Synthesis and Characterization of Cobalt Zinc Ferrite Nanoparticles

Khin May Oo⁽¹⁾, Zar Zar Myint Aung⁽²⁾, Swe Swe Thant⁽³⁾

⁽¹⁾ Technological University (Lashio), Myanmar ^{(2),(3)} Lashio University, Myanmar

Email: dr.dawkhinmayoo@gmail.com

ABSTRACT: Cobalt Zinc Ferrite with a spinel crystal structure was synthesized by using co-precipitation method. Cobalt-Zinc ferrite with the composition of Co_{0.50}Zn_{0.50}Fe₂O₄ prepared by this stoichiometric ratio. The required amount of cobalt chloride hexahydrate (CoCl₂.6H₂O). zinc sulphate heptahvdrate (ZnSO₄.7H₂O), and anhydrous ferric chloride (FeCl₃) were used to prepare as the sample. The precursor solution was heated in vacuum chamber at 500°C for 2 h. The grown ferrite sample was characterized by X-ray diffraction (XRD) and Scanning Electron Microscopy (SEM). The structural properties of crystal structure, lattice parameters, crystallite size and morphological features of the sample were studied in this work.

KEYWORDS: Ferrite, co-precipitation, X-ray diffraction (XRD), Scanning Electron Microscopy (SEM)

1. INTRODUCTION

Ferrites have very important applications according to their electrical and magnetical properties. The substitution effect and the change of the preparation condition are allowed to improve some ferrites with ferrites with different composition to be used in wide frequency range from microwaves to radio wave frequencies. Cobalt Ferrites are good dielectric materials and have attracted considerable attention and continued efforts to investigate them for their technological importance to the microwave devcices, high speed digital tape or disk recording, repulsive suspension for use in levitated railway systems, and magnetic refrigeration systems [(Adam A, et al. (2009), Bondyopadhyay A K et, al. (2010)]. The conventional way of preparing the ferrite is by solid- state reaction, which involves the mixing of oxides with intermittent grinding followed by high temperature sintering between 1300°C and 1700°C. Though the process remains simple it has several drawbacks such as high reaction temperature, larger particle size, limited degree of homogeneity, and low sinterability. On the other hand, the wet chemical processes such as sol gel and co-precipitation method yield sub-micron sized particles with good homogeneity, high sinterability, and good control of stoichiometry [Pillai S O (2006)]. The most important properties of ferrites include high magnetic permeability and high electrical resistance. High permeability to magnetic fields is particularly desirable in devices such as antennas. High resistance to electricity is desirable in the cores of transformers to reduce eddy currents. Ferrites of a type known as square-loop ferrites can be magnetized in either of two directions by an electric current. This property makes them useful in the memory cores of

digital computers, since it enables a tiny ferrite ring to store binary bits of information. Another type of computer memory can be made of certain single-crystal ferrites in which tiny magnetic domains called bubbles can be individually manipulated. A number of ferrites absorb microwave energy in only one direction or orientation; for this reason, they are used in microwave wave guides [Roelofsen J N et, al. (1992)]. Ferrites with the spinel structure form a group of technologically important materials. There are many methods for the preparation of ferrites, including conventional ceramic method (solid state reaction), co-precipitation method, hydrothermal method, high-energy ball milling method and sol-gel method. Among these methods, coprecipitation method appears to have attracted much attention for preparing ferrites nanoparticles. But particles prepared by co- precipitation method require heat treatment to get better crystalline, so the process need long time consuming with bad quality control and easy chemical contamination [(Adam A,et al. (2009), Bondyopadhyay A K et, al. (2010), Chattopadhyay K K et, al. (2009)]. In the present work, cobalt-zinc ferrite (Co_{0.50}Zn_{0.50}Fe₂O₄) has been prepared by coprecipitation method and characterized by powder X-ray diffraction and Scanning Electron Microscopy (SEM).

2. MATERIALS AND METHODS

Cobalt-zinc mixed ferrite (Co_{0.50}Zn_{0.50}Fe₂O₄) has been prepared by co-precipitation method. Aqueous solutions of Analar (AR) grade nickel chloride hexahydrate (NiCl₂.6H₂O), zinc sulphate heptahydrate $(ZnSO_4.7H_2O),$ cobalt chloride hexahydrate (CoCl₂.6H₂O) and anhydrous ferric chloride (FeCl₃) with stoichiometry were mixed thoroughly stirrer at 80°C. It is then transferred immediately into a boiling solution of sodium hydroxide (NaOH) under stirring throughout the reaction. Conversion of metal salts into hydroxides and subsequent transformation of metal hydroxide into ferrites takes place upon 100°C and maintained for 1 h until the reaction is complete.

The formed ferrites were isolated by centrifugation and washed several times with de-ionized (DI) water followed by acetone and then dried at room temperature. The dried ferrites powders were ground and then sintered at 500 °C for 2 h in vacuum chamber by using DELTA A Series Temperature Controller DTA4896. The K-type thermocouple was used as the temperature sensor to read-out the real temperature of the sample in the chamber.

Photographs showing the experimental set-up of sample preparation system, DELTA A Series Temperature Controller DTA4896, weighed starting materials, solutions of starting materials, filtration and as-prepared cobalt-zinc ferrite, $Co_{0.5}Zn_{0.5}Fe_2O_4$ are shown in Fig 1 (a)-(e). The preparation of cobalt-zinc mixed ferrite, $Co_{0.50}Zn_{0.50}Fe_2O_4$, using co-precipitation method and the experimental measurements of X-ray diffraction (XRD) and Scanning Electron Microscope (SEM).













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Fig.1 Photographs showing the (a) weighted starting materials (b solutions of starting materials) (c) filtration of the precusor solution (d) experimental set-up of sample preparation system and (e) DELTA A Series Temperature Controller DTA4896 at temperature 500 °C

3. RESULTS AND DISCUSSION

3.1 Structural Analysis of Cobalt Zinc Ferrite

The experimental results of structural analysis and microstructural characteristics of the cobalt zinc mixed ferrite ($Co_{0.50}Zn_{0.50}Fe_2O_4$) from the XRD measurement. Powder X-ray diffraction pattern of cobalt-zinc mixed ferrite ($Co_{0.50}Zn_{0.50}Fe_2O_4$) is shown in Figure 2. The observed XRD lines are compared to those of JCPDS data library files of pure Nickel ferrite, Cobalt ferrite ($CoFe_2O_4$), and pure zinc ferrite($ZnFe_2O_4$). The collected XRD lines are well assigned with JCPDS files because the observed XRD lines are found to agree with standard JCPDS and/or the collected diffraction lines with corresponding JCPDS files are also coincided.

As shown in Figure 1, the (311) plane is found to the strongest in intensity (peak height = 100 %) among the observed XRD lines in each of the ferrite samples. From the XRD patterns, the appearance of the observed diffraction peaks demonstrates that cobalt-zinc mixed ferrite ($Co_{0.50}Zn_{0.50}Fe_2O_4$) sample is single-phase spinel type cubic lattice or the sample is successfully prepared by co- precipitation method. The collected data were used to refine the unit cell parameters from the observed 2 θ values with JCPDS. The observed XRD data of diffraction angle (2 θ), atomic spacing (d), miller indices (h k l), Full Width at Half Maximum (FWHM) and peak height (%) of the sample are tabulated in Table 1.

Table 1. XRD data of the Cobalt Zinc Ferrite

No	20	(h k l)	d (Å)	FWHM	Height
	(°)			(°)	(%)
1	18.21	111	3.73	0.16	11.20
2	30.01	220	2.92	0.23	30.50
3	35.17	311	2.55	0.21	100
4	36.62	222	2.45	0.19	7.80



Fig 2. XRD pattern of Cobalt Zinc Ferrite

According to XRD patterns, cobalt-zinc mixed ferrite ($Co_{0.50}Zn_{0.50}Fe_2O_4$) belongs to cubic structures at room temperature. The lattice parameters are evaluated by using crystal utility of the equation of,

$$d = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$$

The lattice parameters of the sample are obtained as a = b = c = 8.4577 Å. From XRD data, crystallite size of the sample is calculated by using the Scherrer formula,

$$D = \frac{0.9\lambda}{B\cos\theta}$$

where, D = the crystallites sizes (nm), λ = wavelength (Å), θ = diffraction angle of the peak under consideration at FWHM (°) and B = observed FWHM (radians). In the present work, the crystallite size of the cobalt zinc ferrite (Co_{0.50}Zn_{0.50}Fe₂O₄) is obtained the crystallite size as 39.82 nm.

3.2 Morphology Analysis of Cobalt Zinc Ferrite

Figure 3 shows Scanning Electron Microscopy (SEM) was employed for the morphological features of cobalt zinc ferrite $(Co_{0.50}Zn_{0.50}Fe_2O_4)$.



Fig 3. SEM micrograph of Cobalt Zinc Ferrite

As shown in Figure 3, the grain shape of the sample is non-uniform block shape couple with each other and the grain sizes are obtained as $0.50 \ \mu m - 3.00 \ \mu m$. From the SEM micrograph, it is indicated that the cobalt zinc ferrite ($Co_{0.50}Zn_{0.50}Fe_2O_4$) is successfully prepared by coprecipitation method followed by the annealing at 500°C for 2 h in the vacuum chamber.

4. CONCLUSIONS

The chemical co-precipitation method was successfully used for the preparation of cobalt-zinc ferrite (Co_{0.5}Zn_{0.5}Fe₂O₄). Lower temperature was sufficient for the reaction to occurred, high sinterability, and good control of stoichiometry. The sample was characterized by powder XRD method. According to XRD pattern, cobalt-zinc ferrite (Co_{0.5}Zn_{0.5}Fe₂O₄) belongs to spinel type cubic structure at room temperature and the lattice parameters are obtained as a = b = c = 8.4577 Å. The crystallite size of the sample is obtained as 39.82 nm. From the SEM micrograph, the sample was found to non-uniform block shape couple with each other and the grain size.

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AN INVESTIGATION OF LINER ATTENUATION COEFFICIENTS OF VARIOUS MATERIALS USING G.M COUNTER

Mar Mar Yee ⁽¹⁾, Khin May Oo⁽²⁾, U Soe Pying⁽³⁾ ⁽¹⁾ Pyay University, Myanmar ⁽²⁾ Technological University (Lashio), Myanmar ⁽³⁾ Pyay University, Myanmar

Email: marmaryee12345@gmail.com

ABSTRACT

The Geiger Muller counter was useful for detecting radioactive particles. Intensity of radiation can be measured. Different shielding materials were used to reduce the radiation to a level safe for humans. The linear attenuation coefficient of Copper and Aluminium materials were measured and compared by using radioactive main source ⁶⁰Co for ST 360 Geiger-Muller counter. The linear attenuation coefficients of Copper were found to be high.

KEYWORDS: Aluminium ,Copper, source ⁶⁰Co, attenuation coefficients

1. INTRODUCTION

Ionization chamber, Proportional counter, G.M counter and Semiconductor counter are electric detectors. Scintillation counter, Cerenkov counter, Photographic emulsion, Cloud chamber, Bubble chamber and Spark chamber are optical detectors. Geiger-Muller tube is a device used for the detection and measured of all types of radiation alpha, beta and gamma radiation. The gamma-ray sources based on beta decay are generally limited to energies below about 2.8 MeV. ⁶⁰Co gamma rays decrease in intensity with the 5.27 year half-life characteristic of ⁶⁰ Co.

1.1 Linear Attenuation coefficient

If a collimated (parallel) beam of monoenergetic gammy rays of intensity I_0 pass through a thickness x of absorber the intensity I of the emerging photons which have not suffered any interaction is obtained by integration of result equation is

 $Ln I / I_o = -\mu x$

 $I = I_o e^{-\mu x}$ Where, I = shielded dose rate

 $I_0 = initial dose rate$

 μ = the linear energy absorption attenuation coefficient in cm

x = shield thickness in cm

2. EXPERIMENTAL SET-UP

The GM counter equipments are SPECTECH ST-360 counter with GM tube, shelf-stand, source holder, standard radioactive source and serial cable. The standard radioactive source ⁶⁰Co was used in this work. The GM tube is placed into the top of the shelf stand with the window down. The radioactive source ⁶⁰Co is carefully guided to a distance of 4 cm from the end- window

counter. This setting is fixed for throughout the whole measurement. Firstly, the counting measurement is started at 700 V setting. The counting time is made for 60 s. The voltage is increased 20 V. But the voltage is not go higher than the highest voltage (1200 V) listed on the certificate for that particular GM tube.

Table 1. The information about of standard gamma source

Source	Initial	Half-	Manufactur-	Present
	Act	L	ed Date	Act
	ivit	i		ivit
	У	f		у
	(µCi)	e		(µCi)
		(yr)		
⁶⁰ Co	1	5.27	Sept 2016	0.74

Table 2. Observation of background counts

Time	Voltage	Average	Average
(sec)	(V)	(counts/min)	(counts/min)
100	860V	75.667	0.76

Table 3. The experimental data with various	high voltage
using G-M counter	

High Voltage	Count/min
(V)	
600	
620	
640	
660	
680	
700	
720	1190
740	1216.8
760	1279.2
780	1311.4
800	1309.8
820	1306.2
840	1388.6
860	1444.4
880	1449.6
900	1430.6

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920	1501.8
940	1499.6
960	1510.8
980	1565.8
1000	1547.6
1020	1588
1040	1595
1060	1630
1080	1671.6
1100	1652.4
1120	1725.2
1140	1709
1160	1712.8
1180	1752.6
1200	1761.6



Graph (1) Plot of applied voltage v/s Counts/min

The voltage characteristic curve is drawn using these data as illustrated in graph(1). The threshold was increased in the voltage range will produce little effect on the counting range. The plateau curve is obtained by plotting counting rate (counts/second) versus the applied voltage. The optimal operating voltage is established from this plateau curve. The slope of the plateau curve is also calculated in this study. The threshold was increased in the voltage range will produce little effect on the counting range. This region is plateau. The slope of the plateau is 7.0376% per 100 volts in this present work as illustrated in Figure. The plateau should have a slope of less than 10% per 100 volts for good tubes. The operating voltage should be selected within the initial 1/3 of the plateau. The following calculation of operating voltage and the slope of plateau;

Starting voltage $V_s = 600$ Threshold voltage $V_1 (V_{th}) = 760$ Voltage at which plateau end $V_2 = 1040$ Plateau length L = 1040-760 = 280Working voltage from graph (1) $V_w = V_{th} + L/3$

$$= V_{th} + L/3$$

- 760 + 280/

= 760 + 280/3= 853.3V

$$\approx 0.00$$

≈ 860V

Slope(%) =
$$\frac{100 \frac{(R2 - R1)}{R1}}{V2 - V1} x100\%$$

Slope(%) = $\frac{100 \frac{(1543 - 1289)}{1289}}{1040 - 760} x100\%$
= 7.0376%

3. RESULTS AND DISCUSSION

The atomic number of Copper is 29 and its density is 8.9 g.cm⁻³. The atomic number of Aluminium is 13 and its density is 26.3815 g.cm⁻³. The linear attenuation coefficients of Copper mineral was calculated from Table (4) and drawn the graph (2). The linear attenuation coefficients of Aluminium material was calculated from Table (5) and drawn the graph (4). Graphs were drawn between the thickness of the material and the corresponding number of counts from the G.M counter. Graph (3) and graph (5) were expressed of XRD results of Copper and Aluminium materials. The linear attenuation coefficients of Copper was found to be high. It may be due to the atomic number Z of the absorber element increases as the stopping power values for beta particles decreases. The ability to absorb energy from beta particle depends on the number of absorbing electrons in path of the beta.

(Copper) material Thickness I_0 I u (mm^2/g) (count/mi (count/min) (mm)n) 3.25 2040.667 2024.6666 0.78 6.5 2040.667 1940 0.72 9.75 2040.667 1903 0.64 13 2040.667 1914.6666 0.49 16.25 2040.667 1839 0.24

Table 4. Varying of intensity with absorber thickness



Graph (2) Plot of Thickness of Cu sheet vs Counts/min



Graph (3) XRD result of Cu material

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Technological University Lashio Journal of Research & InnovationTable 5. Varying of intensity with absorber thickness (Al)**REFERENCES**

Thickness	Io	Ι	μ
(mm)	(count/min)		(mm ² /
			g)
0.2	2040.667	1883.6666	0.400
0.4	2040.667	1812.0000	0.296
0.6	2040.667	1793.0000	0.215
0.8	2040.667	1823.6666	0.140
1.0	2040.667	1760.0000	0.148
1.2	2040.667	1704.6666	0.150
1.4	2040.667	1683.6666	0.137



Graph(4) Plot of Thickness of Al sheet Vs Counts/min decreases. The properties of chemical compound and elements were found identically due to the XRD results.



Graph (5) XRD result of Al material

4. CONCLUSIONS

Geiger-Muller counter was used for detection of radiation. In this paper, to reduce the radiation to a level safe for humans different shielding materials were used. The linear attenuation coefficient of Copper was found to be greater than Aluminium materials. A small linear attenuation coefficient indicates that the material is relatively transparent. The density of a substance for higher atomic number was given of stop electrons. As thickness of absorber increases the transmission intensity higher atomic number was given of stop electrons.

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Application of Electrical Capacitance and Dielectric Measurement in Paddy

Khin Sandar Win⁽¹⁾, Hmwe Hmwe Kyu ⁽²⁾, Kyi Lin Lin Kyaw⁽³⁾

⁽¹⁾Technological University (Mandalay), Myanmar ⁽²⁾West Technological University Yangon, Myanmar ⁽³⁾West Technological University Yangon, Myanmar

> Email: khinsandarwin267@gmail.com hmwehmweq@gmail.com kyilinlinkyaw5@gmail.com

ABSTRACT: This study the application of capacitance and dielectric were used to measure moisture content in the paddy rice. In Myanmar, the majority of the population is employed in agriculture and the main agricultural product is rice. Moisture content is an important quantity for agriculture products. The moisture content in paddy rice can be measured by direct and indirect methods. In this measurement indirect method was used and electrical characteristics such as resistance, capacitance, conductivity, and dielectric were calculated. The integrated circuit ICL8038 was used to generate the frequency signal. The microcontroller ATmega1280 was applied to calculate the moisture content. The results of moisture content equation evaluated was 97.95% accurate and the result of the proposed method for the paddy rice moisture content showed 97.71% accuracy. The measurement range of moisture content paddy is 7.5% to 21.4% wet basis. The indirect method of measuring the moisture content allows an easy way and low-cost effective MC meter which can be affordably used by farmers.

KEYWORDS: *paddy rice, moisture meter, physical measurement, capacitance, dielectric properties*

1. INTRODUCTION

In Myanmar rice is an important agriculture product and Asia's largest exporter of rice. Agriculture is important to human beings because it forms the basis for food security. It helps human beings grow the most ideal food crops and raise the right animal with accordance to environmental factors. Rice remains the country's most crucial agricultural commodity. It has enough water resources and a good climate for rice. The majority of Myanmar's sown area is planted to monsoon rice, whereas summer rice is planted between November and February in the country's lower part and from January to March in the central dry zone regions. Rice in Myanmar is not only food and but also stands at the center of the creation. Exporting rice from Myanmar often goes much increasing volumes. The rice plant growing takes about 5-6 months from germination to maturity, depending on the variety and the environment. The circle of rice is 190 days and the harvest season lasts for about 30 days in mid-September to October.

The moisture content measurement was based on the principle of capacitance. Dielectric constant (ε) of the rice grain was measured by using the capacitance technique in the radio frequency range of 200Hz - 2 kHz. The relationship between the dielectric constant and moisture content was measured. The moisture content was also measured by using the principle of the microwave attenuation at 10.5 GHz and paddy rice moisture content can be measured by direct and indirect methods. An exposure magnetic coil and magnetic resistance sensor were used by the measurement method. After, the paddy moisture content detector was used by measuring an electrical conductivity. The electrical conductivity was the measurement of ability of material to conduct an electric current. The integrated circuit was applied to show the moisture with the LM3914, LED display. The experimental results were presented by using three LEDs: red for wet samples, yellow for medium wet samples and green for dry samples. This paper presents the paddy rice moisture content meter which uses electrical capacitance properties to estimate the percentage of the moisture content. The moisture content of paddy rice and as a result, rice which contains high moisture content was obtained with a low price. In addition, paddy rice moisture content meters can be effectively used by farmers.

