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Study The Current Density-Voltage (J-V) Characteristics of α-Fe_2O_3 Thin Film Prepared by Spray Pyrolysis Technique

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ABSTRACT:

In this work was measured characteristics (current - voltage) for the (α--Fe_2O_3) thin films . The characteristics of the current density-voltage(J-V) were calculated at in both dark and light (100 mW/cm^2) conditions. The parameters for this research of the photovoltaic samples, that is, were obtained directly from the curves of the resulting characteristics on the basic variables for the solar cell: the short circuit current density (J_{sc}) , saturation current (J_o), open-circuit voltage (V_{oc}) , fill factor (FF), and efficiency of solar energy conversion (yield) η .

KEYWORDS: Fe_2O_3 , thin film , current density, fill factor, solar cell .

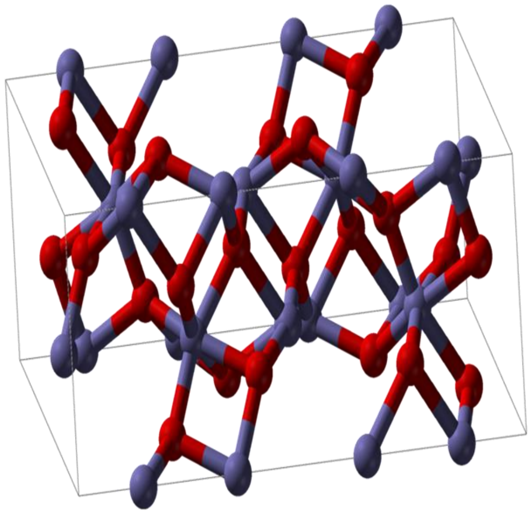
1. INTRODUCTION

The ferric oxide is one of the thermodynamic phases of iron and one of trivalent iron compounds, the Iron is considered as one of the most important transition elements oxides and the ferric oxide is considered most stable one among all of other iron oxides. The characterized of this material is of it has energy gap of (2.5eV) [1]. Today the use of semiconductor materials keeps a prominent place in basic and applied research , Iron oxide thin film (Fe_2O_3) among other oxides is considered it the most stable, is one of the most important oxides of transition elements that found in nature as hematite, [2]. that is characterized by good thermodynamic stability at high temperatures, abundance , low cost and non-toxicity .These characteristics make it wide use for various uses , such as electrochromism, , photo-oxidation of water, solar energy conversion photocatalysis , interference filters , gas sensitive material[3]. the hematite (Fe_2O_3) was chosen as a prototype because of its technological use as catalyst and a photocatalyst . Furthermore, it has found applications are getting increase due to its breakthrough having unexpectedly great thermopower and dielectric properties [4]. Solar cell is considered as a device which converts photons in solar rays to voltage and direct-current (DC), also which are part of the light group are described as being photovoltaic , the technology is named Solar Photovoltaic which symbolizes the abbreviation (SPV). Many different photovoltaic technologies have been developed for the purpose of converting solar energy more widely [2]. Solar filters can be designed with the highest optical quality by evaluating the appropriate parameters for the purpose of synthesizing thin films with iron oxide where the necessary information can be shown to future researchers in the field of dealing with iron oxides. [5].

2-Theoretical part

2-1 Iron(III) oxide

Ferric oxide or so-called Iron oxide (III) with the commonalty formula (Fe_2O_3) is considered the inorganic compound of many chemical compounds. It is considered one of the three main oxides type of iron that exists in nature, as for what the other two being iron(II,III) oxide (Fe_3O_4), which also occurs naturally as the mineral magnetite. As the mineral known as (hematite), and iron(II) oxide (FeO) , which is rare; the main source of iron for the steel industry is Iron(III) oxide . which is readily attacked by acids. Iron(III) oxide is frequently named rust, and This designation is somewhat acceptable, Because this similar composition and its many characteristics are found in rust. Rust is a substance that is not defined as described and is known to a chemist by the name or term of ferric oxide , figure(1) [6].



Figure(1). Iron(III) oxide [6]

2-2 Solar Cell Variables

The solar cell operates in the fourth quarter of the graph , where energy can be extracted from the cell and thus this quarter is the important part of the distinctive curve . It is therefore generally accepted in most references scientific that this part of the graph line is drawn so inversely on the axis of voltage as shown in figure (2) [7].

