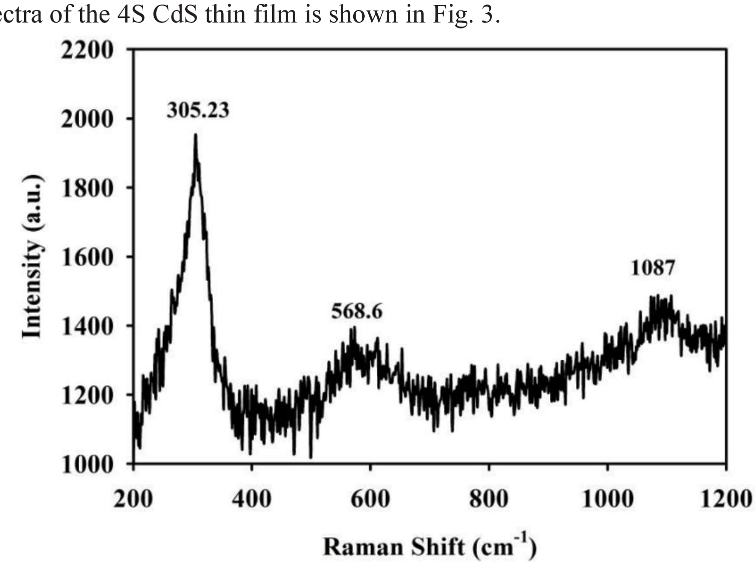


Fig. 3. Raman spectra of the prepared CdS thin film (4S).

The Raman spectrum shows a one major peak at 305.23 cm^{-1}, which corresponds to the A1 (LO) mode of CdS, with additional peak at about 568.6 and 1087 cm^{-1}. All the peaks observed were well reported in the literature of the CdS. The FWHM of peal 305.23 cm^{-1} is account 43 cm^{-1}. The broadness of the Raman peak indicates the formation of the crystals in the nano scale. No other then CdS peaks can be identifies, that indicates the purity of the crystal structure. Raman analysis is also in accordance with the optical analysis of the films. Further the hot probe confirms the prepared films exhibit the n-type conductivity.

CONCLUSION

Thin films of CdS were prepared by simple spin coating techniques. Raman studies signify the formation of pure CdS phase. Optical band gap in the range of 2.5 eV shows the nano-crystalline films of the CdS. Hot probe method indicates the n-type behavior of the films.

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