2. MATERIALS AND METHODS

2.1 Indirect measurement of electrical capacitance

The moisture indirect measurement of electrical capacitance properties of the paddy rice moisture content were carried out the signal generator as illustrated in Fig. 1. In the paddy the integrated circuit ICL8038 was used to generate the signals and the capacitor was replaced by the cylinder container of paddy rice. The square wave signal was applied for frequency measurement and the capacitance was computed. The frequency is defined by the resistance R_A , R_B and capacitance C. The initial of resistance values were $R_A = 115 \text{ k}\Omega$, $R_B = 28 \text{ k}\Omega$. In this case no paddy rice was present in the container and electrical capacitance was defined as stray capacitor C_{stray} . The ICL8038-based signal generator circuit was showed in Fig. l, and the cylindrical plastic container has the diameter of 8 centimeter and the length of 10 centimeters with connecting lead attached to the inside of the cylindrical plastic container. This container was connected to the signal generator and the frequency was generated by the resistance and the capacitance. In this finding where two resistance values of R_A and R_B from the general circuit are not equal. The capacitance is calculated by using following equations (1) and (2)

$$f = \frac{1}{\frac{R_A C}{0.66} \left[1 + \frac{R_B}{2R_A - R_B}\right]}$$
(1)

$$C = \frac{1}{\frac{R_A f}{0.66} \left[1 + \frac{R_B}{2R_A - R_B} \right]}$$
(2)

The paddy rice capacitance was very low, which is in picofarads (pF). A small cylindrical plastic container was used to measure the capacitance of paddy rice. The diameter of the cylindrical container for paddy rice was 8 centimeters, the length of 10 centimeters and the volume of 560 cm^3 was used.



Fig. 1 The integrated circuit ICL8038 **2.2 Capacitance Computation of**

The indirect methods for moisture content measurement used the electrical properties which include resistance and capacitance. The electrical capacitance depends on the dielectric properties of the material inserted between the plates of the capacitor and the capacitance was calculated in equation (3),

$$C = \frac{K\varepsilon_0 A}{d} \tag{3}$$

Where *C* is capacitance (pF), *A* is surface area of the plates, (m²), *d* is distance between the plates, (m), ε_0 is permittivity in vacuum (8.854 x10⁻¹² F/m), *K* is dielectric constant of the dielectric material. The frequency which was used to compute the capacitance by Eq. (2) can be measured. First, the frequency was measured by without putting paddy rice inside the cylinder container and can be set as f_{stray} . Then, paddy rice was put into the cylindrical container and the output frequency was measured at pin 9 of ICL8038. Therefore, the paddy rice capacitance can be calculated from Eq. (4)

$$C_{paddy} = C_{rice\ contained} - C_{stay}$$
 (4)

Where C_{paddy} is capacitance of paddy rice, $C_{rice \text{ contained}}$ is the capacitance when paddy rice is placed in the container, C_{stray} is the capacitance without putting paddy rice in the cylindrical container.

3. EXPERIMENTAL SETUP

3.1 Moisture Content of Paddy Rice Calibration

The paddy rice moisture content requires to be determined the relationship between the moisture content and the capacitance by the calibration method. First, a sample of paddy rice was weighed before drying and then, drying process was done. The weight of dried paddy rice remained constant and the actual moisture content in each sample was estimated by using Eq. (5).

$$MC = \frac{W_{i} - W_{f}}{W_{i}} \times 100\%$$
(5)

Where *MC* is moisture contents, W_i is weight initial drying, W_f is weight after drying. Table I shows the result of the standard moisture content of paddy rice computed by using Eq. (5). The average of paddy rice moisture content was 21.4% *Wb* which is used to setup to be the standard values for moisture content computation. After the moisture content standard is known, the method to measure the relationship between the moisture content. Then, paddy rice was put into the cylindrical container and the frequency signals were measured by using microcontroller ATmega 1280.

Table 1 7	The paddy	rice	moisture	content
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Number of Samples	Weight of Sample before Drying (g)	Weight of Sample after Drying (g)	MC (%)
1	100	79	21
2	100	80	20
3	100	79	21
4	100	78	22
5	100	77	23
Average			21.4

3.2 Capacitance Computation

 C_{paddy} can be calculated from Eq. (4), and used to model paddy rice moisture content equation. As described in Eq. (4), the value of 36.31(pF) capacitance was measured when no paddy rice was put in the cylindrical container. The weight of paddy rice was 350grams before drying. The results of the capacitance of paddy rice for each moisture value were shown in Table 2.

Table 2 Paddy rice capacitance

MC (%)	Weight (g)	Capacitance (pF)
22.50	350	3.42
18.70	338	2.95
15.24	328	2.24
13.00	319	1.5
7.50	315	0.54

The experimental setup of the performance of the proposed method used the 560 ml paddy rice to evaluate the capacitance. Experimental results of paddy rice capacitance moisture content of paddy grain measurement range decreases from 22.50% - 7.5% *Wb* are shown in Table 2. This relationship between the

moisture content and the capacitance can be used to build an equation of the moisture content. The result of paddy rice moisture content in the paddy was presented in figure 3. The accuracy result of the moisture content equation was 97.95 %.



Fig. 3 The paddy rice moisture content equation

3.3 Moisture Content Test Measurement

In the moisture content measurement the equation of moisture content was evaluated and in order to verify the proposed method. The paddy rice was collected from Mataya Township, near Mandalay region. The paddy of 560 ml in volume and 350 gram in weight was used in the experiment as illustrated in Fig. 4 and the moisture content, frequency and capacitance were measured.



Fig. 4 Paddy rice

In this calibration process, the value of the moisture content was defined by weighing, before and after drying, paddy rice with different ranges of wet basis moisture content were 7.5%, 13%, 15.24%, 18.70%, and 22.5%. After the capacitance had been calculated, Eq. (6) was used to find the percentage of the moisture content were 6.95%, 12.84%, 14.76%, 18.20% and 21.98%. The experimental results of paddy rice moisture content measurement are presented in Table 3 and Fig. 5.

Table 3 The results of paddy rice moisture content measurement

Weight of Sampl es after Dryin g (g)	MC Standa rd (%)	Capacitan ce (pF)	Accurac y (%)
350	21.98	3.45	99.50
338	18.20	2.73	98.24
328	14.76	1.85	96.99
319	12.84	1.22	95.42
315	6.95	0.53	98.43
Average			97.71



Fig. 5 The capacitance of paddy rice moisture content

The capacitance of paddy rice changed in the range of 0.53 pF to 3.45 pF. The result of the proposed method showed 97.71% accuracy for the paddy rice moisture content.

4. CONCLUSIONS

Moisture content is the weight of water contained in paddy rice expressed in percent. The results of the paddy rice moisture content meter studied on the principal of electrical capacitance properties showed the proposed method can measure the moisture content of paddy grain decreases from 22.5% Wb to 7.5% Wb. In this method the results showed 97.71% accuracy and therefore the proposed method is successful. An efficiency of moisture content meter was evaluated and the average time for each measurement takes 10 second. The cost of paddy rice moisture meter is nearly 60000 MMK and therefore it can be affordably used. All the physical properties of paddy grain varieties are dependent on their moisture contents. Measuring moisture content is important in managing and marketing paddy and rice because depend on the purpose of quality.

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VECTOR TRACKING METHOD FOR SOFTWARE DEFINED GPS RECEIVER

Nay Min Aung Monywa University, Myanmar Email: nayminaung86@gmail.com

ABSTRACT: This paper presents the vector tracking method for software defined GPS receiver. A number of methods have been developed to enhance the robustness of Global Positioning System (GPS) receivers when there are a limited number of visible satellites. In this work, vector tracking method is developed to improve the accuracy of positions of GPS receiver. It utilizes information from all channels to aid the processing of individual channels to generate receiver positions and velocities. The work analyzes relationships among code phase, carrier frequency, receiver position and velocity and presents a vector loop-tracking algorithm using an Extended Kalman filter implemented in Matlab. The GPS signals from front-end receiver are collected and processed using the developed software. When some of the satellites are blocked, the vector tracking loop provides better carrier frequency tracking results for the blocked signals and produces more accurate navigation solutions compared with traditional scalar tracking loops in same the condition. The results show that the performances of the vector loop is better than the scalar loop in latitude, longitude, height of the receiver.

KEYWORDS: *GPS* software receiver, vector tracking method. extended Kalman filter

1. INTRODUCTION

The Global Positioning System (GPS) has gained widespread application in recent years and the demands for GPS under challenging environments are growing rapidly. The performance of GPS receivers under low signal-to-noise ratio (SNR) and high dynamic conditions is degraded due to compromised signal conditions. For a conventional GPS receiver, the code and carrier tracking loops are one of the most critical and weak links. Under low SNR or high dynamic environments, tracking loops cannot be able to maintain lock-on signals because of incorrect estimation of pseudorandom code phases, carrier frequencies and carrier phases. To enhance the robustness of tracking loops, the concept of "vector tracking" was proposed and various designs and implementations of vector tracking have been presented.

2. THEORETICAL BACKGROUND 2.1 Specification of GPS Vector Tracking

In a conventional GPS receiver all channels process incoming signals independently. This architecture is easy to implement and channels do not affect each other if one of them loses lock. However, this independency also prevents one channel from helping another because information obtained from one is not utilized by others. Since all channels share the same receiver position and velocity, and feedbacks of the position and velocity from the navigation filter is exploited by all tracking channels so that they can comprehensively process signals from different satellites. In a conventional tracking loop, each channel processes a unique satellite signal and generates pseudo-ranges and range rates between the satellite and receiver, and decodes the navigation data. The outputs from all channels are combined to produce the receiver position, velocity, and time. At an arbitrary time epoch, all channel signals are related via one common navigation solution. This connection among channels is never utilized by conventional tracking loops. Vector tracking jointly processes signals from different channels to generate concurrent navigation solutions by taking this connection into consideration. All channels share information to aid signal tracking.

2.2 Design of GPS Vector Tracking

On the software receivers, vector tracking is replaced the conventional carrier frequency and code phase tracking loops with an extended Kalman filter (EKF) based vector tracking loop. The received GPS signals are used to test the performance of the vector tracking loop. Ignoring all other non-Gaussian error sources such as satellite clock, multipath, hardware bias, etc, the relationship between position error and code phase error can be written as the equation below.

$$E_{code,k} = \hat{\varphi}_{j,k} - \varphi_{j,k} + \eta_{j,k}$$

= $t_{b,k} + (\boldsymbol{X}_k - \hat{\boldsymbol{X}}_k)^T . a_{j,k} + \eta_{j,k}$ (1)

where, the subscript k refers to measurement epoch,

 $E_{code,k}$ is the code phase error, φ is the code phase measurement, the symbol "^" represents the estimation of

a variable, $t_{b,k}$ is the receiver clock bias, X_k is the receiver

position vector, $a_{j,k}$ is the unit line of sight (LOS) vector from the receiver to the jth satellite, and η is the white Gaussian noise. Similarly, the carrier frequency error impacts the receiver velocity measurement error:

$$E_{carrier,k} = f_{j,k} - f_{j,k} + w_{j,k}$$

= $t_{d,k} + (V_k - \hat{V}_k)^T . a_{j,k} + w_{j,k}$ (2)

where $t_{d,k}$ is the receiver clock drift and $w_{j,k}$ is the white Gaussian noise. In a typical GPS receiver, the code phase and carrier frequency measurements in equations (1) and (2) can be obtained from the tracking loops. As shown in equations (1) and (2), the receiver position and velocity are directly affected by the code phases and carrier frequencies observables. Therefore, the outputs of the discriminators are used as the measurements for the integrated Kalman filter as shown in equation (3). $\delta \mathbf{Z}_k = \mathbf{H} \delta \mathbf{X}_k + \mathbf{V}_k$

$$= \begin{bmatrix} z_{code,1,k} & z_{carrier,1,k} & \dots & z_{code,n,k} & z_{carrier,n,k} \end{bmatrix}_{l \times 2n}^{T}$$
(3)

where, $z_{code,1,k}$ is the code phase discriminator output of

channel 1 at time epoch k, $z_{carrier,1,k}$ is the corresponding carrier frequency discriminator output and the terms in transition matrix **H** are determined by the following two equations.

$$z_{code,j,k} = a_{jx,k} \delta x_k + a_{jy,k} \delta y_k + a_{jz,k} \delta z_k + t_{b,k} + \eta_{j,k}$$
(4)

$$z_{carrier,j,k} = a_{jx,k} \delta v_{x,k} + a_{jy,k} \delta v_{y,k} + a_{jz,k} \delta v_{z,k} + t_{d,k} + w_{j,k}$$
(5)

where, $a_{jx,k}$, $a_{jy,k}$ and $a_{jz,k}$ are the x, y, and z components of the LOS vector pointing from the receiver to the jth satellite at kth epoch, and δx_k and $\delta v_{x,k}$ are the x direction position and velocity errors at kth epoch respectively. For convenience, the discrete equations of extended Kalman filter (EKF) from as the following: Prediction:

$$\hat{X}_{k/k-1} = \hat{X}_{k-1} + f(\hat{X}_{k-1}, t_{k-1})^T$$
Estimation:
(6)

$$\hat{\boldsymbol{X}}_{k} = \hat{\boldsymbol{X}}_{k/k-1} + \delta \hat{\boldsymbol{X}}_{k} \tag{7}$$

Estimation error calculation:

$$\delta \hat{\boldsymbol{X}}_{k} = \boldsymbol{K}_{k} \delta \boldsymbol{Z}_{k} = \boldsymbol{K}_{k} \left[\boldsymbol{Z}_{k} - h \left(\hat{\boldsymbol{X}}_{k/k-1}, k \right) \right]$$
(8)

Kalman gain:

$$\boldsymbol{K}_{k} = \boldsymbol{P}_{k/k-1} \boldsymbol{H}_{k}^{T} \left(\boldsymbol{H}_{k} \boldsymbol{P}_{k/k-1} \boldsymbol{H}_{k}^{T} + \boldsymbol{R}_{k} \right)^{-1}$$
(9)

Prediction mean square error:

$$\boldsymbol{P}_{k/k-1} = \boldsymbol{F}_{k/k-1} \boldsymbol{P}_{k-1} \boldsymbol{F}_{k,k-1}^{T} + \boldsymbol{Q}_{k-1}$$
Estimation mean square error (10)

Estimation mean square error:

$$\boldsymbol{P}_{k} = \left(\boldsymbol{I} - \boldsymbol{K}_{k} \boldsymbol{H}_{k}\right) \boldsymbol{P}_{k/k-1} \left(\boldsymbol{I} - \boldsymbol{K}_{k} \boldsymbol{H}_{k}\right)^{T} + \boldsymbol{K}_{k} \boldsymbol{R}_{k} \boldsymbol{K}_{k}^{T}$$
(11)

In equations (6) to (11), f is the one-step transition function and **F** is the discrete transition matrix, \mathbf{Q}_k and \mathbf{R}_k is the covariance matrices for process and measurement noises, h is the measurement function and **H** is its discrete matrix.

2.3 Results of GPS Vector Tracking

On the software receivers, vector tracking is replaced the conventional carrier frequency and code phase tracking loops with an extended Kalman filter (EKF) based vector tracking loop. The received GPS signals are used to test the performance of the vector tracking loop. In vector tracking loop: when some tracking channels have very weak signals from certain satellites, other channels with strong signals can help those channels to "track" their weak signals; vector tracking loops can maintain tracking and provide moderately accurate navigation solutions even if the number of visible satellites falls below four. The vector tracking loop architecture is shown in figure1. The experiment results show that the performances of the vector loop on the scalar loop for latitude, longitude, height in strength signal and comparing receiver position precision for each method.



Fig 1. vector tracking loop architecture

3. EXPERIMENT

3.1 Experiment apparatus

In this experiment, the GPS signal is captured by SiGe SE4110L front-end receiver. The SiGe SE4110L GPS receiver is small and inexpensive device (US\$-350). The sampling parameters are

- frequency of the received signal is about 1575.42 MHz
- intermediate frequency (IF) 1.364MHz and
- sampling frequency is 5.456MHz.



Fig 2. SiGe SE4110L GPS/GNSS receiver and antenna



Fig 3.The functional block diagram of GPS receiver

3.2 *Data*

Table (1) and (2) show the typical standard deviation of position in scalar and vector loop for latitude, longitude and height deviation errors. From table (1) and (2), the results show that the vector loop have less standard deviation error than the scalar loop in latitude, longitude and height (altitude) estimation for the receiver positions. Thus, the vector loop has less standard deviation errors than the scalar loop in the calculation of position points for the mean receiver position.

Table 1. Typical standard deviation of position in scalar

100p			
Position	standard deviation , σ		
Latitude	12.3079e-05 [degree]		
Longitude	10.9632e-05 [degree]		
Height	25.9260 [m]		

Table 2. Typical standard deviation of position in vector

loop					
Position	standard deviation , σ				
Latitude	4.8206e-05 [degree]				
Longitude	3.0989e-05 [degree]				
Height	3.1019 [m]				

4. ANALYSIS

The collected dataset is also processed by the vector tracking loop and the scalar tracking loop for comparison purposes. The performance of vector loop is comparing with the scalar loop for latitude, longitude, height and the receiver position precision. The navigation results from the vector loop and the scalar loop are plotted in the figures 7 and 8. For comparison, the latitude results from the scalar loop and vector loop is plotted in Figure 4. Figure 5 and 6 exhibit the longitude and height results from both scalar loop and vector loop. Figures 4, 5 and 6 indicate that when the strength signal is received, the vector loop can estimate the navigation coordinates results with less noise errors than the scalar loop. When the weak signal is received, the scalar loop cannot estimate the navigation data of some PRNs due to the independent processing of each channel while the vector loop maintains lock by utilizing outputs from other PRNs for weak one.



Fig 4. Latitude estimation in vector and scalar tracking



Fig 5. Longitude estimation in vector and scalar tracking



Fig 6. Height estimation in vector and scalar tracking



Fig 7. Positions in UTM system with vector tracking method



Fig 8. Positions in UTM system with scalar tracking method

5. CONCLUSIONS

The SiGe SE4110L GPS receiver is small, inexpensive and OEM device that enhance the design and algorithm for GPS signal tracking to receive preside position than other receiver. The experiment is conducted on a Matlab-based software defined receiver platform to evaluate the post-processing performance of the proposed vector tracking method. The vector tracking loop is based on an extended Kalman filter design which exploits the relationship between the GPS receiver navigation solutions and the code phase and carrier frequency of the received signal. The results demonstrate that if there are four or fewer satellites available, the proposed vector tracking loop can maintain tracking on a blocked satellite signal and generate reasonable navigation solutions. Comparing to the scalar loop working under the same scenario but with sufficient amount of visible satellites, the vector loop provides slightly less accurate but almost identical navigation solutions. Thus, comparing with the

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navigation solutions.

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DETERMINATION OF SOME HEAVY METAL CONTENTS IN DRINKING WATER AND SEDIMENT SAMPLES IN LAKES FROM THREE VILLAGES IN SOUTH YANGON DISTRICT

Khet Khet Tun⁽¹⁾, Khin Sandar Khaing⁽²⁾

⁽¹⁾East Yangon University, Myanmar ⁽²⁾East Yangom University, Myanmar

Email: khettun3@gmail.com

ABSTRACT: The drinking water and sediment samples in three lakes were collected from three villages of Sitpinkwin, Thapyaykan and Kayinseik. The aim of this study was to analyze some heavy metal elements such as cadmium (Cd), lead (Pb), chromium (Cr) and copper (Cu) in drinking water and sediment samples from Thanlyin Township at South Yangon District by using Atomic Absorption Spectroscopy (AAS) method. The results were compared with the guideline recommendation values for drinking water by World Health Organization (WHO). Although the contents for Cr and Cu elements were observed in all these samples due to the air and water pollution, these elements were lower than the permissible value of WHO. But, the content of Pb element was not found in all these samples. Moreover, the content of Cd element was not observed in all sediment samples but it was found a few amount in W (2) sample from all drinking water samples which was less than the limitation value of WHO.

