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THE CHANGE OF ENERGY GAP AND EFFICIENCY OF CARBON SOLAR CELL WHEN DOPED BY SOME ELEMENTS

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ABSTRACT

When the carbon solar cell was doped with Mg, Al, S, Cu, Zn and Cd , the energy gap and efficiency changes. For Mg, Al, S, and Zn with atomic numbers Z: 12, 13, 16, and 30, the energy gap E_g increases and takes values 1.879, 1.897, 1.918, 1.925 eV respectively. This may be related to the fact that, according to hydrogen like atoms, the energy gap increases with atomic number. However the efficiency decreases for this group to be 0.780, 0.730, and 0.023 for Al, S, and Zn respectively. This is since the increase of energy gap decreases the number of electron that reaches conduction band, which in turn decreases efficiency. For Cu and Cd with Z= 29 and 48 E_g decreases to be 5.184 and 5.107 respectively. This is related to the inverse effect of atomic radius on E_g , where r increases with Z. The efficiency increases as E_g decreases

Keywords: Carbon, Dope, Energy gap, Efficiency.

I. INTRODUCTION

Solar cells are one of the most promising renewable energy sources. It convert sun radiation energy to electrical energy [1, 2] .Despite this advantage solar cells suffer from noticeable setbacks . First of all they have low efficiency and high cost. The commercially available types are fabricated by using complex processes [3, 4]. This forces scientists to try to find a new patch way to fabricate cheap, high efficiency solar cells. Intensive research is concentrated on nano solar cells, which are cheap and can be easily fabricated [5, 6]. However their efficiency are still low [7, 8]. Thus one has to use new materials for solar cell fabrication. These are done in this work by using carbon as a host material, and then dope it with some elements to study its performance.

II. EXPERIMENTAL WORK

In this work six samples were prepared where C is doped with Zn, Mg, Al, S, Cd and Cu. The absorption, energy gap and V-I characteristic for each sample are exhibited here.

Results

a. Optical properties

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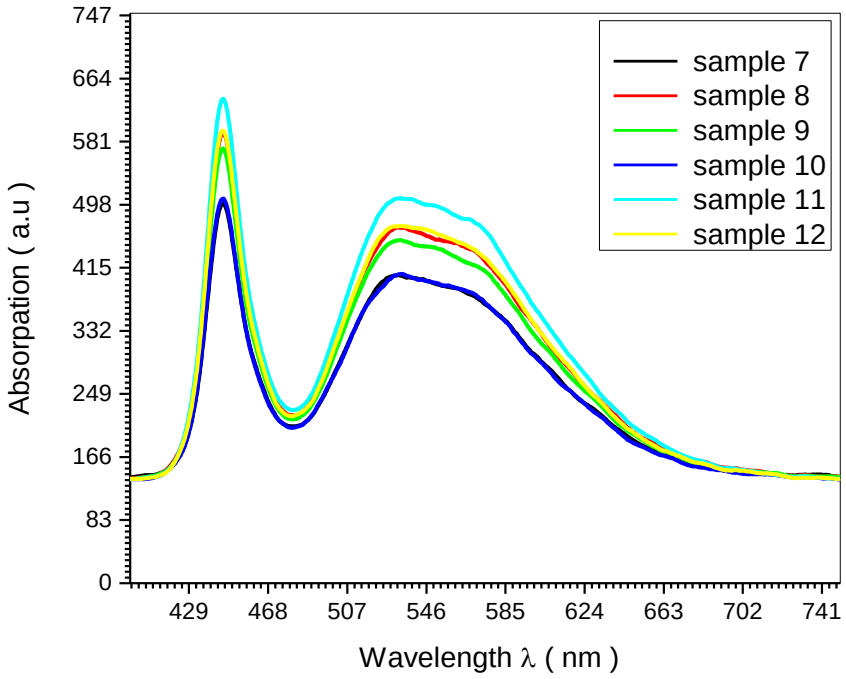