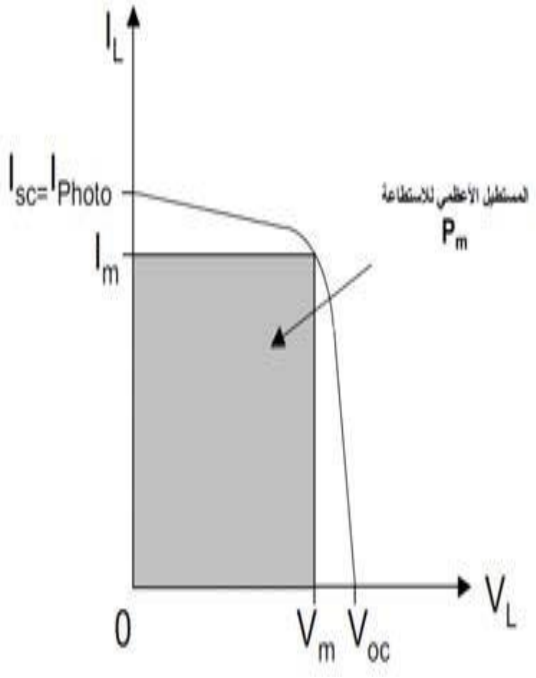


Figure (2): Characteristic and variables of the solar cell in the first quarter [7]

From figure (2) four variables are typically used to study what comes out of a solar cell , these variables are:

1 -Short - circuit current- I_{sc} : The output current is equal to the light mediation at the difference , its value is zero, which is obtained at the palace $I_{sc} = I_{ph}$

2 -open circuit voltage - V_{oc} : we get it when a current does not pass through the cell, ie by making the current zero , where I = J A , A = Cell surface [8].

$$V_{oc} = \frac{kT}{q}\ln\left(\frac{I_{ph}}{I_o}+1\right) \quad \text{………..(1)}$$

$$P_m = I_{mp} \times V_{mp} \quad \text{………….…….(2)}$$

3- Fill factor FF : Its value for cells with acceptable efficiency between (0.7-0.85)

$$FF = \frac{I_{mp} . V_{mp}}{I_{sc} . V_{oc}} \quad \text{……………..(3)}$$

4- Efficient solar energy conversion η: It can be expressed by the following relationship[7]:

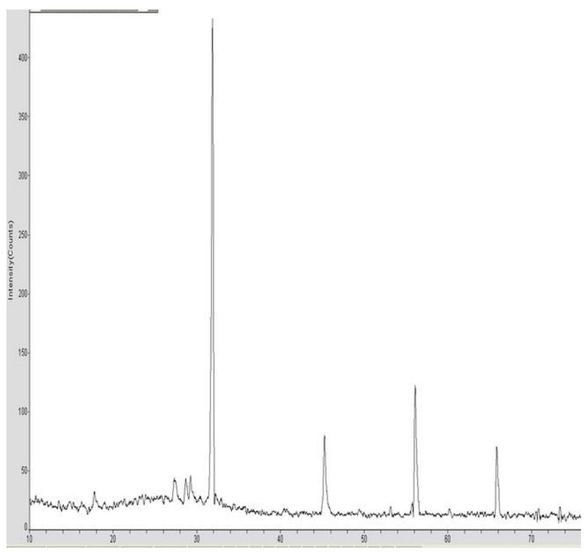
$$\eta = \frac{I_{mp} . V_{mp}}{P_{in}} = \frac{V_{oc} . I_{sc} . FF}{P_{in}} \quad \text{…..(4)}$$

Where P_{in} is the total power of light on the cell.

3-practical part

3-1 Structural Measurements

By using x-ray diffraction, at room temperature the crystallization of the membrane was determined. as shown in figure (3) , that shows the X-ray diffraction patterns of α-Fe_2O_3 thin film sharp peaks at 2θ equal to 24.35^o , $32.14\ ^0$, $45.03\ ^o$, 54.14^o referred to (012),(104), (113) and(116) direction respectively . Also, this figure confirms that the preferential orientation is in the (104) direction. After procedure the structural tests of the membrane, it was shown that the membrane had a polycrystalline structure . this agrees with [9 ,10 ,11].



Figure(3). XRD pattern of sample.