KEYWORDS: water samples, sediment samples, AAS, WHO, heavy metal elements

1. INTRODUCTION

Heavy metals such as (mercury, lead, chromium and cadmium) may originate in industrial discharges, runoff from city streets, mining activities, leachate from landfills, and a variety of other sources. Also agriculture can contribute to heavy metal pollution as these elements are contained in some pesticides and as trace in fertilizer. Most of these metals which are generally persistent in the environment are hazardous for any aquatic ecosystem as well as for human health. The pollution potential of heavy metals depends not only on their concentration in water but also on the form in which they are present.

Heavy metals including both essential and nonessential elements have a particular significance in ecotoxicology, since they are highly persistent and all have the potential to the toxic in living organisms. Heavy metals such as copper, manganese, zinc, chromium and nickel are essential metals since they play an important role in biological systems. Lead is non-essential metal as it is toxic even in trace elements. These essential metals can also produce toxic effect when the metal intake is excessively elevated. [2]

From the human point of view, water is one of the most important resources in the world, i.e., the most important element of material life but water supply is limited to disposable amounts and its distribution. It maintains an ecological balance-balance in the relationship between living thing and environment. Water pollution due to heavy metals has become a public and scientific concern as evidence of toxicity to human health and biological systems.

Sediments are the final storage of most of the pollution entering waterways. There is an increasing public knowledge and concern for the health of waterways. Sedimentation in lakes is both physical and chemical processes. Physical processes are caused by waves and currents but they do not play a significant role in most lakes at sea. Because they are absence of tides and are difficult of producing large waves in small water bodies. Waves and current in most lakes have little or no effect at a short distance below the surface.

Inorganic chemical processes do not seem to have much importance. Doubtless there are chemical and reactions leading to precipitation in lakes. There are chemical reactions connected with rise of temperature.

Organic chemical processes are important. On the basis of nutrient matter and oxygen in their water, lakes may be placed in three classes; eutrophic, with little oxygen in the bottom water and much nutrient matter; oligotrophic, with considerable oxygen in the bottom water and limited nutrient matter; and dystrophic, with scanty oxygen in the bottom water and little nutrient matter. Transportation in lakes naturally varies with conditions. There are currents due to winds, to inflow and outflow of stream, to differences in densities of water from temperature. [1]

2. THEORETICAL BACKGROUND

2.1 Specification Condition for Atomic Absorption Spectroscopy

In AAS, atoms of the element of interest are generated by vaporization and thermal decomposition of the sample. They are irradiated by light at a specific wavelength (resonance lines) which can be absorbed by the element of interest. The absorption wavelengths from each element limit the very narrow binding. Light at these wavelengths can be generated by heating pure samples of the element. One of the most common methods used to produce the vapor of an atom is to use flame. Absorption from a particular resonance line is monitored with a monochromator, phototube and appropriate readout electronics. To achieve stability, despite changes in the intensity of the light emitted by the hollow cathode, a double-beam optical system is employed in the instrument which will be used.

The atom source used must be able to produce free an analytic atom from the sample. The source of energy for free atom production was usually heat and in the form of an air-acetylene or nitrous oxide-acetylene flame. The sample was introduced as an aerosol into the flame. The flame burner head was adjusted as the light beam passes through the flame absorbing light.

Atomic absorption spectroscopy uses the same basic optical system as other forms of absorption spectroscopy. The components include a radiation source, a sample container, a monochromator to select the desired wavelength of radiation and limit the spectral slit width and a detector for measuring the intensity of radiation after it passes through the sample. [10] The block diagram of atomic absorption spectrometer is expressed in figure 1.



Fig 1. Block diagram of atomic absorption spectrometer

2.2 Measurement Condition for AA 6300 Shimadzu

The AA-6300 is a true double beam flame atomic absorption (AA) spectrophotometry designed for the analysis of metals. The unit is equipped with a Dynamic Beam Management System (DBMS) that ensures long-term baseline stability with low noise level for precise analysis. The AA-6300 includes an automatic dual detector for maximum sensitivity at all wavelength ranges. The dual detectors are a photomultiplier tube (PMT) and a semiconductor. The system includes dual background correction modes which cover the entire analytical wavelength range.

AAS techniques background corrections include Deuterium (D2) and Self-Reversal (S-R) mode. The burner height is automatically set for each element and matrix. The system includes an automatic 4 step slit width setting. The AA-6300 includes an automatic 6lamp turret with next lamp warm up. System includes Air-Acetylene Burner Head. PC workstation included. The absorption wavelength, lamp current, preferred flames and slit width for flame atomic absorption was shown in table 1.

Table 1. Absorption wavelength, lamp current, preferred lames and slit width for flame atomic absorption

tames and sitt width for frame atomic absorption				
	Absorptio	HCL	Preferre	Slit
Elements	n	curren	d flame	widt
	wavelengt	t (mA)		h
	h (nm)			(nm)

vation		Vol. 1, Issue: 2			
Cadmium (Cd)	228.8	8	AA (ox)	0.7	
Chromiu m (Cr)	357.9	10	AA (ox)	0.5	
Lead (Pb)	217.0	15	AA (ox)	0.7	
Copper (Cu)	324.8	5	AA (ox)	0.7	

Used for flame composition

AA Air acetylene (C_2H_2) (99.98 % Pure)

ox Oxidizing flame (excess oxidant air)

Software security functions include user login ID passwords, user groups with various rights, audit trails and electronic signatures. The user friendly WizAArd software is included and contains QA/QC acceptance criteria. [5] The photograph of AA-6300 Atomic Absorption Spectrometer was represented in figure 2.



Fig 2. Photograph of AA-6300 Atomic Absorption Spectrometer

3. EXPERIMENT

3.1 Sample Collection and Preparation

In this research work, drinking water and sediment samples were collected from Thanlyin Township during period in December, 2018. Thanlyin Township is located at about 16°45' North Latitudes and also about 96°15' East Longitudes. It is included in the Southern part of Yangon Region. Thanlyin Township is situated about 6.48 miles (10.42 kilometer) away from Yangon City. W (1) and D (1) samples were collected from the Sitpinkwin village which is located about 6.21 miles (10 kilometer), W (2) and D (2) samples from the Thapyaykan village which is situated about 13.04 miles (21 kilometer) and W (3) and D (3) from the Kayinseik village which is located about 9.32 miles (15 kilometer) away from Thanlyin Township. [6] The map of the collected water and sediment samples in three lakes from Thanlyin Township was shown in figure 3. The photographs of Sitpinkwin, Thapyaykan and Kayinseik villages were represented in figure 4, 5 and 6.



Fig 3. Map of the collected drinking water and sediment samples in three lakes from Thanlyin Township



Fig 4 Photograph of lake in Sitpinkwin village



Fig 5 Photograph of lake in Thapyaykan village

Fig 6. Photograph of lake in Kayinseik village

At first, each collected drinking water sample was immediately added in each plastic bottle at room temperature. After one week, these samples were filtered with filter papers and placed into the new plastic containers.

At first, the sediment samples collected from three villages were cleaned and dried under the room temperature for a week in order to get very fine powders. After drying, these sediment samples were passed through small mesh sieve to remove the larger grain. Then, one gram of each sample was weighed by using digital balance and was added ten milliliter of hydrochloric acid into the evaporating dish. After that, it was gently heated and stirred up with glass rod about a few minutes to be homogeneous at 150°C by using electric oven.

After heating, the evaporating dish was cooled down about one hour. The cooled sample was mixed with ten milliliter of deionized water and gently heated. The used evaporating dish was blackened and it was cooled down about one hour. In the next step, it was pouring and shaking with ten millimeter of deionized water and then it was filtered into the volumetric flask. Finally, 100 ml of the solution of tested sample was filtered into the volumetric flask. [3]

3.2 Data from Measurement

In this study, Atomic Absorption Spectrometer (Shimadzu AA-6300) at Amtt Company in Yangon was used for the determination of the concentrations of heavy metal elements in all drinking water and sediment samples from three lakes in Thanlyin Township.

The list of heavy metal concentrations in water samples with WHO and the list of heavy metal concentrations in sediment samples with WHO were represented in table 2 and 3.

Table 1. The list of heavy metal concentration in water samples with WHO

	sumples with write					
Floments	W (1)	W (2)	W (3)	WHO		
Liements	(ppm)	(ppm)	(ppm)	(ppm)		
Cr	0.012	0.021	0.006	0.05		
Cu	0.004	0.010	0.013	2.00		
Cd	ND	0.0019	ND	0.003		
Pb	ND	ND	ND	0.01		

ND-Not Detect

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Table 2.	The list	of	heavy	metal	concentration	in
	1.		1	• . 1	MULO	

Elements	W (1) W (2) W (2)		W (3)	WHO
Elements	(ppm)	(ppm)	(ppm)	(ppm)
Cr	0.010	0.019	0.010	0.05
Cu	0.006	0.005	0.005	2.00
Cd	ND	ND	ND	0.003
Pb	ND	ND	ND	0.01

ND – Not Detect

Sample Name

W (1), D (1) – Sitpinkwin village

W (2), D (2) - Thapyaykan village

W (3), D (3) – Kayinseik village

4. CONCLUSIONS

A wide range of analytical methods are available for trace element analysis. AAS is well established method for trace element analyzes of different kinds of samples because it can detect much lower level (mg/L or ppm) concentration of toxic elements. And then, this method could describe not only analyzes various heavy metals but also certain reliability by showing good precision, accuracy at trace level and was only analyzed single element in each time and it was suitable for finding the heavy metal elements.



Fig 7. Comparison of Cr element contained in all drinking water samples with WHO





The comparisons of contents of chromium element in all drinking water and sediment samples with the standard value by WHO were expressed in figure 7 and 8. The contents of chromium which is non-nutritive

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and heavy metal element in all drinking water and sediment samples were detected in the amount ranging from 0.006 to 0.021 mg/L or ppm and ranging from 0.010 to 0.019 mg/L or ppm. They were observed that the results were less than the standard value in drinking water by WHO (0.05 mg/L or ppm). [4]

Chromium is an essential trace element for humans. It helps regulate metabolism throughout the body, and also aids in insulin action and glucose metabolism. It plays a vital role in the metabolism of fats and carbohydrates and stimulates the synthesis of fatty acids and cholesterol which are important for brain and other body functions. Chromium toxicity is not possible when taken through food and drinking water. It may even improve health and cure neuropathy and encephalopathy. Some people experience side effects such as skin irritation, headaches, dizziness, nausea, mood changes and wrong thinking and decision. Chromium exposure includes diarrhea, stomach, intestinal bleedings, cramps, liver and kidney. [8]



Fig 9. Comparison of Cu element contained in all drinking water samples with WHO



Fig 10. Comparison of Cu element contained in all sediment samples with WHO

The contents of copper in all drinking water and sediment samples were compared with the permissible value in drinking water by WHO in figure 9 and 10. This element in all drinking water and sediment samples was detected in the amount varies from 0.004 to 0.013 mg/L or ppm and varies from 0.005 to 0.006 mg/L or ppm. According to the WHO, they were found to be Copper occurs free or complex with ligands in drinking water. Thus, copper in drinking water can readily reach the bloodstream, bypassing the liver processing. Consequently, the bioavailability of copper in drinking water is considered greater than that in food. Copper also aids in the production of Melanin which irritates a person's skin and eyes, as well protects one from the harmful UV rays of the Sun. If copper deficiency is happening since childhood, it leads to the development of hypotension (low blood pressure). If adults suffer from copper deficiency, they develop hypertension (high blood pressure). While lack of copper can cause thyroid gland malfunction, excessive of copper also thyroid gland dysfunction causing hyper or hypo thyroids among patients. [9]



Fig 11. Comparison of Cd element contained in all drinking water samples with WHO

The comparison of cadmium element contained in all drinking water samples with WHO was shown in figure 11. The content of Cd which is non-nutritive and heavy metal element in all analyzed water samples was detected in the amount of 0.019 ppm in W (2) sample from Thapyaykan village which is less than the limitation value (0.003 ppm) in drinking water by WHO. [4] But this element was not observed in all sediment samples because it may be very less concentration than the detection limit.

Cadmium is a non-essential and harmful element to humans. The WHO has dissolved that cadmium has high potential to cause health effect like nausea, vomiting, diarrhea, muscle cramps, salivation, sensory, disturbances, liver, injury, convulsion, shock and renal failure in short period of time. In a life-time exposure to cadmium at levels exceed 0.005 mg/L can cause kidney, liver, bone and blood damage. [7]

The content of lead which is non-nutritive and heavy metal element was not detected in all drinking water and sediment samples due to very less concentration than the detection limit and the standard value of this element in drinking water by WHO is 0.01 mg/L. [4]

According to the results, it was obvious that these drinking water and sediment samples taken for the study were lower than the standard recommendation limits for the quantity of drinking water by WHO. Therefore, these drinking water can reduce headaches and migraines, the risk of bladder infections, hangover, sugar cravings and aid weight maintenance and help prevent kidney stones, constipation in children and adults, improve exercise performance, memory and mood. If these results were above the recommendations of guideline value by WHO, these drinking water can cause some diseases such as diarrhea, nausea, vomiting, fatigue, cramps, intestinal bleedings and kidney. Therefore, this study provides general indication which cannot be harmful for environment in these areas and the information presented in this report will be useful for public health point of view. Moreover, it does not effect on physiological of the body.

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Investigation of Structural, Microstructural and Electrical Properties of LaAlO₃ Thin Films

Aye Aye Thant⁽¹⁾, Than Than Swe⁽²⁾, Win Win Khaing⁽³⁾

⁽¹⁾Yadanabon University, Myanmar.
 ⁽²⁾Yadanabon University, Myanmar.
 ⁽³⁾Yadanabon University, Myanmar.

Email: <u>ayeayethantpinlon@gmail.com</u> Email: <u>sandarsandardr@gmail.com</u> Email: <u>makhaing132@gmail.com</u>

ABSTRACT: The lanthanum aluminate thin films were formed on silicon substrate by spin coating method. The X-ray diffraction (XRD) analysis was used to study the structure and crystallite size of LaAlO₃:Si nanoparticles. The morphology and microstructural properties of films was studied by SEM analysis. The Electrical properties of LaAlO₃:Si films were characterized by I-V measurement dark and under illumination. In dark condition, the ideality factor (η) of LaAlO₃:Si thin film was slightly increased with increasing process temperature. Under illumination, photovoltaic parameters such as short circuit current I_{sc}, open circuit voltage V_{oc}, fill factor FF and overall conversion efficiency η_{con} for the fabricated cells were determined under illumination.

KEYWORDS: *XRD, SEM, conversion efficiency, fill factor.*

1. INTRODUCTION

Lanthanum aluminate (LaAlO₃) crystal has an ideal cubic perovskite structure at high temperature, which transforms into a rhombohedral form at a temperature below 800K ^[1,2] Single crystal LaAlO₃ has also been widely used as a substrate for depositing superconducting thin films ^[3]. LaAlO₃ is promising substrate for the epitaxy of thin oxide films and has potential use as buffer layer for the epitaxial growth of various perovskite-type film such as a high temperature superconductors, ferroelectrics and colossal magneto resistance oxides [4] .Thin film technologies have gained much interest because of their potential for low cost, large area fabrication. However, this lack of long range atomic order also results in high defect densities, limiting the film thickness to values ~ 300-500 nm for efficient charge collection. Optical absorption in thin layers is generally weak at infrared wavelengths and therefore requires a light trapping mechanism to increase the path of light travel within the film. Therefore, there is an ongoing interest in improving cell efficiencies while maintaining the low-cost large area advantage of thin film technology [5]

2. THEORETICAL BACKGROUND

2.1 Thin Film Technology

The thin film technology group is working on problems concerning the deposition of thin coatings of mainly chemical compounds like metal oxides, nitrides, oxynitries and also metalfluorides onto various substrates. Thin films are thin materials layers ranging from fractions of a nanometer to several micrometers in thickness. Electronic semiconductor devices and optical coatings are the main applications benefiting from thin film construction. Thin film processing technique exist a huge variety of thin film deposition process and technologies which originate from purly physical or purely chemical processes. The more important thin film processes, are based on liquid phase chemical techniques, gas phase chemical processes glow discharge processes and evaporation methods ^[6].

2.2 Spin Coating Technology

Spin coating involves the acceleration of a liquid puddle on a rotating substrate. Spin coating is a producer used to apply uniform thin filns to slat substrates. A machine used for spin coating is called spincoater, or simply spinner. A spin coater used to apply photoresist to the surface of a silicon wafer.Spin coating is widely used in microfabrication Spin coating has been used for several decades for the application of thin films ^[7].

2.3 Silicon Substrate

Silicon is the chemical element that has the symbol Si and atomic number 14. Each silicon atom has four valance electrons, which is in the outer most shell of an atom and can form four covalent bond, with four neighboring silicon atoms which are directed along the corners of a regular tetrahedron. Silicon is an indirect-gap semiconductor. Silicon with band gaps between 1eV and 2eV have theoretical efficiency in excess of 20 percent and if they can be considered solar cell materials. Silicon is widely used in p-n junction cells because of its more advanced technology and lower cost ^[8].

3. EXPERIMENTAL DETAILS

The raw materials of LaCl₃.7H₂O and AlCl₃.6H₂O were chosen as starting materials. Firstly, lanthanum chloride and aluminium chloride were mixed to form LaAlO₃ with stoichometric ratio and stirred with glass rod for 1 hr, then homogeneous mixture was obtained. After that four drops of NH₄OH (ammonium hydroxide) and 0.1 ml of distilled water were added to homogenous mixture and stirred with glass rod. This mixture was left for 48 hr and heated with oil bath 110°C for 3 hr. After heating LaAlO₃ sol-gel was formed. The viscosity of the resulting sol-gel ultrasonification and centrifugal washing was repeated 5-6 times for each bath of precipitated sol-gel. After this sol-gel was dried in an oven at 100° C for

30 min. After cooling down at room temperature LaAlO₃ precursor sol-gel was obtained. Then the silicon wafers were cleaned in distilled water and dried on flat oven at 100°C in open air for a few minutes. Finally, the cleaned Si-wafer was obtained. The clear precursor sol-gel was poured onto cleaned p-Si (100) substrate which was placed on substrate holder of spinner. The spinning speed was 800 rpm. The substrate temperature was 120°C and the spinning time was 5 min. After fabrication, LaAlO₃ films were annealed at 400°C, 500°C, 600°C respectively for 1h. And then, LaAlO₃ thin film was obtained, LaAlO₃ thin film (size $1 \text{ cm} \times 1 \text{ cm}$) three plates were made window layer formation. Then Ni- layer was coated on LaAlO₃ sample by using electroless Ni-plating for 5min and dried at room temperature. After removing the mask, front and back nickel conductive layers were observed. Finally, Cu wire were soldered on the Nickel conductive layer Ni/LaAlO₃/Ni with Cu electrode cell was obtained.

4. RESULTS AND DISCUSSION

XRD technique was used to investigate the LaAlO₃:Si crystallographic properties and make the plane identification. It was performed using monochromatic Cu-K α radiation (λ =1.54046A°) operate at 40kV (tube voltage) and 20mA (tube current). Sample for scanned from 10° to 70° in diffraction angle, 20 with a step-size of 0.01°. The XRD spectrum of LaAlO₃:Si samples were indicated as shown in Fig 1(a-c). On the XRD patterms of samples, strongest peak (113) was clearly observed at 400°C, 500°C, 600°C. The crystallite sizes of each of the samples were estimated by using the Scherrer formula, G = $0.9\lambda/B \cos\theta$, G is the crystallite size (nm), λ is the wavelength of incident X-ray (A°), θ is the diffraction angle of the peak under consideration at FWHM (°) and B is the observed FWHM (radians). The obtained crystallite sizes are tabulated in Table 1. The crystallite sizes are in the range 48.60 - 67.23 nm and it indicates the nanosized or nanocrystalline materials. The crystallite size of the samples increased with the increasing temperature.