Figure (2.a.1) Absorption versus wavelength for all samples

Sample 7 : C +Zn
Sample 8 : C +Mg
Sample 9 : C +Al
Sample 10 : C+S
Sample 11 : C+Cd
Sample 12 : C+Cu

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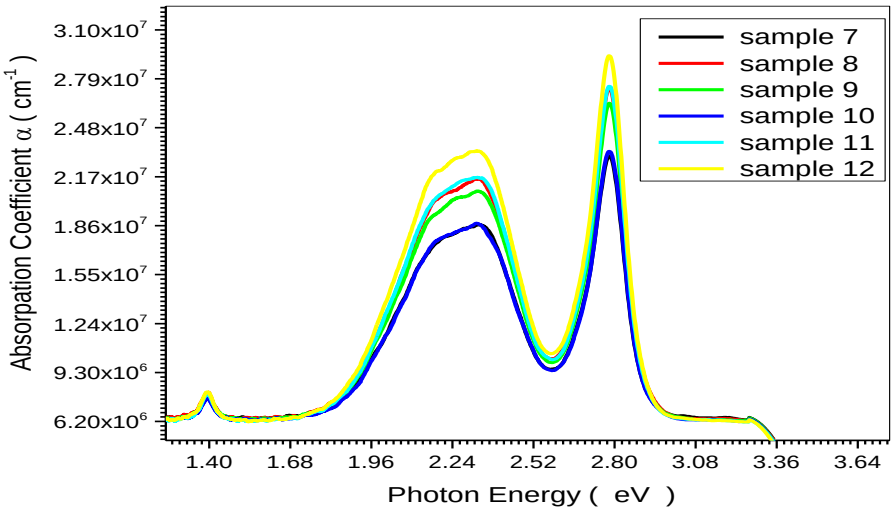

Figure (2.a.2) Absorption coefficient versus photon energy for all samples

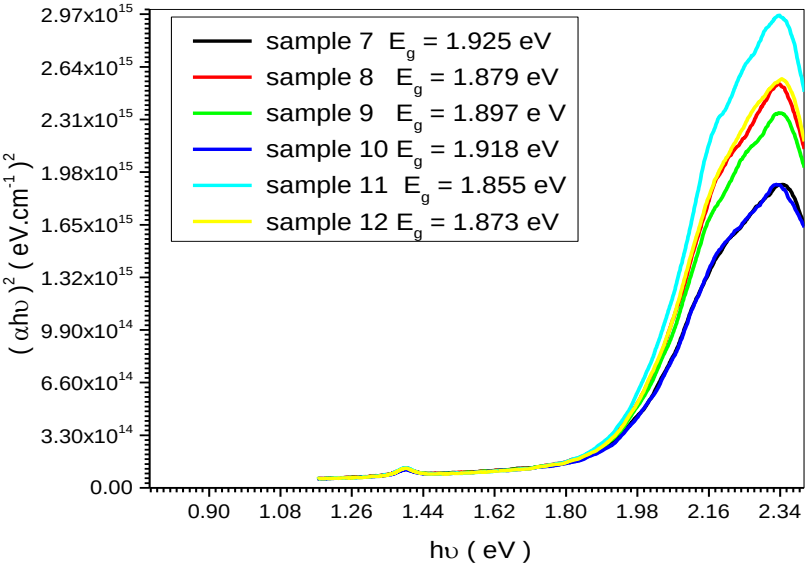

Figure (2.a.3) Energy gaps for all samples

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b. Electrical properties

Table (2.b.1) Relation between I and V for Zn (sample 1)

I (mA)	V (V)
37.73803	7.32388
37.83672	0.01441
37.69811	0.02319
37.26038	0.02935
36.69811	0.03383
35.47925	0.03799
30.58273	0.04149
23.94557	0.04384
13.12627	0.0469
0	0.04695