The infrared spectrum which symbolizes it by (FTIR) of the produced Fe_2O_3 was in the range of wavenumber (500-4000) cm^{-1} explained in figure (3), which the functional groups in addition to chemical bonds in the compound. The (FTIR) spectra of Fe_2O_3 sample show in figures (4). In figure (4) around it observe the appearance of a weak broad band (592.15) cm^{-1} because of Fe-O vibration , see appears a broad band at (1176.58) cm^{-1} because of bending vibration of C-O , around it we see or observe the appearance of a weak broad band (1562.34) cm^{-1} also because of bending vibration of H-O-H and We also see a wide band at (3134.33) cm^{-1} as a result of the stretching vibration of O-H . These results and forms are all consistent with the findings of researchers by [7] .

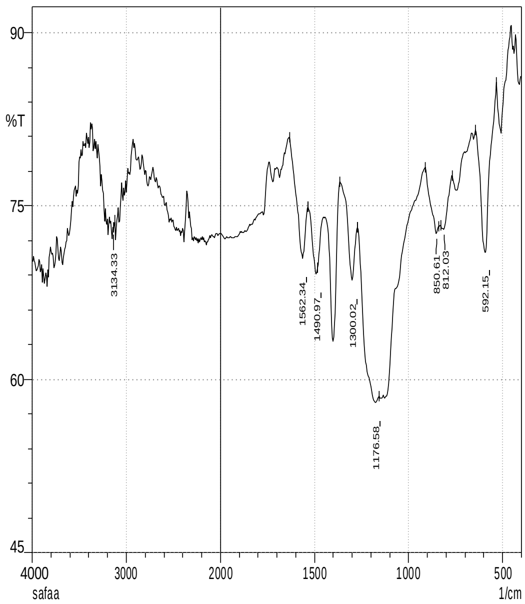


Figure (4). FTIR spectra of Fe_2O_3 sample.

3-2 Method a solar cell

Initially the samples to be deposited is cleaned and include steps cleaning on:

Steps to clean silicon strips : Include

1-Clean slides with distilled water.

2- Immerse in 99.999% high purity ethyl alcohol for 5 minutes.

3- m chemical etching to get rid of impurities and oxide layer on the surface where it is submerged in hydrofluoric acid (HF) at a concentration of (10%) for (3-4) minutes.

4- Apply with distilled water and then immerse in alcohol to remove residual acid residue.

5- Hot air drying process is then placed in a glass container from vacuum air

Then the material is deposited on the silicon and finally the electrodes are made of aluminium purity 99.999% .

Preparation of Membrane

Ferric oxide membranes (Fe2O3) thin-film prepared by thermo-chemical analyzers technique. We used Nitrate (Fe(NO3)3.9H2O). Is a white color and solid material if it is completely dry, and when melting with water is color light orange, i t is soluble in a water , molecular weight (404.02 ، g/mol) , it's done prepare their solutions with a molar concentration (0.1mol/L) by adding (4.0402 gm) including in (100 ml) of the distilled water

gradually using a magnetic mixer . After obtain the appropriate solution by completion of the process of dissolving, then filter well by using filter paper to get a smooth homogeneous solution free of plankton. Finally this solution is placed in the spray tank , by using the following relationship to get on the weight to be dissolved within the standard in the above .

$M = (W_t / M_{wt}) \times (1000/V)$ … (1) Where

M: molaric concentration , W_t: volume of distilled water , V: molecular weight of material:

Then after obtaining the solution and completing the process of dissolving, for an appropriate time leaves to ensure it is cooled before spraying , then placed in the spray machine after spraying and deposition on the glass bases prepared in advance ,and after they have been cleaned bases well with water and alcohol. According to the following chemical equation we get the ferrous oxide membranes:

$$4\,Fe(NO_3)_3 \longrightarrow 2Fe_2O_3+12NO_2\uparrow+3O_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2).$$

The temperature of the glass bases was (500 $_0$C) which is suitable for the formation of ferric oxide membranes (Fe_2O_3) , the sedimentation rate is (10 cm^3/min) to obtained homogeneous membranes, and high spray device about (30) cm about glass bases , to avoid sudden cooling of the bases use the time of deposition (15 sec) which leads to leading to membrane failure, for a duration of (3 min) the sedimentation process is followed to ensure to complete the process of crystalline development and the heat back to the original value , finally, related films obtained were reddish brown in color