Table 1. FWHM and crystallite size

No	Temperature (°C)	FWHM (deg)	Crystallite size (nm)
1	400	0.176	48.60
2	500	0.138	61.92
3	600	0.127	67.23



Figure 1. XRD profile of LaAlO₃:Si thin film device at (a) 400°C (b) 500°C (c) 600°C

Microstructural properties was made on aAlO₃:Si thin films by SEM technique. The surface morphology and grain morphology of LaAlO₃:Si thin films were investigated by using scanning electron microscope (JEOL, Model No. JSM- 5610 LV) with acceleration voltage 15kV and magnification 5000. The grain size of LaAlO₃:Si thin films were observed from the SEM images. The resulting SEM image of LaAlO₃:Si thin films were shown in Fig 2 (a-c). The surfaces were seemed to be crack-free and uniform grain distribution. The density of SEM image looked fairly low. The images were found

to be rough and particles were oriented toward left-side. Some pores and grain-growth patterns were also observed on these images. The minimum grain size was $1.71 \mu m$ at 400°C. Film thicknesses were measured by cross-sectional SEM micrographs. The set of film thickness micrographs were shown in Fig 3(a-c)The film thickness was 25.3µm at 400°C, $35.1\mu m$ at 500°C and $36.0\mu m$ at 600°C. The minimum film thickness of LaAlO₃:Si film was appeared at 400°C.







(c)





(a)



(b)



(c)

Figure 3 Cross-sectional SEM image of LaAlO₃:Si thin film device at (a) 400°C (b) 500 °C (c) 600°C

Current-Voltage (I-V) characteristics in dark condition of LaAlO₃:Si film was measured. Fig 4 showed typical current-voltage characteristics of LaAlO₃:Si samples, in dark condition with different process temperatures. The value of saturation current when the diode is forward-biased, were decreased considerable with the increase in process temperature 400°C to 600°C. The ideality factor (η) of LaAlO₃:Si thin film was slightly increased with increasing process temperature. The ϕ_{bo} values of the LaAlO₃:Si film with 400°C, 500°C and 600°C were 0.3528eV, 0.3535eV and 0.3553eV respectively. The transition voltage changed from ohmic contact to space charge limited current were about 0.8V. The saturation current, ideality factor, zero-bias barrier height and transition voltage of LaAlO₃:Si film were organized and tabulated in Table 2.



Figure 4. I-V characteristics of LaAlO₃:Si thin film devices at various process temperatures under dark

Table 2. The photovoltaic parameters for LaAlO₃:Si films with different process temperatures

Daramatars	Process Temperature				
rarameters	400 °C	500 °C	600 °C		
Saturation current $I_s(A)$	2.91x10 ⁻ 7	2.82x10 ⁻ 7	2.63x10 ⁻ 7		
Ideality factor η	1.5451	1.5469	1.5513		
Zero-bias barrier height ϕ_{bo} (eV)	0.3528	0.3535	0.3553		
Transition voltage (V)	0.8776	0.8715	0.8844		

The current-voltage characteristics of LaAlO₃:Si films under illumination were represented in Fig 5. According to the figure, it was found that the current starting from third quadrant increased gradually through the fourth quadrant and finally reached to first quadrant of the circle. According to this graph, it was known that the voltage changed from fourth quadrant to first quadrant was nearly to 3V for all films. As the detail analysis of short circuit current (Isc) and open circuit voltage (Voc) for LaAlO3:Si films processed at 400°C, 500°C and 600°C, it was clearly obvious that the voltages changed from fourth quadrant to first quadrant were 2.66V, 3.19 V and 2.66 V. According to the figure, maximum short-circuit current was found at 500°C.The fill factor (FF) of LaAlO3:Si films were observed and they were 0.3508, 0.3893 and 0.3546 at 400°C, 500°C and 600°C respectively.

The fill-factor, the variation of quantum yield (Y) and the photovoltaic parameters for LaAlO₃:Si films with different process temperature were collected in Table 3.



Figure 5. I-V characteristics of LaAlO₃:Si thin film devices at various process temperatures under illumination

Table 3. The photovoltaic parameters for LaAlO₃:Si films with different process temperatures

Paramet	Process	Process Temperature			
e-rs	400 °C	500 °C	600 °C		
$I_{m}(A)$	0.866 x10 ⁻⁶	1.45 x 10 ⁻⁶	1.02 x 10 ⁻⁶		
$V_{m}(V)$	1.2754	1.8956	1.2684		
$P_{m}(W)$	1.1045x10 ⁻⁶	2.7490 x10 ⁻⁶	1.294x10 ⁻⁶		
I _{sc} (A)	1.35 x 10 ⁻⁶	1.22 x 10 ⁻⁵	1.62 x 10 ⁻⁶		
V _{oc} (V)	2.661	3.193	2.657		
η_{con} (%)	4.2903	10.6508	5.0144		
\mathbf{F}_{f}	0.3508	0.3893	0.3546		
Y	6.00×10^3	11.20×10^3	6.95 x 10 ³		
R _s	1978	8195	1710		

5.CONCLUSIONS

From the XRD analyses of lanthanum aluminate samples, there were 8 reflections on XRD Pattern of sample at 400°C. Six of all reflections were well consistent with the standard peak. As the fabricated specimen at 500°C, only four peaks were matched with that standard. The six reflections were matched as the sample at 600°C. The minimum crystallite size was 48.6nm was grown at processing temperature 400°C.

The SEM surface was seemed to be crack-free and uniform grain distribution. The density of SEM image looked fairly low. The images were found to be rough and particles were oriented toward left-side. Some pores and grain-growth patterns were also observed on these images. All microstructures were examined to be temperature dependence. The film thicknesses were 25.3 μ m, 35.1 μ m and 36.0 μ m respectively. Minimum film thickness of LaAlO₃:Si films were appeared at 400°C. From the normal characteristic curve, it was seemed that Schottky contact was formed between film and nickel layer. In the first quadrant of normal characteristic curve, current was exponentially increased with forward region.

The ideality factor of LaAlO₃:Si thin film was slightly increased with increasing process temperature. The ϕ_{bo} values of the LaAlO3:Si film with 400°C, 500°C and 600°C were 0.3528eV, 0.3535eV and 0.3553eV respectively. The transition voltage changed from ohmic contact to space charge limited current were about 0.8V. From illumination, it was found that observed the voltage changed from fourth quadrant to first quadrant was nearly to 3V for all films. According to the detail analysis of short circuit current (I_{sc}) and open circuit voltage (V_{oc}) for LaAlO₃:Si films processed at 400°C, 500°C and 600°C, it was clearly obvious that the voltages changed from fourth quadrant to first quadrant were 2.66V, 3.19 V and 2.66V. It was found the laboratory-fabricated LaAlO₃ sol solution was actually formed and can be applied as a promising candidate for PV cell application.

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STUDY ON THE STRUCTURAL AND OPTICAL CHARACTERISTICS OF ZINC OXIDE NOVEL MATERIAL POWDER BY CHEMICAL PRECIPITATION METHOD

Amy Aung⁽¹⁾, Tin Tin Phyo Lwin⁽²⁾, Myint Myint Maw⁽³⁾

⁽¹⁾Monywa University, Myanmar ⁽²⁾Monywa University, Myanmar ⁽³⁾West Yangon University, Myanmar

Email: mie.amyaung@gmail.com Email: tintinphyolwin@gmail.com Email: myintmyintmaw261@gmail.com

ABSTRACT: In this paper, zinc oxide powders (ZnO) were prepared by using zinc chloride and sodium hydroxide as the precursors at different annealing То determine the structural temperature. characterization, the observable ZnO powders were characterized by X-ray diffraction (XRD), Scanning Electron Microscopy (SEM) and Ultraviolet visible spectrophotometer (UV-vis). The obtainable zinc oxide provided hexagonal Wurtzite structure nature. Lattice strain, c/a ratio and dislocation density parameters were obtained from XRD analysis results by using Debye Scherrer's equation. According to the average crystallite size, the size of the particles increases as the annealing temperature is increased. The particle size increased about 38 nm and 41 nm with the increase of the temperature. The SEM results have visualized the morphology of ZnO anoparticles with irregular spherical in shape and highly agglomerated. With an aim to investigate the optical characteristic of the grown zinc oxide, the absorption spectra are evaluated in the ultraviolet-visible (UV-Vis) range. Due to the optical absorbance spectra analysis, the energy band gap of different annealing temperature samples is calculated from the linear extrapolated line of $(\alpha h \gamma)^2$ vs. hy plot.

KEYWORDS: XRD, c/a ratio, crystallite size, SEM, UV-Vis

1. INTRODUCTION

Zinc oxide (ZnO) nanopowders are multifunctional material which is known as n-type semiconductor with wide energy band gap is used as transparent conductive oxide (TCO) layer in organic and non-organic photovoltaic cell preparation [Ahamed A.J, et al. 2016]. The families of II-VI nano scale semiconductors of ZnO material which have a wide band gap and allow devices to operate at higher temperature. In photo electronic fabrication field, Zinc oxide is recently useful in high research field [Baisakh Ket et al. 2017; Bhakat. C, et al. 2012]. Nanostructures zinc oxide is widely used in a number of applications like varistors, UV lasers, gas sensors, photoprinting, electrochemical nanodevices, sunscreen lotion cosmetics, medicated creams, solar energy conversion, optoelectronic devices, catalysis, gas sensors, etc. Zinc oxide is key element for many industrial processes like paints, ceramics, rubber, soap, textiles and floor coverings [Bhumika G, et al. 2015]. There are various methods for the preparations of ZnO

nanopowders like chemical co-precipitation method, sol-

el method, thermal decomposition, hydrothermal method, chemical vapor deposition and electrochemical method [Bindu P, et al. 2014]. Among the different techniques, the co-precipitation approach to be one of the most promising methods to prepare ZnO nanoparticles due to its interesting properties like wide band gap of 3.39 eV. The as-prepared powders were annealed at different temperatures (400°C and 500°C) and obtained pure wurtzite hexagonal phase ZnO powder particles.

However, the co-precipitation method became a very attractive preparation method due to simple equipment involved and low cost compared to other techniques. The phase formation behavior and the microstructures evolution of the samples are investigated by using X-ray diffraction (XRD) and Scanning Electron Microscope (SEM), respectively. The optical characteristics are analyzed by using UV-visible absorption spectrometer.

2. THEORETICAL BACKGROUND 2.1 Properties of Zinc Oxide (ZnO)

Zinc oxide is an inorganic compound with the <u>formula ZnO</u>. ZnO is a white powder that is insoluble in water. It is used as an additive in numerous materials and products including cosmetics, food supplements, rubbers, plastics, ceramics, glass, cement, lubricants Battez A. H, et al., 2008] paints, ointments, adhesives, sealants, pigments, foods, batteries, ferrites, fire retardants, and first-aid tapes. Although it occurs naturally as the mineral zincite, most zinc oxide is produced synthetically [Liedekerke D. M, 2006]. ZnO is wide-band gap semiconductor of the II-VI а The native doping of the semiconductor group. semiconductor due to oxygen vacancies or zinc interstitials is n-type [Özgur Ü, et al., 2005]. Other favorable properties include good transparency, high electron mobility, wide band gap, and strong roomtemperature <u>luminescence</u>. Those properties are valuable emerging applications in for transparent electrodes in liquid crystal displays, energy-saving or heat-protecting windows, and electronics as thinfilm transistors and light-emitting diodes. Pure ZnO is a white powder, but in nature it occurs as the rare mineral zincite, which usually contains manganese and other impurities that confer a yellow to red color [Klingshirn C, 2007]. Zinc oxide is an amphoteric oxide. It is nearly insoluble in water, but it will dissolve in most acids, such as hydrochloric acid [Greenwood N. N, et al., 1997]. ZnO reacts slowly with fatty acids in oils to corresponding carboxylates, produce the such

as oleate or stearate. ZnO forms cement-like products when mixed with a strong aqueous solution of zinc chloride and these are best described as zinc hydroxy chlorides [Nicholson J. W, 1998]. This cement was used Zinc oxide in dentistry [Ferracane J. L, 2001]. crystallizes in two main forms, hexagonal wurtzite [Fierro J. L, 2006] and cubic zincblende. The wurtzite structure is most stable at ambient conditions and thus most common. The zincblende form can be stabilized by growing ZnO on substrates with cubic lattice structure. The hexagonal structure has a point group 6 mm (Hermann-Mauguin notation) or C_{6v} (Schoenflies <u>notation</u>), and the <u>space group</u> is P6₃mc or C_{6v}^4 . The lattice constants are a = 3.25 Å and c = 5.2 Å; their ratio $c/a \sim 1.60$ is close to the ideal value for hexagonal cell c/a = 1.633 [Rossler U, 1999]. As in most group II-<u>VI</u> materials, the bonding in ZnO is largely <u>ionic</u> (Zn²⁺– O²⁻) with the corresponding radii of 0.074 nm for Zn^{2+} and 0.140 nm for O^{2-} . This property accounts for the preferential formation of wurtzite rather than zinc blende structure [Klingshirn C. F, et al., 2010] as well as the strong piezoelectricity of ZnO. ZnO has a relatively large direct band gap of ~3.3 eV at room temperature. Advantages associated with a large band gap include higher breakdown voltages, ability to sustain large electric fields, lower electronic noise, and hightemperature and high-power operation. A small amount of industrial production involves wet chemical processes, which start with aqueous solutions of zinc salts, from which zinc carbonate or zinc hydroxide is precipitated. The solid precipitate is then calcined at temperatures around 800 °C. The applications of zinc oxide powder are numerous, and the principal ones are summarized below. Most applications exploit the reactivity of the oxide as a precursor to other zinc compounds. For material science applications, zinc oxide has high refractive index, high thermal conductivity, binding, antibacterial and UVprotection properties. Consequently, it is added into materials and products including plastics, ceramics, glass, cement [Sanchez-Pescador R, et al., 1988], rubber, lubricants [Battez A. H, et al., 2008], paints, ointments, adhesive, sealants, concrete manufacturing, pigments, foods, batteries, ferrites, fire retardants, etc.

2.2 Theory of Chemical Precipitation Method

Chemical precipitation or coprecipitation (CPT) or co-precipitation is an important issue in chemical analysis, where it is often undesirable, but in some cases it can be exploited. In gravimetric analysis, which consists on precipitating the analyte and measuring its mass to determine its concentration or purity, coprecipitation is a problem because undesired impurities often coprecipitate with the analyte, resulting in excess mass. This problem can often be mitigated by "digestion" (waiting for the precipitate to equilibrate and form larger, purer particles) or by redissolving the sample and precipitating it again [Harvey, et al., 2000]. On the other hand, in the analysis of trace elements, as is often the case in radiochemistry, co-precipitation is often the only way of separating an element. Since the trace element is toodilute (sometimes less than a part per trillion) to precipitate by conventional means, it is typically coprecipitated with a carrier, a substance that has a similar crystalline structure that can incorporate the desired

element. An example is the separation of francium from other radioactive elements by coprecipitating it with <u>caesium</u> salts such as <u>caesium perchlorate</u>. There are three main mechanisms of coprecipitation: inclusion, occlusion, and adsorption [Harvey, et al., 2000]. An inclusion occurs when the impurity occupies a lattice site in the crystal structure of the carrier, resulting in a crystallographic defect; this can happen when the ionic radius and charge of the impurity are similar to those of the carrier. An adsorbate is an impurity that is weakly bound (adsorbed) to the surface of the precipitate. An occlusion occurs when an adsorbed impurity gets physically trapped inside the crystal as it grows. Besides its applications in chemical analysis and in radiochemistry, coprecipitation is also "potentially important to many environmental issues closely related to water resources, including acid mine drainage, radionuclide migration in fouled waste repositories, metal contaminant transport at industrial and defense sites, metal concentrations in aquatic systems, and wastewater treatment technology" [Zhu c, et al., 2003]. Coprecipitation is also used as a method of magnetic nanoparticle synthesis [Lu A. H, et al., 2007].

3. EXPERIMENT

The synthesized nanoparticles zinc oxide powders are characterized to investigate their microstructures and optical properties. The crystallinity and the phase composition of as- prepared were examined with X-Ray diffractometer, (MD-10) (Rigaku, Japan). The size of the particles and morphology of ZnO were studied by Scanning Electron Microscopy (JEOL-JSM 5610LV). Optical transmission and absorption spectra of ZnO were recorded using Shimadzu UV-Vis Spectrophotometer (UV-1800).

3.1 Preparation of Zinc Oxide solution

In this process, the starting materials used were zinc chloride (ZnCl₂) and sodium hydroxide (NaOH). Aqueous solution was prepared by dissolving 6.8 grams of zinc chloride in 100 ml of distilled water. It was stirred continuously with magnetic stirrer for 30 minutes in ambient atmosphere so that zinc chloride can be dissolved properly. After 30 minutes stirring, the temperature was raised to 80°C for 2 hours. Sodium hydroxide 5 grams was dissolved in 25 ml distilled water. The prepared aqueous solution of sodium hydroxide was added slowly drop by drop (dropped for 45 minutes) into the stirring solution zinc chloride solution by touching the walls of container/vessel under continuously stirring.

The reaction was allowed to proceed for 1 hour after complete addition of sodium hydroxide and then removed the magnetic stirrer from the container. After that the mixture solution was heated for 1 hour at $60 \sim 80^{\circ}C$ without stirring. A milky white solution was obtained which the reaction was allowed to proceed for 3 hours after complete addition of sodium hydroxide. The precipitate obtained was washed with distilled water many times and filtered using filter paper. The mixture was dried in air at 70°C for 3 hours. The sample powders were annealed for 1 hour at different temperatures 400°C and 500°C, respectively. The reaction equations are as follows;

$$ZnCl_2 + 2 NaOH \rightarrow Zn(OH)_2 + NaCl$$

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4. ANALYSIS

4.1 XRD Analysis

The XRD patterns of the obtained ZnO powders with different annealing temperatures at 400°C and 500°C labeled as sample 1 and 2 were shown in Figure 1 (a) and (b). All diffraction peaks can be indexed to the hexagonal wurtzite phase of ZnO crystals a match well with standard data.

The pattern suggests that the ZnO samples with different annealing temperatures are constituted in hexagonal wurtzite structure with a preferred orientation of (101) diffraction plane. No additional peaks correspond to the other impurities were detected in the XRD pattern, such as Zn and O are found in XRD patterns confirming that all the samples exist as main ZnO phase. The phase of ZnO powders can be prepared at different annealing temperatures at 400°C and 500°C for 1 hour.

The major diffraction peaks are present between 20° and 70° (2 θ). The detected peaks at scattering angles (20) values at 31.7°, 34.4°, 36.3°, 47.5°, 56.6°, 62.8° and 66.4° which corresponds to (100), (002), (101), (102), (110), (103) and (200) crystal plane respectively (JCPDS: 36-1451) at different temperatures (400°C and 500°C). To identify the effect of annealing and investigate the reason for the diffraction peak shift the lattice parameters (a and c) were estimated from the relation. The experimental average lattice constant a and c of ZnO powders for lattice planes were determined as a = 3.2546Å, c = 5.2141 Å at 400°C and a = 3.2484, c = 5.2035 Å at 500° C respectively, giving average lattice constant as a = b = 3.2507 Å, c = 5.20723 Å. These values were much closed to ZnO ones in the JCPDS card result, i.e, a = b =3.264Å and c = 5.219Å. The mean ratio c/a of ZnO powders were 1.602 and 1.601. The values of the lattice parameter 'a' and 'c' decreased with an increase in annealing temperature, attributed the decrease in the values of lattice parameter to the lattice contraction that may have resulted from the presence of dangling bonds on the surface of ZnO. The above structural analysis reveals that an annealing temperature of 500°C essentially required to obtain ZnO powders with high crystallinity quality and minimum stress.

The sharp diffraction peak of ZnO (101) plane was much stronger than the other peaks. The average crystallite size of the prepared nanopowder ZnO were calculated using the Debye-Scherer formula,

$D = 0.9\lambda/\beta Cos\theta$

Where D is the crystallite size, λ is 1.5406Å for CuK_{a2}, β is the full width at half maximum (FWHM) of the peak in radian and θ is the Bragg angle indicated the calculated particle size of the ZnO diffraction peak. The average crystallite size of the samples 1 and 2 was found to be 38.15 nm, and 41.38 nm, respectively. It was observed that the crystallite size of ZnO nanaopowders increased during annealing point out to the tendency of large grain growth in the nanoparticles that occurs as a result of movement of atoms to the favorable positions to merge into adjacent particles forming larger particles due to annealing. ZnO powder annealed at 500°C registered the highest intensity, indicative of most enhanced crystallinity and grain growth.