I ≡ Current , V ≡ Voltage

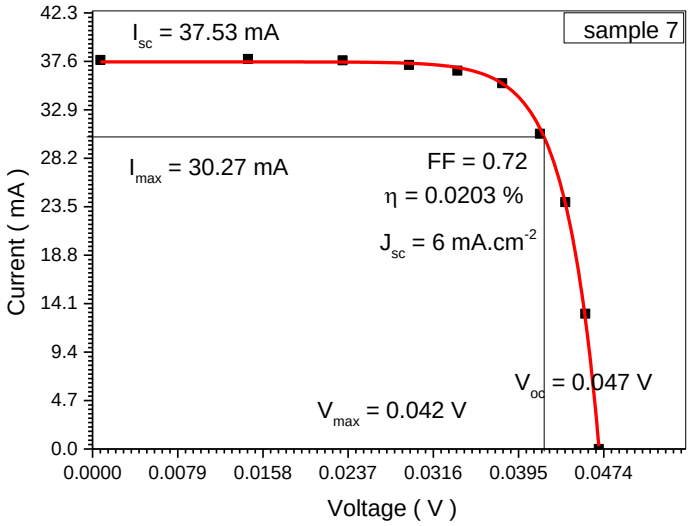

Figure (2.b.1) Relation between I and V for Zn

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Table (2.b.2) Relation between I and V for Mg (sample 2)

I (mA)	V (V)
15.33159	0.00102
15.20819	0.01061
15.20819	0.01722
15.08549	0.023
15.118	0.02784
15.47271	0.03822
11.20499	0.04654
6.42683	0.0523
0	0.0558

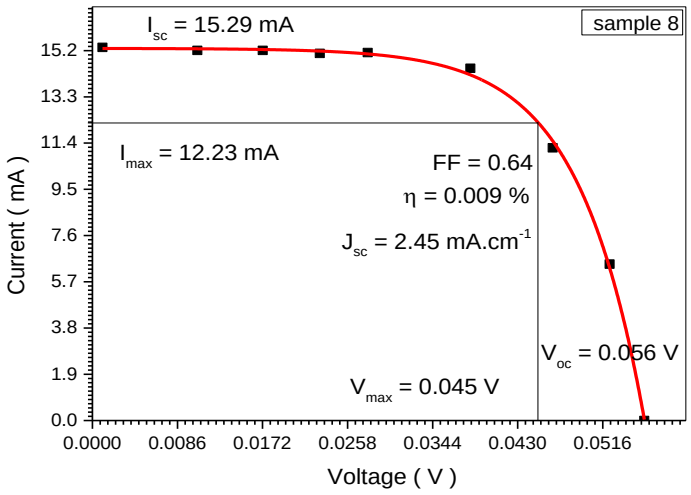

Figure (2.b.2) Relation between I and V for Mg

Table (2.b.3) Relation between I and V for Al (sample 3)

Current (mA)	Voltage (V)
0.12627	0.44.23
41.33309	0.43041
51.37083	0.41649
58.56821	0.41546
65.97242	0.40799
75.33454	0.3674
78.18868	0.3067
79.33309	0.22345
79.7881	0.10619
80.1328	0.05825
80.1328	6.44334

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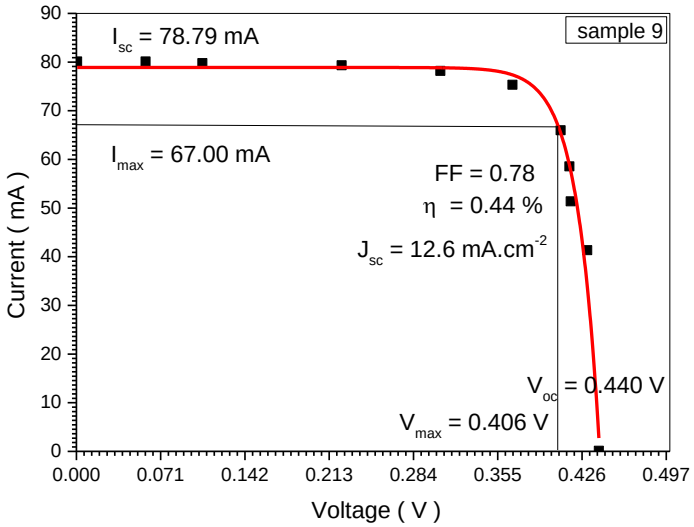