4- Result and discussion

From figures (5,6) we observed that , the figure 5 drawing between the density of current and the difference of voltage in the case of darkness, the figure 5 drawing observed relationship between the density of current and voltage difference in the lighting condition ,through the laws and drawing, the four factors were calculated and the efficiency of the solar cell was determined as shown in the table (1) below . This is consistent with the findings of the researcher [4]

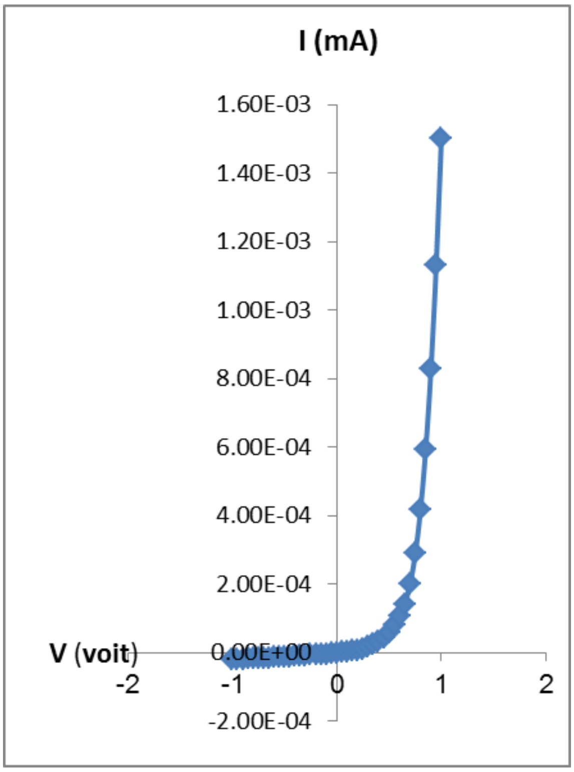


Figure (5): J-V characteristics for Fe_2O_3 under darkness

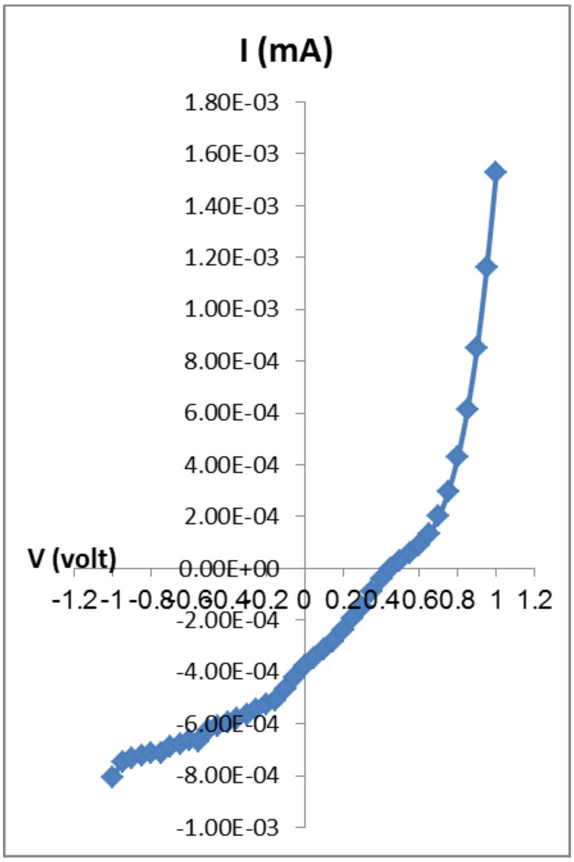


Figure (6): J-V characteristics for Fe_2O_3 under Light

V_{oc}(v)	0.45
V_p(v)	0.2
J_{sc}(mA/cm^2)	3.75×10^{-4}
J_p (mA/cm^2)	2×10^{-4}
P_{max} (mW/cm^2)	100
F.F	0.237
η	0.03

Table (1) representing the values of solar cell variables .

5- Conclusions

The obtained values of photovoltaic cell characteristics when lighting conditions, that is, short-circuit current density which is symbolized by (J_{sc}) , open-circuit voltage which is symbolized by (V_{oc}), fill factor which is symbolized by (F.F), and energy conversion efficiency which is symbolized by (η) are presented in table .The highest J_{sc} , V_{oc}, and efficiency of these samples obtained using Fe_2O_3 film. In this research, we have found that this material is good for use in the manufacture of solar cells because the energy gap is small compared to the rest of the materials and is comparatively good efficiency.

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