The decreased in the FWHM of the diffraction peaks with the increase of the annealing temperature can be attributed to the coalescences of grains at higher annealing temperatures. The shift to a higher angle of diffraction peak (101) with the increase in annealing temperature is occasioned by a change in stress in the ZnO and may be related to decrease of lattice parameters that come from the oxygen deficiency and strain caused by crystallinity during annealing process.

Additionally, ZnO nanopowders known to have defects such as zinc performs, oxygen vacancies and lattice disorders, which are reported to disappear with annealing resulting to the contraction of lattice. It was observed that the diffraction peak (101) of the annealed samples were located at a higher diffraction angle, which meant smaller d value. During annealing, oxygen vacancies were generated while the majority of Zn atoms were in the same valence state. It was suggested that oxygen vacancies might reduce the lattice strain and corresponding lattice parameters, at least the c value.

The dislocation density (δ) , which represents the number of defects in the sample is defined the length of dislocation lines per unit volume of the crystal and is calculated using the following equation;

$\delta = 1/D^2$

Where D is the crystallite size. The dislocation density for ZnO films annealed at different temperatures at 400°C and 500°Cwere 6.87×10^{14} m⁻² and 5.84×10^{14} m⁻². In addition, the micro strain (ε) of samples were calculated by the following equation;

$\varepsilon = \beta \cos\theta/4$

The macrostrains of the ZnO powders were 9.08×10^{-4} and 8.37×10^{-4} at 400°C and 500°C. Table 1 summarized XRD analysis results of ZnO samples at (101) planes.

Table 1. The energ	y gap, grain size and crystalli	te size
of ZnO	powders at (101) planes	

	01 21	10 po we	(101) at (101)	Junes	
Temp	(hkl)	c/a ratio	Crystallit e size (nm)	Grai n size (µm)	Energ y Gap (eV)
400°C	(101	1.60 2	38.15	0.32	3.15
500°C	(101	1.60 1	41.38	0.47	3.39



(a)



Fig 1 XRD patterns of ZnO powder samples annealed at (a) 400°C and (b) 500°C

4.2 SEM Analysis

The investigation of microstructural properties such as grain size, pore and homogeneity are checked by SEM. Figure 2 shows the surface morphology at temperature ranging from 400°C and 500°C. The particle of ZnO powder with the range particle size of 0.32 μ m, and 0.47 μ m for samples 1 and 2. All ZnO powder samples tend to spherical shaped nanoparticles. As the temperature is increased further the shape of the particles is changed and size of the particles also increases. Reaction temperature is an important parameter which influences the structural morphology of the particles as well as the particle size.

As the annealed temperature is increased there is increase in the particle size. In heating process when the particles are formed, they collide and either coalesce with one another to form a larger particle or coagulate. The grain size growths of ZnO powders observed mostly probably based on the shape and distribution of grain for each powder. The average grain sizes of the ZnO particles for the samples are shown in Table 1. As the temperature increased further the shape of the particles is changed and size of the particles also increases. The measurement of scanning electron microscopy analysis by using the aid of "image J" software.







Fig 2 SEM images of ZnO powders at different annealing temperatures at (a) 400°C and (b) 500°C

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4.3 Optical Analysis

The optical property of the ZnO powder at different annealing temperature was studied the physical phenomena and optical constant. The preparation of ZnO powder were analyzed by UV absorbance spectra. The absorbance of sample may be influenced by grain size, shape and coverage of sample. Absorbance was checked in wavelength range from 200 to 1100 nm for different annealing temperature 400°C and 500°C. All the samples showed absorption edges around 370 nm which corresponded to the optical band gap of ZnO. The UV spectrum of Zinc Oxide samples are shown in Figure 3 (a) and (b). From the dependence of the absorption band edge on wavelength, the energy band gap of the material can be determined. To determine the optical band gap, absorption coefficient a of the ZnO film was calculated using,

α (γ) = 2.303 (A/t)

Where A is the optical absorbance and t is the thickness of cuvette. The optical band gap of the film was estimated by means of Tauc's equation,

$(\alpha h \upsilon)^2 = (h \upsilon - E_g)^{1/2}$

Where h γ is the photon energy and E_g is the optical energy gap. These energy gaps are calculated from the intercept of straight line on the photon energy (h υ) of the (α h υ)² vs (h υ) plot and the value listed in Table 1. The calculated band gap values were 3.15 eV and 3.39 eV treated samples at 400°C and 500°C. The UV emission corresponds to near band edge emission due to the fee excitation recombination.

The optical band gap of ZnO reduced appreciable with a change in nanoparticle size from 38.15 nm and 41.38 nm as caused by the increase in annealing temperature. The band gap energy may be attributed to the increase in particle size with increasing annealing temperature as shown by XRD and SEM data. The observed increased in the optical band gap with the increase in annealing temperature could be due to the variation in lattice defects and stress. The annealing process improved the crystallinity, increased the average grain size and band gap energy increased.



Fig 3 Plots of $(\alpha h\nu)^2 vs(h\nu)$ to determine the energy of the optical absorption coefficient for ZnO powder samples at (a) 400°C and (b) 500°C

4. CONCLUSIONS

Zinc oxide Nano powders by the chemical coprecipitation method and annealed at different temperatures 400°C and 500°C. Various properties of ZnO nanostructures have been characterized. The XRD patterns of the samples showed a hexagonal wurtzite crystal structure confirming the synthesis process The SEM revealed the formation of efficiency. agglomerated particles. The research finding, the energy band gap for ZnO was 3.39 eV while the crystallite size 41.38 nm by using UV-vis and XRD. In addition, there was a reaction temperature was important parameter which influences the structural morphology of the particles as well as the particle size. As the reaction temperature was increased there was increased in the particle size. In heating process when the particles are formed, they collide and either coalesce with one another to form a large particle or coagulate. When the temperature was increased, the c/a ratio decreased and the crystallite size increased. The band gap of ZnO powders increased from 3.15 and 3.39 eV with an increase in temperature from 400°C and 500°C. The results of this work show that ZnO nanopowders annealed at 500°C is most suitable to make photo electrode which was in a good agreement with the value of optical band gap for ZnO at 3.39 eV and micro strain was the lowest 8.37 \times 10⁻⁴ because of the dislocation density was found to be 5.84×10^{14} m⁻². The results indicate that the ZnO nanopowder prepared by chemical precipitation method can be used for solar cell. Then, the samples were characterized by means of XRD, SEM and UV-Vis measurement.

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Design and Construction of Real Time Data Logging System by Using Arduino and Bluetooth

Myint Myint Soe⁽¹⁾,Kyi Kyi Aung ⁽²⁾,Aye Thida⁽³⁾ ⁽¹⁾Sagaing University, Myanmar ⁽²⁾Yadanarbon University, Myanmar ⁽³⁾Shwe Bo University,TULSOPhys-61 Myanmar

Email:soemyintmyint11@gmail.com

STRACT: A kind of data logging system is designed and constructed. It is intend to apply in environmental study concerning with light, temperature, humidity, UV (Ultra Violet) intensity effects on living things. The data can be monitored on a serial monitor of an android phone and data logging can be control from the android phone directly. This system can be measured and recorded the UV intensity. The system design consists of an Arduino Uno development board, an ultraviolet sensor module, a real time clock module (DS3231), a Bluetooth serial module, a micro-SD card module, a CR2032 li-ion battery and two 3.7V rechargeable li-ion batteries. The whole system is constructed on a specially designed printed circuit board. The data of observing UV intensity are logging in a micro-SD card. The program code was created by using Arduino IDE software. This real time logging system could be applied to investigate environmental effect and research tool for environmental researcher. It could be support the condition of weather reporting system.

KEYWORDS: *Microcontroller, Arduino, ultraviolet sensor, Bluetooth serial module*

INTRODUCTION

Data logging system is an electronic measuring device, which logs the data over a period of time with a sensor. The sensors are embedded in instrument or connected as external add-on devices. There are various kind of data logging systems such as measuring and collecting electrical data (voltage, current, and frequencies), biological data of a patient (heartbeat, body temperature and pressure), and environmental data in an area (air pressure, intensity of light, temperature of water, level of water, water content in soil, dissolved oxygen, measurement of rain, motion of wind and its direction), etc. This system can be measured and recorded the UV intensity. Ultraviolet radiation lies between wavelengths of about 400 nanometers (1 nanometer [nm] is 10⁻⁹ meter) on the visible-light side and about 10 nm on the Xray side. In physics, ultraviolet radiation is traditionally divided into four regions: near (400-300 nm), middle (300-200 nm), far (200-100 nm), and extreme (below 100 nm). Based on the interaction of wavelengths of ultraviolet radiation with biological materials, three divisions have been designated: UVA (400-315 nm), also called black light; UVB (315-280 nm), responsible for the radiation's best-known effects on organisms; and UVC (280-100 nm), which does not reach Earth's surface.

All types of UV radiation have the potential to damage your skin, but each type affects your skin differently. UVA rays, which account for 95 percent of radiation that reaches the earth's surface, cause wrinkles, "sun spots," and other types of premature aging. They are also strongly linked to skin cancer. UVB rays, which affect skin's top layer, cause skin cancer and most sunburns. Although UVA and UVB rays pose the greatest risk for sun damage, people who work with welding torches or mercury lamps may be exposed to UVC rays, the most dangerous type of UV radiation. Too much exposure to UV light (such as that emitted from our Sun) can cause harmful effects to the livings. But, ultraviolet light has been used for things such as UV lasers, fluorescent lamps and disinfecting wastewater. Basic structure of the system is illustrated with a block diagram in figure 1.



Figure 1 Block diagram of the circuit.

DESIGN AND CONSTRUCTION OF CIRCUIT

The schematic diagram of the system is shown in figure 2. As shown in the diagram, there are various components in the circuit; an Arduino Uno, a micro SD Read/Write module, a Bluetooth serial module, a DS3231 real time clock module with a separate CR2032 Battery, a uv sensor module (ML8511), and two 3.7V liion batteries.

The whole circuit is controlled by a microcontroller and it is located on the Arduino Uno development board. It is ATMEGA328p. There are 20 I/O pins on the Arduino Uno, but only 12 I/O pins are used in the circuit. Four circuit modules are connected with the Arduino Uno. They are ultraviolet intensity sensor module, real time clock module, micro SD card reader module and Bluetooth serial modules. The uv sensor is an analog output device and the output pin is connected with the analog input pin A0 of microcontroller. The 3.3V pin and EN pin of the sensor is connected with the 3.3V power output pin of the Arduino Board. At the same time, the 3.3V power pin is connected with the analog input pin A1 of the microcontroller. The GND pin of the uv sensor is connected with the ground line of the circuit.

The real time clock module used in the circuit is an I2C device, and consists of five female terminal pins. The Vcc and Gnd pins are connected with the 5V and Gnd lines of microcontroller. The SDA pin is connected with the A4 (SDA) pin of microcontroller and the SCL pin is connected with the A5 (SCL) pin of microcontroller respectively. The module consists of a small 3V li-ion cell battery permanently soldered on the board. The battery voltage is very low and cannot keep the time. Therefore, it is removed from the board and a CR2032 lithium cell battery is wired with the battery terminals on the board. A casing for CR2032 is soldered on the board.

The micro SD card reader module is a Serial Peripheral Interface module (SPI) device. It consists of six terminal pins. The Gnd and Vcc pins are connected with the ground pin and supply pin of the microcontroller. The MISO pin is connected with the pin 12 of Arduino Uno. The MOSI pin is connected with the pin 11 pin of Arduino Uno. The SCK pin is connected with the pin 13 of Arduino Uno and the CS pin is connected with the pin 10 of the Arduino Uno respectively.

The Bluetooth module is a serial device and consists of six terminal pins. But only four pins are connected with the Arduino Uno. To avoid programming difficulties, the built-in serial pins of Arduino Uno are not going to use. Instead, digital pin 8 and 9 are used as serial pins and they are connected with the serial pins of the Bluetooth module. In this case, pin 8 is used as TX pin and pin 9 is used as RX pin. The Vcc pin and Gnd pin are connected with the 5V supply line and ground line of the Arduino Uno respectively.

There are a few other components on the schematic. Two LEDs are connected with the digital pin 4 and 5 of Arduino Uno. The cathodes of LEDs are connected with the ground line, the anode of red LED is connected with the digital pin 4 through a 560W current limiting resistor. The anode of green LED is connected with the digital pin 5 through a 270W resistor. Although there is a reset switch on the Arduino board, an external Reset switch is added in the circuit. The power input terminal is connected with the series connection of two 3.7V li-ion batteries. But there is a DPST switch between the battery terminal and V_{in} of the Arduino Uno. The flow chart of the research is shown in figure 3.



Figure 2 Schematic diagram of Bluetooth control real time data logging system

2.1 Flowchart diagram of program



Figure 3 Flowchart diagram of Bluetooth control real time data logging program

CIRCUIT OPERATION

The photo of labeled components of the circuit board is shown in figure 4. If the power supply is switched on, the circuit is ready to test. Initially, the red LED on the Bluetooth serial device is flashing. In this case, it is finding the device to connect and currently it was not connected.

Therefore, the Bluetooth function of an android phone is enabled and search for the new Bluetooth device. When the device was found, it shows the newly searched devices. But it was not being paired. Therefore, it is required to pair the two devices. When pairing, a pairing code was requested to enter. In this case, the default

paring code 1234 was entered. The device was shown in the paired device list as shown in figure 5. And Select the Bluetooth serial device on serial terminal to connect the two devices is shown in figure 6.

Now, it is ready to connect the two devices. In this case, a Bluetooth serial monitor application was utilized. It can easily download for the google play store. Then the application was opened and search for the device name with correct address. Then simply tap on the connect button. As soon as the two devices connected the Ardiuno Uno circuit and transmit Bluetooth serial data to the android phone continuously as shown in figure 7. It is currently in the normal state.

Now it is going to log the uv intensity data on the micro SD card. In this case, the character "l" is send from the keypad as shown in figure 8. Then each data are logged in the micro SD card. On every data logging, a green LED is illuminated for a few seconds. Data logging and the green LED illuminate is shown in figure 9. After completed the data logging complete was illustrated on the serial monitor as shown in figure 10. The data logging can also be made for the whole day with 5 min delay between each data by sending serial command "d" from the serial monitor. The stored data file in the micro SD card can be deleted by using serial command "e" from the serial monitor. In this case, the red LED on the circuit board will be illuminated and serial monitor will inform the file is deleted as shown in figure 11.



Figure 4 Labeled components of the circuit board



Figure 5 Paired devices added on Android device list



Figure 6 Select the Bluetooth serial device on serial terminal to connect



Figure 7 Device connected and received data are displayed on the Serial Terminal



Figure 8 Sending serial data "l" to log 5 data on micro SD card



Figure 9 Data logging and the green LED illuminate.

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Figure 10 Data logging finished



Figure 11 Deleting the data file in micro SD card

3.1 Data Results

Practical experiment on data logging was made by using a super bright LED torch light sources from various distances by collecting five data. The data logging can be made for various power light sources, to investigate their power of uv light emission. The logging data from the micro SD card is illustrated on the figure 12.

UVDATA - Notepad				-	
File Edit Format	View Help				
27/7/2020	17:54:13	1.2	0.13 mW/cm^2	DataNo.1	
27/7/2020	17:54:16		0.13 mW/cm^2	DataNo.2	
27/7/2020	17:54:19		0.13 mW/cm^2	DataNo.3	
27/7/2020	17:54:21		0.13 mW/cm^2	DataNo.4	
27/7/2020	17:54:24		0.13 mW/cm^2	DataNo.5	
DATE	TIME	305	UV_VALUE		
27/7/2020	17:55:10	1.1	0.13 mW/cm^2	DataNo.1	
27/7/2020	17:55:12		0.13 mW/cm^2	DataNo.2	
27/7/2020	17:55:15	1	0.13 mW/cm^2	DataNo.3	
27/7/2020	17:55:18		0.13 mW/cm^2	DataNo.4	
27/7/2020	17:55:21		0.13 mW/cm^2	DataNo.5	
DATE	TIME		UV_VALUE		
27/7/2020	17:57:32		0.13 mW/cm^2	DataNo.1	
27/7/2020	17:57:35		0.13 mW/cm^2	DataNo.2	
27/7/2020	17:57:37		0.13 mW/cm^2	DataNo.3	
27/7/2020	17:57:40		0.13 mW/cm^2	DataNo.4	
27/7/2020	17:57:43		0.13 mW/cm^2	DataNo.5	
27/7/2020	17:59:15		0.13 mW/cm^2	DataNo.1	
DATE	TIME		UV_VALUE		
27/7/2020	18:4:34		0.13 mW/cm^2	DataNo.1	
27/7/2020	18:4:37		0.13 mW/cm^2	DataNo.2	
27/7/2020	18:4:40		0.13 mW/cm^2	DataNo.3	
27/7/2020	18:4:43		0.13 mW/cm^2	DataNo.4	
27/7/2020	18:4:46		0.13 mW/cm^2	DataNo.5	
DATE	TIME		UV_VALUE		
27/7/2020	18:6:10		0.13 mW/cm^2	DataNo.1	
27/7/2020	18:6:13		0.13 mW/cm^2	DataNo.2	
27/7/2020	18:6:16		0.13 mW/cm^2	DataNo.3	
27/7/2020	18:6:19		0.13 mW/cm^2	DataNo.4	
27/7/2020	18:6:21	1.1	0.13 mW/cm^2	DataNo.5	
DATE	TIME		UV_VALUE		
27/7/2020	18:7:56		0.13 mW/cm^2	DataNo.1	
27/7/2020	18:7:59		0.13 mW/cm^2	DataNo.2	
27/7/2020	18:8:1		0.13 mW/cm^2	DataNo.3	
27/7/2020	18:8:4		0.13 mW/cm^2	DataNo.4	
27/7/2020	18:8:7		0.13 mW/cm^2	DataNo.5	
27/7/2020	18:8:25		0.13 mW/cm^2	DataNo.1	

Figure 12 Logged data result file from the micro SD card

4 CONCLUSIONS

The design of the Real Time Data Logging System for UV intensity is constructed and tested for its properties. Finally, conclusions were made for the system. The system is much cost effective compared to existing products. The system is fully automatic data collection device, if a micro SD card is available on the system. Moreover, the stored files in the micro SD card can easily deleted from the serial monitor. The stored data from the micro SD card is illustrated on the result table. The sensors can be calibrated without difficulties. Designed system consumes very less power, and built in li-ion batteries can achieve portability and easy to collect outdoor data very easily. The system is very useful and testing results showed that the developed system satisfactorily performed the required observations and data logging.

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Experimental Error Analysis of Gravitational Acceleration Value

Moe Moe Swe⁽¹⁾, **Thanda**⁽²⁾, **Khin Thin Kyi**⁽³⁾ ⁽¹⁾⁽²⁾⁽³⁾ University of Computer Studies (Monywa), Myanmar

moemoeswe007@gmail.com, than.da.da@gmil.com, khinthinkyi@ucsmonywa.edu.mm

ABSTRACT: Acceleration due to gravity can be determined by many methods such as free fall, simple pendulum, physical pendulum and Atwood's machine. During this paper, the idea results and analysis of the experimental error are employed by applying Physics Rotational Method of the straight forward pendulum. Furthermore, Physics Direct Method is additionally inclined to represent the equations. If the numerical solution increase equations, the results could also be variables like displacement, angle, damping, mass of the pendulum bob and more. Among them, the length of the swinging pendulum is that the most interesting variable. The connection between the length and therefore the square of the period for one swing has been researched for several times. The Physicists, Newton and Galileo, found an accurate value 9.806 m/s² for the gravitational acceleration 'g'. Then, they have need allowed to use this value to get within the experiments. Therefore, the final results obtained from experiments are going to be compared with the commonly accepted values.