Figure (2.b.3) Relation between I and V for Al

Table (2.b.4) Relation between I and V for S (sample 4)

I (mA)	V (V)
16.5016	7.51718
16.59536	0.13391
16.63948	0.53823
16.31959	0.88939
15.91147	1.12137
14.9079	1.50687
12.71263	1.72917
9.06154	1.87146
2.1	1.96
0. 11582	1.97348

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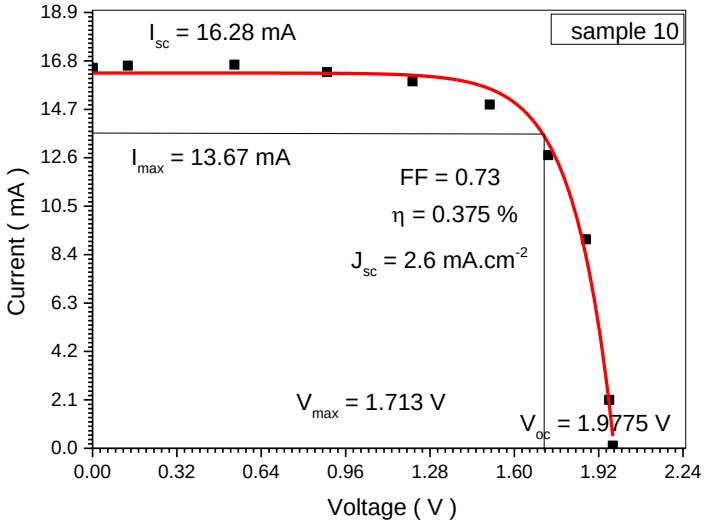

Figure (2.b.4) Relation between I and V for S

Table (2.b.5) Relation between I and V for Cd (sample 5)

I (mA)	V (V)
22.66986	0.00168
22.72793	0.01363
22.66986	0.0237
22.786	0.03117
23	0.0411
22.85134	0.04732
20.38328	0.05616
14.56156	0.06324
8.5511	0.06512
0.01089	0.06549

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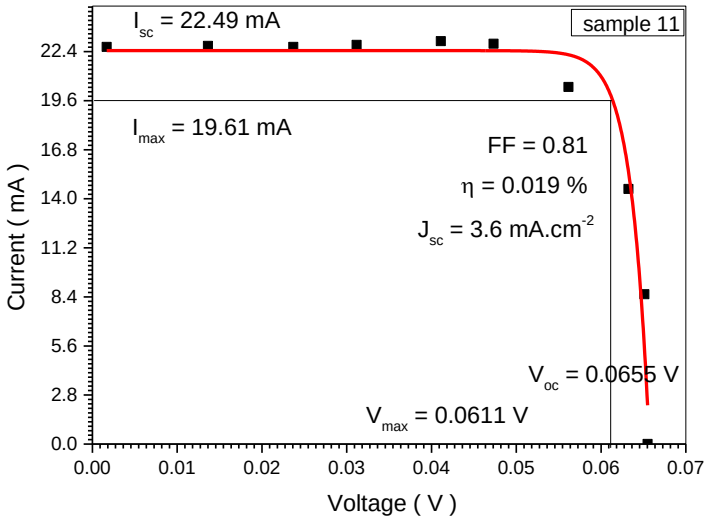

Figure (2.b.5) Relation between I and V for Cd

Table (2.b.6) Relation between I and V for Cu (sample 6)

Current (mA)	Voltage (V)
51.25907	7.51718
51.67997	0.22734
51.79608	0.52534
51.73803	0.73851
51.49855	0.98711
51.59869	1.298
46.03411	1.80058
37.32583	1.97348
25.48984	2.04489
0.08708	2.15212