KEYWORDS: *Physics rotational method, simple pendulum, numerical solution*

1. INTRODUCTION

The symbol g are often defined acceleration of the gravity of the Earth. It's the acceleration of a body which is caused by the field working on the body to the center of the work without including air resistance and mass. Firstly, the worth of gravitational acceleration (g) was denoted by Galileo in 1604. Sir Isaac Newton formulated the law of gravity and published this law in1687. The magnitude of g that ranges over the Earth's surface is measured from different locations [Mac Dougal D W 2012]. According to JS Clark [1939] and AH Cook [1965], a reversible pendulum and free motion experiments can be used to measure the absolute g constants. The value of g from these experiments were almost the same as the mean of g absolute determination by using other methods. After that, Cook [1967] state that the absolute g value was determined by using the British Fundamental Gravity Station in the N. P. L. The standard deviation of 0.0005 cm/s² is 981181.75 mgal and the National Bureau of Standards near Gaithersburg, Maryland 980.1018 cm/s² [D R 1968]. The most accurately numerical value of the acceleration of gravity is also knows 9.8 m/s². For example, the measurement of Earth's gravity field after the gravity field and stead-state ocean circulation explorer mission by the European Space Agency program [Cesare S, Aguirre M, Allasio A, Leone

B Massotti L, Muzi D and Silvestrin P 2010] has recently been provided to many researchers with gravitational acceleration computations (using innovative technologies). Furthermore, they proposed a method. This method can extract the gravitational acceleration from additional accelerations depend on a simplified walking model [Lee H, Lee J, Cho J and Chang N 2016]. Simple pendulum is used to measure that acceleration for teaching undergraduate students in Physics laboratory. The word's gravitational acceleration [Wick K and Ruddick K 1999] was estimated at 9.78120 m/s² [Jonjana S, Lohawijarn W and Durrast H 2010 - Sirisathitkul C, Glawtanong P, Eadkong T and Sirisathitkul Y 2013] by the National Institute of Metrology in nearby Songkhla province, southern Thailand.

The simple pendulum's motion is analyzed in this study. Pendulum can swing freely because of a weight suspended from a pivot. When a pendulum is displaced sideways from its position of equilibrium, due to gravity, it is a problem for a restore force to accelerate it again to the position of equilibrium [Kidd, R.B. and S.L. Fogg 2002 - Kenison, M. and W. Singhose 1999]. While released, the force of restoring combined with the cause of mass of the pendulum is to oscillate approximately the functions of equilibrium swinging from back to forth. The experiment was of value since the gravitational force is one all people perpetually experience and the accumulation and analysis of data proved to be a rewarding learning experience in error analysis. Furthermore, the best examined a mathematical model for the gravity value that makes use of the approximation of the small-angle and the proportional relationship between the square of the oscillation time and pendulum length. Covered precision in both length and time size equipment reaction time of the stopwatch holder and accuracy of the stopwatch with recognize to the lab atomic clock. The very last result of 'g' takes into account the correction for the error brought the usage of the approximation. There are opportunities to accurate for results of mass distribution, air buoyancy and damping and string stretching. Presently, our outcomes do not take those results into account.

2. Experimental Procedure

The period of an oscillation is

$$T = 2\pi \sqrt{\frac{L}{g}} \tag{1}$$

Where: T= the period in second, s.

L= length of pendulum= the string of length+ radius of spherical bob in cm.

G= is that the acceleration thanks to gravity. By squaring each sides of the equation yields,

$$T^2 = 4\pi^2 L/g$$
 ------ (2)

If we solve equation for 'g', then we obtain. OR Figure 1 pendulum experiment found out to live gravitation acceleration.

$$g = 4\pi^2 \frac{L}{T^2}$$
 OR $g = \frac{4\pi^2}{slope}$ ------(3)

Experimental Apparatus using simple pendulum to find the acceleration due to gravity, the apparatus was constructed from string (length l) connected to a metal ball, which were attached to the ingot as shown in figure 1. This experiment used an oscillation angle of but 15° . With the pendulum experiment, stopwatch was used to detect the time of the metal ball (bob) swing of 20 revolutions with seven repetitions.



Fig. 1. Simple pendulum experiment set up to measure gravitational acceleration

The experimental set us was adequate to the diagram shown in fig. 1. Use a micrometer to measure the diameter d of the spherical bob and from this calculates its radius r. Record the values of the diameter and radius in meters are shown in table 1. Measuring the diameter of bob is shown in figure 2.



Fig. 2. Micrometer to measure the diameter of the bob.

Table1.	Determination of the Diameter of the Pendulum
	Bob

	LS read - ing	CS in Line with linear Line	CS reading	Diame ter read ing	Rad ius read ing
1	21 mm	19	$19 \times 0.01 =$	21.19	10.59
•			0.19		3
2	21 mm	26	26x0.01= 0.26	21.26	10.63
3	21 mm	30	30x0.01= 0.3	21.3	10.65

The distance from the point of suspension to the center of the ball is determined the length of the simple pendulum. Using a meter stick, the length of the string ls from the point of suspension to the top of the ball is measured and recorded the value. And then the radius of the ball is added to the string length ls and the length of the pendulum $(l=l_s + r)$ is recorded. The pendulum is displaced about 15° from its equilibrium position and let it swing back and forth. So as to scale back possible randon errors within the time measurement we repeated the measurement of the period three times for each of the seven lengths.We also measured the time for 20 successive swings to further reduce the error. As stated earlier, it had been decided to live the time for 20 swings, so as to scale back the random errors. These measurements would be repeated two more times, and in total seven length were used, ranging from 20 cm to 80 cm for every following measurement. A meter ruler was used to determine the length of the string. One additional challenge in calculating the length of the pendulum was the relative large ambiguity that gave rise to the exact length, as the metal bob added just one centimeter to our string length, calculated from the middle of the bob. This resulted in an uncertainty in length that was higher than one would normally except. The table clamp was wont to secure the stand position, while the pendulum was swung. All measurement, were taken under anequivalent conditions, using an equivalent metal bob, ruler, with in the same room and at approximately 15°.

3. Results and discussion

Table 2. Data Analysis of Various Lengths					
Time ta (in seco	Length (in meter) ±0.005 meters				
First Trial	Second Trial	Third Trial	All Trails		
17.98	18.30	18.36	0.2		
22.19	22.23	22.34	0.3		
25.45	25.57	25.65	0.4		
28.32	28.40	28.34	0.5		
30.55	30.78	30.71	0.6		
32.78	32.85	32.9	0.7		
35.02	35.08	35.01	0.8		

Table 2 shows the data analysis of various lengths, such as 20cm, 30cm, 40cm, 50cm, 60cm, 70cm and 80cm respectively. From this table, it can be seen that as the length of pendulum increases, the period also increases. \pm 0.34 sec uncertainly in time changed into aquired by means of comparing the spead for the different measurements. The time measurement for the 0.5m length, had the largest spead (\pm 0.3s), and changed into consequently used because the uncertainty inside the time

measurement. In table 1 the theoretical uncertainty within the length measurement could be 0.05cm (a meter ruler was used). But, inside the experimental set-up, the two end points (the one tied to the clamp, and the one time to the metal bob) gave rise to a larger uncertainty, the exact endpoints could not be precisely determined. We envisioned the uncertainty in length to be 0.5cm or 0.005m. these statistics in table 1 want to be processed, earlier than we are able to continue our analysis. To start with, the average of the three trails want to be found, so that it will reduce our errors. Further, to which our absolute error, the time for one swing or one cycle needs to be found, but not our percent error. It should also be stated, that for all of the measurements, a constant, and small angle. If maximum displacement became used .The

angle became kept between 10° to 15° small enough to ignore the friction found in our experiment set-up. Other than these measurements, one extra experiment become carried out to look how a good deal daming was found in our set-up. It took, on average, between 50 and 100 swings, before the motion had seemed stop. This showed that there has been damping present, however this did no longer significantly affect the measurement of just 20 swings.

Table 3. Processed Data and the Uncertainties

Period Squared (T ²)(s ²)	% Uncertainty ² in T ²	Absolute Uncertainty in T ² (s ²)	Length (m) ±0.005 m
0.829	3.298	0.027	0.2
1.239	2.696	0.033	0.3
1.631	2.348	0.038	0.4
1.989	2.116	0.042	0.5
2.356	1.956	0.046	0.6
2.696	1.826	0.049	0.7
3.066	1.712	0.052	0.8

Table 3 describes the processed data and the uncertainties. The relationship between the variable used is obviously not a linear one when drawing the graph for the data in table 2. The proposed square-root relationship between length and period. It must be interchanged and the axis modified to linearize this curve. It is shown in figure 3.





Fig. 3. Period vs Length graph

Table 4. Data for T², % Uncertainty, Absoulue uncertainty, Length

Averagetimetakenforoneswing(inseconds)±0.3seconds	Percentage Uncertainty In Period (in seconds)	Length (in meters) ±0.005 meters
0.911	1.649	0.2
1.113	1.348	0.3
1.277	1.174	0.4
1.417	1.058	0.5
1.535	0.978	0.6
1.642	0.913	0.7
1.751	0.856	0.8

Table 4 shows that data for T², % Uncertainty, Absolute uncertainty, Length. It should be linear relationship between T² and length, base on Simple Harmonic Motion theory and equation 1. The regression line must be linear, going through point (0,0) and with agradient equal to, or $4\pi^2/g$ when graphing such two modified variable.



Fig 4. Period-squared vs Length Graph

Figure 4 describes the period- squared vs length graph. It appears to be linear, but does not across the y-axis at zero. The graph is nearly a straight line showing that the time

 Table 5. Percentage Error for Several Lengths

Length (m) ±0.005 m	Accepted value (m/s ²)	Experiment ally value (m/s ²)	(%) error
0.2	9.806	9.52	3.00
0.3	9.806	9.56	2.57
0.4	9.806	9.687	1.23
0.5	9.806	9.92	1.15
0.6	9.806	10.05	2.43
0.7	9.806	10.25	4.33
0.8	9.806	10.30	4.80

Table 5 also describes that the percentage error with the various lengths. It can be seen that lengths 0.7 m and 0.8 m are above 4%, but the 0.3 and 0.6 are below 3%. And length 0.2 m is 3%. Length 0.4 m and 0.5 m are under 2%. yet it not approach to the true value.

In figure 4 grappling the length against T^2 clearly show, in agreement with the theory, a linear relation. The real best fit line does not go through (0, 0) which indicates a systemic error in our experiment. Yet when graphing a best fit line, we consider a line with a gradient of 1.989 and a correlation coefficient of 0.5 with the condition that it will pass through (0, 0), which further implies a very strong linear association between our selected variables.

 $g_{best} = 9.92 m s^{-2} \pm 0.1$









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 Table 6. Period measurements at different angles

Degree	3	5	10	15	20
Average					
Period of	28.35	28.41	28.43	28.68	29.24
20	3	8	6	1	1
oscillatio					
n					
Average					
Period of	1.417	1.421	1.422	1.434	1.462
oscillatio					
n					
T^2	2.007	2.019	2.022	2.056	2.137
g	9.835	9.777	9.762	9.601	9.237

Table 6 shows that data for period measurement at different angle. The result for g value obtained from both measured of fit length (L) and different value of T^2 . The value of g situated in small angle is the best and it also has the least error. If this g value has large angle, the error of the value will be more increase.

4. CONCLUSIONS

The uncertainty was found in this value by taking half the difference between the lowest possible value for g and the highest possible value for g. Comparing our estimated value with agreed theoretical value for gravitational acceleration g gives us an error of 5 percent, well within the error margins we measured. This is a fair outcome, considering the equipment we were facing and the time constraints. Looking at our graph, it cannot be pinpoint outliers. The data values, however, indicate best fit a line that doesn't move through (0,0). If is fit a linear regression on our data values, it passes (0, 0), it can be seen that the line does not 'hit' all the horizontal error bars (length uncertainty). It may suggest a systematic mistake in calculating the pendulum length.

The values of g obtained by calculating fit length 0.5 m and different value of period T^2 . The value of g situated in small angle is the best and it also has the least error. If this g value has large angle, the error of the value will be more increase. It seems that the reported errors in approximating the exact period of the approximation formulae for large amplitudes of a simple pendulum in the range between 0° and 15° are not very accurate for students who perform the simple pendulum experiment.

It is concluded that the value of acceleration due to gravity calculated through this experiment (9.92 ms⁻²) is close to the standard value (9.8ms⁻²), with an uncertainty of ± 1.15 .

The pendulum does not show true simple harmonic motion for any angle it must be less than 10° .

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Characterization of Nickel Oxide (NiO) Sample Prepared by Simple Co-precipitation Method

Khaing Khaing Thinn⁽¹⁾, Khin May Oo⁽²⁾ San Maw⁽³⁾ ^{(1),(2),(3)}Technological University (Lashio), Myanmar

Email: khinekhinethin@tulashio.edu.mm

ABSTRACT: In this study, nickel oxide (NiO) sample was prepared by co-precipitation method by using nickel chloride (NiCl₂), sodium hydroxide (NaOH) and ethylene glycol as starting materials. X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR) and scanning electron microscope (SEM) were used to characterize the prepared NiO sample. The XRD and FTIR results revealed that the prepared sample was nanocrystalline pure nickel oxide (NiO). SEM image showed that the prepared NiO sample was irregular shaped micro-plates.

KEYWORDS: *nickel oxide (NiO), co-precipitation, nanocrystalline, micro-plates*

1. INTRODUCTION

Nanocrystalline metal and metal oxide have attracted attention due to the result of their numerous physical/chemical properties, and their widely applications in various fields. Among various metal oxides, nickel oxide micro/nanoparticles have attracted much attention during past two decades because of their useful catalytic, electronic and magnetic properties (Deng, X.Y., and Chen, Z(2004)).

Nickel oxide micro/nanoparticles can be used in many applications including catalysts, gas sensor, magnetic materials, anode of organic light-emitting diodes and semiconducting materials and so on. Moreover, nanocrystalline NiO powder shows superpara-magnetism effect. Therefore nanocrystalline NiO can be used for drug delivery and magnetic resonance imaging (MRI) agent (Muhammad Imran Din and Aneela Rani (2016), M. Mohammadijoo et al., (2014)).

Therefore, several methods such as thermal decomposition, micro-emulsion, co-precipitation, chemical vapor deposition (CVD), sol-gel, hydrothermal, and microwave assisted synthesis, etc been used to synthesize nickel oxide have micro/nanostructures. Among various methods, coprecipitation method is becoming more popular since they can yield high products and simple direct process for the synthesis (Zahra Monsef Khoshhesab et al, 2010).

Therefore, in this research, NiO sample was prepared via simple co-precipitation method and the obtained sample was characterized by XRD, FTIR and SEM.

2. THEORETICAL BACKGROUND

2.1 Nickel

Nickel, a transition element, is a group 10 element. Under a standard condition it is a hard, silverywhite metal with a similar hardness and strength to iron, but more ductile. The chemical symbol for nickel is Ni, its atomic number is 28 and atomic mass is 58.71. The melting and boiling points of Ni are 1455 °C and 2900 °C (Blainey, G., et. al. (2003).

2.2 Nickel oxide (NiO)

Nickel oxide (NiO), a II-VI composite, is made up of nickel (group II) and oxygen (group VI) from the periodic table (R. Palombari (2003). The bulk NiO crystal is usually a solid with a face centred cubic structure with the space group Fm3m, and a lattice parameter of a = 4.177°A. The cubic structure of NiO is shown in Figure 1 (Bahl, C. R. H. (2006)). Nickel oxide (NiO) is a p-type semiconductor transition metal oxide, which includes direct band gaps of 3.5–3.8 eV (Manal Hashem et al., (2016)).



Fig 1The structure of NiO (Bahl, C. R. H. (2006))

2.2 Co-Precipitation Method

Co-precipitation method has achieved great attention due to simplicity and low-cost. Generally, chloride, nitrate, or acetate groups are used as precursors and distilled water, deionized water, or ethanol are used as solvent. A precursor dissolves in a solvent to form a solution and with constant stirring, a precipitating agent such as sodium hydroxide or ammonium hydroxide is slowly added dropwise to cause the precipitation. The

precipitate is washed several times with one of the solvents to remove any water-soluble impurities. The precipitate is then dried in a hot air oven and then calcined in a furnace to obtain the desired micro/nanomaterials (Govind B.Nair et al., (2018)).

3. EXPERIMENT

3.1 Preparation Nickel Oxide (NiO)

Nickel chloride (NiCl₂) and sodium hydroxide (NaOH) and ethylene glycol (CH₂OH)₂ were used as raw materials. All chemical were used without any further purification.

First, the calculated amount of NiCl₂ and NaOH were weighted. After that, 3 ml of ethylene glycol and 4.35 g of NiCl₂ were mixed with 30 ml of deionized water and stirred for 5 minutes at room temperature. The measured pH value of Ni solution was 5. And then 2.5 g of NaOH was mixed with 20 ml of deionized water and stirred for 5 minutes at room temperature. The pH value of NaOH was 11.

Second, NaOH solution was drop-wisely added into the Ni solution and the mixture solution was stirring for 30 minutes at 100 °C and the green precipitate was obtained. The pH value of the mixture solution was 8. Then, the green precipitate was washed five times with ethanol to obtain pH 7. The green filtered sample was dried in an oven at 100 °C for 6 hours. Finally, the dried sample was calcined at 350 °C for 2 hours to obtain NiO sample. Figure 2 and Figure 3 show the flow chart and photographs of the preparation of NiO sample. The reactions are expressed in equations 1 and 2.

$$NiCl_2.6H_2O+2NaOH \longrightarrow Ni(OH)_2 + 2NaCl$$
 (1)

$$Ni(OH)_2 \longrightarrow NiO + H_2O$$
 (2)

3.2 Characterization

The phase purity, crystal structure and morphology of the prepared sample was characterized by X-ray powder diffraction (XRD), Fourier transform infrared spectroscopy (FTIR) and scanning electron microscopy (SEM). The crystallite sizes were calculated by using Debye-Scherrer's equation ($D = k\lambda/\beta \cos\theta$), where k=0.9 is the Scherrer constant, λ is the wavelength of X-ray diffraction, β is the FWHM of the corresponding plane and θ is the angle.



Fig 2 Flow chart of the preparation of NiO sample





4. ANALYSIS

4.1. XRD analysis

X-ray diffraction (XRD) analysis, the most useful technique for phase identification, was conducted to study the phase purity and crystal structure of the prepared sample. Figure 4 shows the XRD pattern of the prepared NiO sample. The observed diffraction peaks have been indexed at 2θ value of 37.25° , 43.31° and

62.86° corresponding to the reflection from (101), (012) and (110) planes for the crystalline simple cubic structure of NiO.

The XRD pattern was matched with the standard NiO cubic crystal structure (JCPDS- card No.44-1159). The result indicated that $Ni(OH)_2$ was completely decomposed to NiO at the calcination temperature of 350 °C for 2 hours. The broad diffraction peaks implied that the prepared NiO was nanocrystalline sample. As listed in Table 1, the crystallite sizes of NiO sample calculated from Scherrer's equation were consistent with the XRD pattern.



Fig 4 XRD pattern of prepared NiO sample

. 11. .

Table 1 Crystainte sizes of prepared NiO sample				
Plane	EWHM	20	Crystallite	
(hkl)	I' VV IIIVI	(degree)	size (nm)	
(101)	0.619	37.25	13.55	
(012)	0.636	43.31	13.44	
(110)	0.643	62.86	10.47	

4.2 FTIR Analysis

The FTIR spectrum of prepared NiO sample is shown in Figure 5. The spectrum was taken by FTIR 8400, SHIMADZU infrared spectrometer in the range of 4000 - 400 cm⁻¹ at room temperature. The broad absorption band at 424.35 cm⁻¹ showed the Ni-O stretching vibration. The broad band at 3435.34 cm⁻¹ was assigned to the O-H stretching vibration. The bands between 1321.28 cm⁻¹ and 1134.18 cm⁻¹ were assigned to the bending vibration of C-O. The FTIR bands observed in NiO sample are summarized in Table 2.



Fig 5 FTIR spectrum of prepared NiO sample

n Vol. 1, Issue:2 Table 2 FTIR bands observed in NiO sample

Functional modes	FTIR bands (cm ⁻¹)
Stretching vibration of Ni-O	424.35
Stretching vibration of O-H	3435.34
Bending vibration of C-O	1321.28-1134.18
NiO stretching mode	424.35

4.3 SEM Analysis

The morphology of the prepared NiO sample was investigated by field emission scanning electron microscopy (JSM - 5610) with 15 kV. The SEM image of NiO sample is shown in Figure 6. The irregular shaped micro-plates were observed in the SEM image. The formation of micro-plates was attributed to the agglomeration of NiO nano-particles. This result showed that the prepared NiO sample could be used in various applications including catalyst, adsorbent, drug delivery and magnetic resonance imaging (MRI) agent etc.



Fig 6 SEM image of prepared NiO sample

5. CONCLUSIONS

By using simple co-precipitation method, NiO sample was prepared. The XRD result showed the formation of NiO with cubic structure. The FTIR result confirmed the XRD results. The SEM image expressed the prepared NiO sample was micro-plates which were formed the agglomeration of nanoparticles. Further works are needed to study the magnetic, catalytic and adsorption properties of the prepared NiO sample.

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STUDY ON THE POLLUTION STATE OF HEAVY METALS IN AGRICULTURAL SOILS IN TAUNGTHAMAN LAKE

Me Me Nyunt⁽¹⁾, Chann Myae⁽²⁾, Lei Mon Aung⁽³⁾ ⁽¹⁾Department of Physics, Yadanabon University, Myanmar ⁽²⁾Department of Physics, Yadanabaon University, Myanmar ⁽³⁾Department of Physics, Kyaukse University, Myanmar

Email: memeamarapura@gmail.com

ABSTRACT: Soil is the most important natural source after water and it is also the basic for food production. They are essential for life. So, it is necessary to check the contamination of soil because it can accumulate the living and nonliving organisms falling upon it. In this research, four soils samples were collected. The analyzed three samples were agricultural soils in Taungthaman Lake and the rest used as unpolluted background was far from Taungthaman Lake. The elemental concentrations of samples were checked by energy dispersive x-ray fluorescence (EDXRF) method and compared with maximum permissible level recommended by world health organization (WHO). Then the indices for soils such as single pollution index, pollution load index and heavy metal potential ecological risk index were calculated for potassium (K), manganese (Mn), iron (Fe), zinc (Zn) and lead (Pb). According to their criteria, the pollution state of agricultural soils in Taungthaman Lake is in slight pollution.

KEYWORDS : agricultural soils, contamination, indices, criterions, pollution

1. INTRODUCTION

Soil is one of the important parts receiving a significant amount of pollutants from different sources every year. Generally soil not only supplies as sink for the chemical pollutants but also acts as a natural buffer by controlling the transport of chemical elements and substances to the environment. Heavy metals are found everywhere in both polluted and unpolluted soil lavers of many ecological systems on the earth. Although these heavy metals cannot be destroyed, they are accumulated in soil and water. Heavy metals in soils may either be found naturally or generated from anthropogenic activities from transportation, waste products from industries and construction (Naveedullah, et al. (2013)).. Since the heavy metals can build up in the soil and they can be accumulated in crops, the contamination of agricultural soil by toxic elements such as heavy metals attracts the interest of people. They can cause significant potential risk to human health. Due to rapid industrialization in developing countries, excessive application of metals and synthetic chemicals in the terrestrial environment coupled with deficient environmental management have led to a large scale pollution in the environment. Soils contaminated by heavy metals from agricultural activities have raised serious concern in recent decades regarding potential risk

human health through the direct intake, to bioaccumulation through food chain, and their impacts on ecological system (Naveedullah, et al. (2013)). In the present research work, four surface soil samples were collected. Three agricultural surface soil samples were collected in Taungthaman Lake. And then, one soil sample used for unpolluted background material was collected far from the lake. An investigation was carried out to determine the pollution of heavy metals in soil samples. In this study, energy dispersive X-ray fluorescence (EDXRF) spectrometry as a veritable multi element analytical tool was applied for metals present in the soil. The main objectives of the current study was to determine the distribution of heavy metals and to evaluate the contamination status of metals. For this purposes, the applied different metal assessment indices are single pollution index, pollution load index for potassium (K), manganese (Mn), iron (Fe), zinc (Zn) and lead (Pb), heavy metal potential ecological risk index for manganese (Mn), zinc (Zn) and lead (Pb).

2. THEORETICAL BACKGROUND

Several indices namely single pollution index (SPI), the pollution load index (PLI), the heavy-metal potential ecological risk index (RI) were used to assess the metal contamination levels in the soil samples.

2.1 Single Pollution Index

The assessment of the soil contamination was also carried out using the single pollution index (SPI). The contamination factor was calculated using the relation described by Hakanson (1980).

$$SPI = C_n / C_b \tag{1}$$

Where C_n is the concentration of metals in the industrial soil and C_b is the pre-industrial background concentration of individual metal. Five categories of pollution index were defined by Hakanson (1980) as follow (A. M. Thabet, et al. (2014)). SPI<1.0 Safety

$1.0 < SPI \le 2.0$	Slight pollution
2.0 <spi td="" ≤3.0<=""><td>Mild pollution</td></spi>	Mild pollution
$3.0 < SPI \le 5.0$	Moderate pollution
SPI > 5.0	Severe pollution

2.2 Pollution Load Index

For the extent study on metal pollution, each sample was analysed by employing the method based on

Technological University Lashio Journal of Research & Innovationthe pollution load index (PLI) developed by Tomlinson,36et al. (1980) as follow:DI

$$\mathbf{PLI} = \left(\mathbf{SPI}_1 \times \mathbf{SPI}_2 \times \mathbf{SPI}_3 \times \dots \mathbf{SPI}_n\right)^{1/n} \qquad (2)$$

Where n is the number of metals studied in a sample and SPI is the single pollution index as mentioned above. The PLI provides simple but comparative means for assessing a site quality, where a value of PLI<0 denotes perfection; PLI = 1 denotes that only baseline levels of pollutants are present and PLI > 1 would indicate deterioration of site quality (A. M. Thabet, et al. (2014)).

2.3 Heavy-Metal Potential Ecological Risk Index:

The potential ecological risk index method developed by Hakanson was applied in this study. The main function of the potential ecological risk coefficient (\mathbf{E}_r^i) of a single element is to indicate the contamination agents and where the contamination studies should be prioritized. The potential ecological risk index (RI) of multi-element was introduced to assess the degree of heavy metal pollution in sediments and soils. According to this method, \mathbf{E}_r^i and RI can be computed via the following equations:

$$\mathbf{E}_{\mathrm{r}}^{\mathrm{i}} = \mathbf{T}_{\mathrm{f}}^{\mathrm{i}} \times \mathbf{C}_{\mathrm{f}}^{\mathrm{i}} \tag{3}$$

$$C_{\rm f}^{\rm i} = \frac{C_{\rm m}^{\rm i}}{C_{\rm n}^{\rm i}} \tag{4}$$

$$\mathbf{RI} = \sum_{i=1}^{n} \mathbf{E}_{r}^{i} \tag{5}$$

whereas C_f^i is the accumulating coefficient or contamination factor of element i, T_f^i is the toxicresponse factor of element i, C_m^i is the value of heavy metal concentration in the soil samples and C_n^i is the preindustrial back ground values in soil. The toxic-response factors T_f^i for common heavy metals Mn, Zn and Pb are 1, 1 and 5, respectively. The limitations of potential ecological risk coefficient and index are classified as follow (N. Theoneste, et al. (2013)).

$E_r^i < 40$	Slight pollution
$40 < E_r^i < 80$	Moderate pollution
$80 < E_r^i < 160$	Strong pollution
$160 < E_r^i < 320$	Very strong pollution
$E_r^i > 320$	Highly strong pollution
RI<90	Slight pollution
90 <ri<180< td=""><td>Moderate pollution</td></ri<180<>	Moderate pollution
180 <ri<360< td=""><td>Strong pollution</td></ri<360<>	Strong pollution

360<RI<720</th>Very strong pollutionRI>720Highly strong pollution

3. EXPERIMENT

3.1 Samples Collection and Sample Preparation for EDXRF Measurement

For this research work, one surface agricultural soil samples, S-1 was collected in the field near the drain, S-2 sample was from the field at northeast part of Taungthaman lake, S-3 sample was collected from the agricultural field beside U Pain bridge and the last one S-4 was near Kyauktawgyi pagoda. The drain is located in the east of Taungthaman Lake in Amarapura which is one of the township of Mandalay district in Mandalay regional division, Myanmar. The vegetable plants are grown at the base of the drain. To grow the plants, the farmers use the water in drain. The water in the drain is mixed with rainwater, water from the river and the waste water from industries. The photograph of sampling area was shown in Fig. 1.

After collecting, four agricultural soil samples were dried under the room temperature until the constant weight had been obtained. And then, the samples were ground to get powder type. After grinding, these powder samples were passed with the mesh to get very fine powder. Sample preparation is an important role in x-ray fluorescence XRF measurement. Prepared samples must be homogenized. Then the powder samples were obtained to analyze the composition of heavy metals by XRF method without any chemical pre-treatment.



Fig. 1 Photograph of sample collected area



Fig 2 Steps of sample preparation (i) raw condition and (ii) dried and powdered condition

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In this research work, the Rigaku spectrometer was used for analysis of the elemental concentration in agricultural soil samples. The relative concentrations of analysed heavy metal such as K, Mn, Fe, Zn and Pb obtained from this research work was shown in Table 1. But the toxic elements such as As, Cd, Hg in four soil samples were not detected. The regional variations of relative concentration of heavy metals were compared with maximum permissible level (MPL) of these heavy metals recommended by world health organization (WHO) and food and agriculture organization (FAO) of the united nations (1992). The comparison graph was shown in Fig. 3.

Iron concentration of all soil samples are greater than the maximum permissible level of Fe which is 5%. The concentrations of Mn and Pb are less than their respective maximum permissible levels which are 0.2% and 0.01%, respectively. The observed zinc (Zn) levels in S2, S3 and S4 samples were less than the maximum permissible level (0.03%) but S1 sample was a bit greater than the maximum permissible level.

				0	
Elemen	Н	eavy Meta	l Concentr	ation (%)	
ts	S1	S2	\$3	S4	MP L
К	0.922	1.3	1.47	1.12	NA
Mn	0.080	0.063	0.055	0.060	0.2
Fe	73.8	32.9	18.4	32.1	5
Zn	0.033	0.008	0.005	0.022	0.03
Pb	ND	0.006	0.005	0.005	0.01

Table 1. Heavy metal concentration in agricultural soils

MPL = maximum permissible level recommended by WHO/FAO (1992), ND = not detected, NA = not available





4. RESULTS AND DISCUSSION 4.1 Single Pollution Index

To estimate the pollution degree of soil; the single pollution index (SPI) values were calculated by using equation (1) and the results were presented in Table 2. Average SPI values for heavy metals have an descending order as Fe>K>Mn>Zn>Pb. Since the values of the pollution degree for heavy metals (such as Zn, Pb) were less than 1, it is indicated that the study areas were safety according to the average single pollution factors. Since the average SPI values for Fe, K and Mn were between 1 and 2, the soils were slightly polluted due to these heavy metals. The SPI values of four soil samples were illustrated in Fig. 4.

Table 2. Single pollution index values
--

Elements	Single po	ollution inde	x values	Mean	
	S1	S2	S 3	value	
К	0.823	1.161	1.313	1.099	
Mn	1.333	1.052	0.907	1.097	
Fe	2.299	1.025	0.573	1.299	
Zn	1.487	0.371	0.205	0.688	
Pb	ND	1.034	0.915	0.649	



Fig 4. Single pollution index values for agricultural soil samples

4.2 Pollution load Index

Pollution severity and its variation in Taungthaman Lake areas was determined with the use of pollution load index (PLI). This index is a quick tool to compare the pollution status of different places. Table 3 shows the values of pollution load index (PLI). Although the average value of pollution load index (PLI) was less 1, it is very near to 1 and it is indicating that the studied agricultural soils were near to the base line level of pollution.

ruble 5. ronulion foud mater values					
Sample Names	S 1	S 2	S 3	Mean Value	
PLI	1.320	0.864	0.663	0.949	
PLI > 1, deterioration of site quality					

Table 3. Pollution load index values



Fig. 5 Pollution load index values for agricultural soil samples

4.3 Potential Ecological Risk Index

Potential ecological risk index of Mn, Zn and Pb in agricultural soils in Taungthaman Lake were calculated by using equations (3), (4) and (5) and the results were listed as in Table 4. Since the potential ecological risk coefficients of Mn, Zn and Pb in three positions were lower than 40, it is indicated that the analysed soils were slight pollution. The average potential ecological risk index (RI) of three positions was 5.033. Since this value is less than 90, the contamination status is slight pollution. The potential ecological risk index values for three agricultural soil samples was shown in Fig. 6.

Table 4. Potential ecological risk coefficient and potential ecological risk index of heavy metals

potential ecological fisk maex of heavy metals					
Sample Names	Potential ecological risk coefficient for single heavy metal (E ⁱ _r)			Potential ecological risk index	
	Mn	Zn	Pb	(RI)	
S 1	1.333	1.487	ND	2.820	
S 2	1.052	0.371	5.169	6.592	
S 3	0.907	0.205	4.576	5.688	



Fig: 6. Potential toxicity response indices of heavy metals

5. CONCLUSION

Three agricultural soil samples collected from Taungthaman Lake and one unpolluted soil sample were analysed for K, Fe, Mn, Zn and Pb. The contamination of soil samples were checked by using pollution indexes for soil. The results of single pollution index, pollution load index and heavy metal potential ecological risk index were expressed in Table 2, 3 and 4 respectively. To compare these results significantly with the corresponding criteria, the graphs as shown in Fig. 4, 5 and 6 were depicted for single pollution index, pollution load index and heavy metal ecological risk index, respectively.

According to the comparisons, the agricultural soils are in slight pollution. This may be due to long term rainwater storage in Lake and due to the waste water from the industrial zone to the drain and then to the Lake because water in the Lake was used to grow the plants. Another reason may be due to the usage of fertilizer in cultivating the plants. Due to the intensive and prolong cultivation in the region, the heavy metals were enriched in agricultural soil and could migrate to the food chain. Moreover, this pollution can affect the inhalation to the area. Therefore, further research has to be carried out to determine the risk of heavy metals in this environment.

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Synthesis of Beta-Tricalcium Phosphate Bio-Ceramics by Using Sodium Hydroxide Base

Seinn Nwe Aung⁽¹⁾, Aye Aye Thant⁽²⁾, Nwe Ni Hlaing⁽³⁾, Than Htike Win⁽⁴⁾

⁽¹⁾ University of Yangon, Myanmar ⁽²⁾ University of Yangon, Myanmar

⁽³⁾ Pinlon University, Myanmar

⁽⁴⁾ Taunggyi University, Myanmar

Email: sanenwe7@gmail.com

ABSTRACT: Beta-tricalcium phosphate bio-ceramics is used for the repair and regeneration of bone tissues. In this work, the beta-tricalcium phosphate bio-ceramics powders have been synthesized by microwave-assisted co-precipitation method. The calcium nitrate tetrahydrate Ca(NO₃)₂.4H₂O and diammonium hydrogen phosphate (NH₄)₂HPO₄ were used as calcium and phosphorus sources. The pH of the system was maintained up to (pH = 9) by adding of sodium hydroxide base. The synthetic samples have been characterized by using X-Ray Diffractrometry (XRD), Fourier Transform-Infrared Spectroscopy(FT-IR) and Scanning Electron Microscopy (SEM). XRD and FT-IR results show that crystallized hydroxyapatite phase and biphasic calcium phosphate (86% of beta tricalcium phosphate & 14% of hydroxyapatite) has been obtained at calcination temperature of 950 °C. A single phase beta-tricalcium phosphate (β -TCP) ceramics powders has been obtained at calcined temperature of 1100° C. The Scanning Electron Microscopy (SEM) micrograph shows the formation of agglomeration of small particles could be obtained at room temperature. The homogenous microstructures and interconnected micropores could be obtained at calcined temperature of 950° C and 1100° C respectively.

KEYWORDS: *beta-tricalcium phosphate, XRD, FTIR and SEM*

1. INTRODUCTION

Calcium phosphate plays an important role in biomedical materials due to its excellent biological activity and biocompatibility. osteoconductivity. Synthetic calcium phosphate-based bioceramics are chemically similar to the natural bone component and teeth (Silva and F.R.O, (2015). Nowadays, different types of biomaterials were used, such as, natural or synthetic polymers, ceramics, metals, composites and hydrogels. Among various calcium phosphate ceramics; hydroxyapatite (HAP, $Ca_{10}(PO_4)_6(OH)_2$) and beta-tricalcium phosphate (B-TCP ($Ca_3(PO_4)_2$) are getting more concentration due to their biocompatibility and bioactivity. Moreover, their compositions are chemically similar to the natural bone component and teeth. Both HAP and β - TCP are extensively used as bone substitute. HAP gets more important for its use as bioactive and non-biodegradable bone replacement material along with excellent mechanical properties (Asmae Massit et al, (2014). However, the biodegradability of HAP in the human

body is too poor in its limited amount. When comparing with HAP and β -TCP, β -TCP has good biodegradability and higher dissolution rate in the body environment after implantation, which is absorbed and replaced by new bone. The purified β -TCP was useful in filling of defects after bone tumors. It is safe, non-toxic and biocompatible (Santezi, C.; Tanomaru. (2016). In this study, betatricalcium phosphate ceramics were synthesized by microwave-assisted co-precipitation method at calcined temperature 1100°C respectively.

2. THEORETICAL BACKGROUND 2.1 Bioceramics

Bioceramics are a class of materials that is used for repairing or replacing damaged bone tissues. Depending on the application, bioceramics can directly interact with the surrounding tissue, either supporting tissue growth or inducing new tissue regeneration for bioactive ceramics. Bioceramics are used in powder form to fill defect spaces while the natural repair processes restore function and are used as a coating on a substrate and biological activities, such as osteoinduction or osseointegration.

2.2 Crystallite Size

The crystallite size can be estimated using the Scherer's equation:

$$D = \frac{0.9\lambda}{B\cos\theta}$$

Where, B = full width at the half maximum (radian) λ is the wavelength (Å), θ is diffraction angle

2.3 Reference Intensity Ratio (RIR) Value and Weight Percentage

Reference Intensity Ratio (RIR) value and weight percentage of constituent of the sample has been calculated by using following formula (I Y.J. Zhu, F. (2014).

$$\begin{split} RIR_{HAP} &= I_{HAP} / (I_{HAP} + I_{\beta\text{-TCP}}) \\ RIR_{\beta\text{-TCP}} &= I_{\beta\text{-TCP}} / (I_{\beta\text{-TCP}} + I_{HAP}) \\ Weight \% &= (RIR \times 100) \% \end{split}$$

I _{HAP} = maximum intensity of HAP phase I _{β -TCP} = = maximum intensity of β -TCP phase

3. EXPERIMENT

3.1 Experiment apparatus

In this study, calcium nitrate tetrahydrate $Ca(NO_3)_2.4H_2O$, ammonium hydrogen phosphate $((NH_4)_2HPO_4)$ were used as calcium and phosphorus sources and sodium hydroxide has been used for pH

regulation. Distilled water (H_2O) was used as solvent. The Ca:P molar ratio of synthesized sample was 1.67.

3.2 Method

There are various methods of CaP synthesis such as precipitation technique, sol-gel approach, hydrothermal technique, multiple emulsion technique, biomimetic deposition technique, electrode position technique, etc. Each employs various process parameters. In this research, microwave-assisted co-precipitation method has been used to provide enhanced reaction rate and improved product field in chemical synthesis (Karlsruhe, (2018). Preparation of beta-tricalcium phosphate bioceramics powder has been showed in figure (1).



Figure 1 Flow chart of the preparation of beta-tricalcium phosphate

3.3 Data

Table 1. The Value of Crystallite Size and Lattice
Parameter of Hydroxyapatite (before
Calcination, Biphasic Calcium Phosphate
(calcined at 950°C) and Beta-tricalcium
Phosphate calcined at 1100°C.

The theoretical results of lattice parameters a and c have been matched with practical results. It is worth to note that the crystallite size is increased with increasing temperature.