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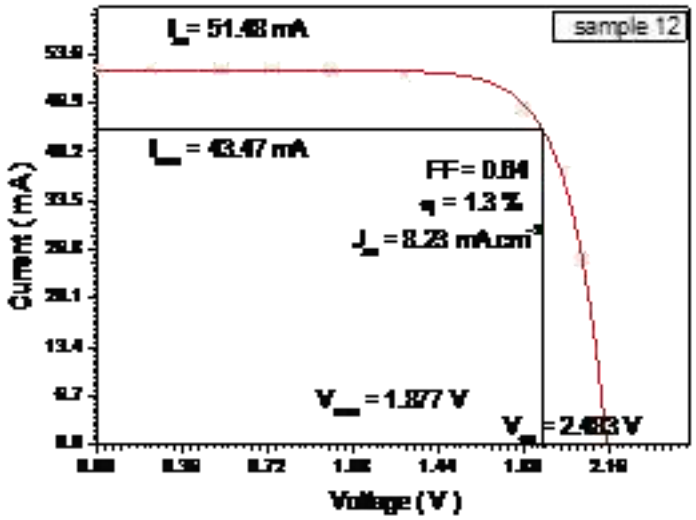

Figgure (2.b.6) Relation between I and V for Cu

Table (2.c) Performance of all samples

Sample number	I_{sc} (mA)	I_{max} (mA)	V_{oc} (V)	V_{max} (V)	J_{sc} mA. cm^{-2}	η	FF	E_g (eV)	Atomic number Z	Element
8	15.29	12.23	0.056	0.045	2.45	0.009	0.64	1.879	12	Mg
9	78.79	67.00	0.440	0.406	12.60	0.780	0.44	1.897	13	Al
10	16.28	13.67	1.9775	1.713	2.60	0.730	0.375	1.918	16	S
12	51.48	43.47	2.483	1.877	8.23	0.64	1.3	1.873	29	Cu
7	37.53	30.27	0.047	0.042	6.00	0.0203	0.72	1.925	30	Zn
11	22.49	19.61	0.0655	0.0611	3.60	0.810	0.019	1.855	48	Cd

III. DISCUSSION

he doping of carbon C with elements can be categorized into two groups. The first group include Mg , Al , S and Zn with atomic numbers 12 , 13 ,16 , and 30 . For this first group the energy gap E_g increases with the atomic number Z. This may be explained by assuming that the energy gap results from the space between two atomic energy levels that have the same band width.The first one is related to the outer most shell and the second one is the level which makes electrons free i.e.

$$E_\infty = E_C = 0$$

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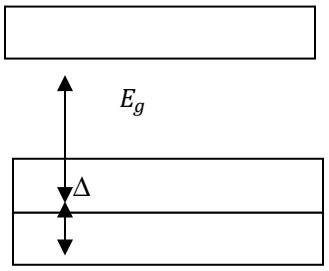
Thus the energy gap is given by :

$$E_g = E_C - E_V \qquad E_C = E_\infty$$

$$E_g = 0 - (-\frac{Z^2}{n^2} e^4 n + \Delta)$$



Thus $E_g \sim Z^2$

This means that increasing atomic number Z increases the energy gap E_g which can successfully explains the empirical relations obtained in this work . It is very interesting to note that for (Z = 13, 16, 30) the efficiency decreases when Z increases . This may be related to the fact that when Z increases E_g increases. The increase of energy gap decreases the number of electrons reaching the conduction band , which in turn decreases efficiency .In the second group which include Cu and Cd with Z = 29 , 48 , when Z increases , the energy gap decreases to assume values 1.873 , 1.855 eV respectively .This may be attributed to the effect of atomic radius r increase which becomes important, since Z for Cu and Cd is nearly double or more than that of the first group. This means that their radius are larger. The energy gap is given by

$$E_g = E_C - E_V = 0 + \frac{C_1}{r} - \Delta$$

Thus increase of Z increases r, thus decreasing E_g , which conform with the experimental results. Again as explained earlier the increase of Z decreases E_g which leads the efficiency η to increase, since more electrons find a chance to reach conduction band when E_g decreases.

IV. CONCLUSION

The efficiency and energy gap of carbon solar cell is affected by the atomic number. This raises a hope in increasing efficiency by doping solar cells with impurities.

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