Table 2The FT-IR Transmission Bands of
Hydroxyapatite before Calcination,
Biphasic Calcium Phosphate calcined at

950°C and Beta-tricalcium Phosphate calcined at 1100°C

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Sample		As- Synthesized	950°C	1100°C
Phase		hydroxy- apatite	Biphasic	beta- tricalcium phosphate
Crystallite size (nm)		20.30	49.65 (HAP) 43.53 (β-TCP)	56.06
Lattice parmeter. 'a' "Å"	theoretical result	9.21	10.32 (HAP) 10.39 (β-TCP)	10.46
	practical results	9.26	10.40 (HAP) 10.40 (β-TCP)	10.42
Lattice parmeter. 'c''Å"	theoretical result	6.85	37.21 (HAP) 37.07 (β-TCP)	37.28
	practical results	6.81	37.28 (HAP) 37.28 (β-TCP)	37.34

Chamiaal	Vibuational	number (ci	umber (cm ⁻¹)	
Group	Mode	before calcination	950 °C	1100 °C
			493.83	
	v1 symmetric (P-O)	962.45	542.62	942.62
			589.42	967.59
	stretening		944.38	999.89
			970.56	
	v 2			414.72
PO4 ³⁻	(O-P-O)	431.10	436.81	447.72
	bending			493.72
	v3 asymmetric		1015.98	
	(P-O)	1026.30	1099.50	-
	stretching		1115.64	
	V4	560.97	603.98	539.30
	(O-P-O) bending	691.40		603.48
OH-	Hydroxyl	3571.00	-	
CO2-	Bending	868.05		1398.92
0.032			-	1554.71
(0.0.)	D 1 14		723.70	724.58
$(P_2O_7)^{2-2}$	Pyrophosphate	-	1210.20	1210.79
CO ₂ -	Stretching	-		2367.91
HCO.	Stratahing			2879.60
HCO3	Stretening	-		3057.06

4. ANALYSIS

The synthetic samples have been characterized by X-ray Diffractrometry (XRD), Fourier Transform-Infrared Spectroscopy (FTIR) and Scanning Electron Microscopy (SEM).

XRD analysis of Precipitated Hydroxyapatite before Calcination

The XRD pattern of calcium phosphate sample by using sodium hydroxide has been shown in Figure 2. Figure 2 (a) shows the XRD pattern of of hydroxyapatite powders before calcination. The hydroxyapatite hexagonal, space group of P63/m (ICDD-00-009-0432) has been observed as a major phase. The sharp intensity peak at 26.45° indicated that hydroxyapatite phase could be attained by simple precipitation method at room temperature.

XRD Analysis of Biphasic Calcium Phosphate (HAP & β-TCP Powders) and Beta-tricalcium Phosphate Powders at Different Temperature

The precipitated HAP powders have been calcined at different temperature. Figure 2 (b) shows the XRD pattern of of synthesized biphasic calcium phosphate powder calcined at 950°C. The formation of crystalline beta tricalcium phosphate (Ca₃(PO₄)₂) was observed as major phase. The peaks appeared at around 13.75°, 14.30°, 20.34°, 21.95°, 29.75°, 31.14°, 35.26°, 35.69°, 37.96° and 47.08° were matched well with the crystal plane of beta tricalcium phosphate (Ca₃(PO₄)₂) with a Hexagonal structure (ICDD-00-009-0432). In addition, hydroxyapatite (Ca₅(PO₄)₃ OH) phase was found as minor phase. The reflection from (210) plane at 2 θ value of around 29.35° represents the hydroxyapatite phase. Biphasic calcium phosphate (66.7% of β -TCP with respect to 33.3% of HAP) phase has been attained.

Figure 2 (c) shows the XRD pattern of of synthesized beta-tricalcium phosphate powders by using sodium hydroxide calcined at 1100°C. The formation of beta-tricalcium phosphate has been found to be well matched with that of beta-tricalcium phosphate (trigonal(H), space group R-3c, hexagonal) reported in (ICDD-00-009-0432). The sharp intensity peak at 31.10°, reflection from (0210) plane indicated that well crystallized beta-tricalcium phosphate could be attained by microwave coprecipitation method involving calcination at temperature of 1100°C.



Figure 2 XRD Patterns of Calcium Phosphate samples (a) hydroxyapatite phase (before calcination), (b) biphasic calcium phosphate pahse phase (calcined at 950°C) and (c) beta-tricalcium phosphate phase (calcined at 1100°C)

FT-IR analysis

FTIR Analysis of Calcium Phosphate Powders at before calcination and calcined at 950°C and 1100 °C

The functional groups generally observed in the FT-IR spectra of calcium phosphate based materials are TULSOJRI September, 2020

 PO_4^{3-} , OH^- , CO_3^{2-} , P_2O_7 and HPO_4^{2-} groups in the range around 4000–400 cm⁻¹.

Figure 3 shows FTIR spectrum of hydorxyapatite (before calcination). The characteristic bands of phosphate groups have been appeared around 560–613 cm⁻¹ and 1100–1000 cm⁻¹. There are sharp and well-separated peaks at 431.1 cm⁻¹, 560.97 cm⁻¹, 601.49 cm⁻¹ and 1026 cm⁻¹ have been all attributed to the PO₄³⁻ group of hydroxyapatite. The peak 3571 cm⁻¹ has been attribute to OH- group and 861.80 cm⁻¹ has been attribute to CO₃²⁻

Figure 4 shows FTIR spectrum of biphasic calcium phosphate (calcined at 950 °C). The characteristic bands of phosphate groups appeared at 561–613 cm⁻¹, and v3 PO₄ band in the range of 1100–1000 cm⁻¹ in all the cases. The presence of bands at 1115.64 cm⁻¹ 1099.50 cm⁻¹ and 1015.98 cm⁻¹ can be assigned to PO₄ groups of β –TCP. In addition, at 723.70 cm⁻¹ shows the presence of P₂O₇⁴⁻ group.

Figure 5 shows beta-tricalcium phosphate powders after calcination (1100°C). The sharp and well-separated peaks at 539.30 cm⁻¹, 603.48 cm⁻¹,724.58 cm⁻¹, 1210.29 cm⁻¹ and 1554.71 cm⁻¹ have been assigned to characteristic peaks corresponding to beta-tricalcium phosphate (β - TCP). These all results are in good agreement with the X-ray diffraction analysis (Santezi, C.; Tanomaru, (2016).



Figure 3. FT-IR spectrum of hydroxyapatite



Figure 4 FT-IR spectrum of biphasic calcium phosphate powders (calcined at 950°C)

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Scanning Electron Microscopy (SEM) Analysis

(SEM) Analysis of Calcium Phosphate Powders before Calcination, Calcined at 950°C and 1100°C

Figure 6(a) shows the small irregular hydroxyapatite microparticles particles which were agglomerated.

Figure 6(b) shows the formation of biphasic microstructure particles and interconnected micropores. The particles size for the sample after calcination has been estimated by using imageJ software. It was found to be 0.75 μ m (HAP) and 0.57 μ m (beta-TCP) respectively calcined at 950°C.

Figure 6(c) shows the formation of beta-tricalcium phosphate microstructure particles and interconnected micropores. The particle size 2 μ m has been estimated calcined at 1100°C (Behzad Mehdikhania, and Gholam Hossein Borhani, 2015).









- Figure 6 SEM images of calcium phosphate powders (a) hydrxyapatite (before calcination)
 - (b) biphasic calcium phosphate (calcined at 950°C)
 - (c) beta- tricalcium phosphate (Calcined at 1100 °C)

4. CONCLUSIONS

The synthesis of single phase beta tricalcium phosphate (B-TCP) powders via microwave-assisted coprecipitation method has been reported at uncalcined, calcined temperature of 950° C and 1100 ° C. The formation of hydroxyapatite phase (before calcination), biphasic (hydroxyapapite & beta-tricalcium phosphate) (calcined at 950°C) and beta-tricalcium phosphate (calcined at 1100°C) have been identified by XRD and FT-IR analyses. The functional groups generally observed in the FT-IR spectra of calcium phosphatebased materials are in agreement with the X-ray diffraction analysis. Note worthily, Observation on morphology proved that the formation of irregular particles could be attained before calcination. The formation of biphasic microstructure particles (calcined at 950°C) and beta-tricalcium phosphate (calcined at 1100°C) respectively could be obtained which are interconnected micropores. The particle size is increased with increasing temperature. These results are in good agreement with the X-ray diffraction analysis.

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Determination of the Threshold Voltage and Transconductance Parameter of Thin Film MOSFETs

Thanda⁽¹⁾, **Moe Moe Swe**⁽²⁾, **Hmwe Hmwe Kyu**⁽³⁾ ⁽¹⁾⁽²⁾University of Computer Studies (Monywa), Myanmar ⁽³⁾West Yangon Technological University, Myanmar

than.da.da@gmail.com, moemoeswe007@gmail.com, hmwehmweq@gmail.com

ABSTRACT: Many methods have been reported to calculate the threshold voltage V_T of a MOSFET. Almost all of these methods extract the threshold voltage V_T from the measured drain current I_D versus the gate bias V_G. Only one method is available to calculate the threshold V_T in the saturation region, based on linearly extrapolating the squared root of the drain current I_D $\frac{1}{2}$ versus the gate voltage V_G plot at the inflexion point to the gate bias axis. For MOSFET modeling, simulation and characterization the threshold voltage and transconductance parameter are the important parameters. In this work, the first part is to fabricate MOSFET by using PZT layer with thermal evaporation method and SnO₂ layer with sol gel method. The drain currents are measured with various gate voltages. And then in the second part, the threshold voltage and transconductance parameter are extracted. They are investigated with three structures and compared the values.

KEYWORDS: *MOSFET, thermal evaporation, solgel method*, SnO_2 , SiO_2 , $Pb(Zr,Ti)O_3(PZT)$, threshold *voltage, tranconductance parameter*

1. INTRODUCTION

Device physics and fabrication technologies regarding to ferroelectric thin films have been received much attention for the past decade and now, many achievements realized the practical application of the ferroelectric thin films in a VLSI memory and sensor. Especially, metal ferroelectric semiconductor (MFS) structure seems to perform an attractive role in nonvolatile memory devices because it does not require a reset operation during read/write cycles. When a gate voltage is applied to this thin SiO₂, thin oxide turns a moderate gate voltage into a high electric field that causes severe stress and high interface trap charges in the SiO₂. By inserting an insulator such as MgO, CeO₂, ZrO₂ and SrTiO₃ can be prevented by the voltage shift of the MOSFET can be controlled by the high dielectric insulator. In this work, PZT thin film is used as an insulator. The electrical characteristics and the C-V characteristics of fabricated SnO₂/PZT/Si structure has been already presented. [1] [4][6]

Incessant abridging of IC technology, together with precision of V_{TH} control techniques and reduction in TULSOJRI Septem

SCE, is asserting the V_{TH} to very low values. For proper operation of MOSFET, we need to evaluate exact threshold voltage (V_{TH}). Perfectly appraised V_{TH} is required to provide proper gate control over device channel conduction. The tens of millivolts miscalculation cannot be neglected as it can prompt serious errors in circuit functionality. Especially for robust nano-scale design of analog circuits with high speed operation, precise valuation of V_{TH} is essential to illustrate the exact device behaviour. Device matching also depends on the estimated V_{TH} values. V_{TH} is frequently used for accessing and predicting device performance. It is also commonly used to check the inconsistency due to manufacturing process technological parameter fluctuations. Other applications of V_{TH} can be listed as to evaluate reliability factors such as radiation damage, hot carrier, stress, temperature instability, ageing degradation etc. The threshold voltage parameter is largely extracted directly from the transfer characteristics of the device. There is no critical point in the I_D-V_{GS} curve that can be recognized as threshold point due to sub-threshold leakage current. This creates vagueness in V_{TH} estimation. The weak inversion region shows exponential deviations while strong inversion shows linear/quadratic deviations. However, the V_{TH} is identified amid weak and strong inversion transition region . V_{TH} also depends on several device parameters (Gate width, Gate Overlap, Gate length, biased bulk, temperature etc.) and process technology limitations (Cox, tox, doping concentration (NA) etc.). This makes V_{TH} estimation more challenging. [2][3][5]

The MOSFET are fabricated using SnO₂/PZT/Si structure. Firstly the SiO₂/Si structure and PZT/Si structure are fabricated using thermal oxidation and sol gel method. And the threshold voltage and transconductance parameters are determined from the SiO₂/Si structure, PZT/Si structure and SnO₂/PZT/Si structure.

2. MEASUREMENT OF PARAMETERS

Transconductance is an expression of the performance of a bipolar transistor or field-effect transistor (FET). In general, the larger the transconductance figure for a device, the greater the gain(amplification) it is capable of delivering, when all other factors are held constant.

Formally, for a bipolar device, transconductance is defined as the ratio of the change in collector current to the change in base voltage over a defined, arbitrarily small interval on the collector-current-versus-basevoltage curve. For an FET, transconductance is the ratio of the change in drain current to the change in gate voltage over a defined, arbitrarily small interval on the drain-current-versus-gate-voltage curve. The symbol for transconductance is *kn*. [7] In this paper, some simple measurements for n-channel MOSFET will be described for the determination of these parameters. The source to substrate voltage V_{SD} is set at a constant value, and the drain current is measured for different values of the gate to source voltage V_{GS} . Since the drain and the gate of the transistor are at the same potential, $V_{DS} = V_{GS}$. The drain current is described by

It is ignored the channel length modulation effect for simplicity.

Now, the square root of the drain current can be written as a linear function of the gate to source voltage

$$\sqrt{I_D} = \sqrt{\frac{k_n}{2}} (V_{GS} - V_{TO})$$
 -----(2)

If the square root of the measured drain current values is plotted against the gate to source voltage, the slope and the voltage axis intercept of the resulting curves can determine the parameters k_n , and V_{TO} .[4] [5]

3. EXPERIMENTAL PROCEDURE

The orientation (100), p type and 10 Ω silicon wafer are used in this paper. To remove metallic impurities, they are cleaned with nitric acid and also treated with hydro fluoric acid to remove native oxide. It is immersed in distilled water for 10 min. For removing any organic impurities, they are cleaned in acetone and methyl alcohol for 5 min and dry. And then the Si substrate is placed in the furnace for about 1000°C to create thin layer of Silicon dioxide, SiO₂ layer by thermal oxidation. To create the windows, a wax coating is deposited on top of SiO₂ layer. Applying hydrofluoric acid solution and acetone the windows are opened, SiO₂/Si structure was formed. And then it is investigated the drain current gate voltage characteristic. Next, to deposit the PZT layer on the gate layer by thermal evaporation method, PZT powder is prepared. by mixture of metal oxides, namely lead oxide (PbO), zirconium oxide (ZrO₂) and titanium oxide (TiO₂) in proper ratios, the PZT power was made. These powders (in weight ratio) were calcining at 800°C for two hours. The distance between the source and the substrate is about 3cm. The calcined powder was evaporated onto the SiO₂ layer at 800 °C for two hours, PZT/SiO₂/Si substrate are formed and measured the drain current - gate voltage characteristic. Finally, precursor solution is prepared for Sol gel method. Tin oxide (SnO_2) is added with methoxyethanol $(C_3H_8O_2)$ at 80 °C in flask. The mixture is distilled at 126 °C to remove water. It is cool at 60 $^{\circ}$ C and reflux to homogenize. The precursor solution is formed. The substrate is cleaned and this mixture is deposited on substrate by spinning technique with 1000rpn and annealed at 500 $^{\circ}$ C for 30 min in the furnace. The step by step preparation of SnO_2 thin film is shown in figure 1.SnO₂/ PZT/ Si substrate are formed and examined the drain current vs gate voltage characteristic. The threshold voltage and transconductance parameter are extracted from the

squared root of drain current vs gate voltage characteristic curve.



Figure 1. Flow Chart for the SnO₂ Sol-gel Process

4. RESULTS AND DISCUSSION

Figure 2 depicts the drain current versus gate voltage characteristics of SiO₂/ Si structure measured in a temperature 800°C. The current value is very small when applied voltage. Figure 3 represents the drain current versus gate voltage characteristics of SiO₂/ Si structure measured in a temperature 800°C. The current value is increased compare to figure 1. The current value is nearly proportional to the voltage. Conduction of leakage current rapidly increased through the voltage ranged 3V to 10 V. The current linearly increasing with applied

voltage. Figure 4 depicts the drain current versus gate voltage characteristics of SiO₂/ Si structure measured in a temperature 800°C. From the figure it can be seen that when the applied voltage is small, the current shows nearly saturate. As the applied voltage increase, the current also increase. The current is nearly proportional to the voltage as in the figure 1 and 2. But the current is more increase than any other structres. Conduction of leakage current rapidly also increased through the voltage range of 3V to 10V. The curve has an ohmic conduction region in which the current linearly increasing with applied voltage. Figure 5 depicts measured data for experimental determination of the parameters V_{TO} , k_n for the SiO₂/ Si structure. The V_{TO} is extracted from the intercept of the $I_D^{1/2}$ versus V_{GS} linear fit. It is seen that the value of $V_{\text{TO}}\ is-9.88V$ and the value of k_n is 0.013 mA/V². Figure 6 represents measured data for experimental determination of the parameters V_{TO} , k_n for the PZT/ Si structure. It is seen that the value of V_{TO} is -1.7 V and the value of kn is 0.01 mA/V². Figure 7 depicts measured data for experimental determination of the parameters V_{TO} , k_n for the SnO₂/PZT/ Si structure. It is seen that the value of V_{TO} is – 2.5V and the value of k_{n} is 0.3 mA/V². From the figures it can be concluded that the square root of drain current can be seen as a linear function of the gate to source voltage. SnO₂/ PZT/Si structure has the largest transconductance parameter than the two other structures. Table 1 also shows the difference values of k_n and V_{TO} for various alternative gate dielectrics. All the value of threshold voltages of structures are negative. This means that the resulting structures will have a conducting channel at V_{GS}=0. It is enabling current flow between its source and drain terminals as long as V_{GS} is larger than the negative threshold voltage. Such a device is called a depletion-type (or normally 0 = on) n- channel MOSFET. SnO₂/PZT/Si has a highest threshold voltage than the other two structures.



Figure 2. Measured I-V Characteristics of SiO₂/Si Structure in a temperature range in800°C



Figure 3. . Measured I-V Characteristics of PZT/Si Structure in a temperature range in800°C



Figure 4 . Measured I-V Characteristics of $SnO_2/PZT/Si$ Structure in a temperature range in 800°C



Figure 5. $\sqrt{I_D} - V_{GS}$ Characteristics for SiO₂/Si Structure



Figure 6. $\sqrt{I_D} - V_{GS}$ Characteristics for PZT/Si Structure



Figure 7 $\sqrt{I_D} - V_{GS}$ Characteristics for SnO₂/PZT/ Si Structure

Table 1 The difference values of k_n and V_{TO} for various alternative gate dielectrics

Structure	$V_{TO}(V)$	k _n A/V ²)	(m
SiO ₂ /Si	-0.988	0.013	
PZT/Si	-1.7	0.1	
SnO ₂ /PZT/Si	-2.5	0.3	

5. CONCLUSIONS

The experimental results of this paper can be summarized that SiO2/ Si structure was fabricated by thermal oxidation. PZT/ Si was fabricated by depositing a PZT on a gate layer by thermal evaporation method and SnO₂/ PZT/Si structure was fabricated by depositing a SnO₂ on a gate layer by sol gel method. And their drain current- gate voltages were studied. The threshold voltage and transconductance parameter were experimentally examined by the squared root of drain current versus gate voltage graph. The results indicate

that the structure all the value of threshold voltage of n channel MOSFET is negative. It shows that the resulting structure will have a conducting channel at $V_{GS}=0$. It is enabling current flow between its source and drain terminals as long as V_{GS} is larger than the negative threshold voltage.[1] Such a device is called a depletiontype (or normally 0=on) n- channel MOSFET. SnO₂/PZT/Si has a lowest threshold voltage than the other two structures. On the basis of this research, it is difficult to do test these samples due to little facilities in our lab. So it is not good result but it is hoped that these experience will be effective when the research center is the best in our university.

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