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

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ABSTRACT

Silicon was doped with Mg, Al, S,Cu, Zn and Cd. For Mg, Al,S and Zn with atomic numbers 12, 13, 16 and 30 the efficiency decreases to be 0.0960, 0.0650, 0.0560, and 0.0280. This decrease of efficiency due to atomic number increase may be attributed to the fact that increase of atomic number decreases atomic and free charge density which decreases current and decreases efficiency.

For Cu and Cd the increase of atomic number from 29 to 48 decreases the energy gap from 5.184 to 5.107 which is related to the fact that increase of atomic number increases atomic radius which decreases the energy gap. The decrease of energy gap increases the efficiency to change from 0.0090 to 0.069.

KEYWORDS: Silicon, Dope, Energy gap, Efficiency.

I. INTRODUCTION

Energy problem is the one of the most standing problem facing people [1]. This forces scientists to search for sustainable, free pollution source. One of the most promising one is the solar energy which is converted to electrical one by using solar cells [2, 3]. One of the most commercially available type is the silicon solar cells [4, 5]. Silicon solar cells are expensive, need complex fabrication process and have low efficiency [6, 7]. Attempts were made to fabricate nano solar cells, which are cheap and can be easily fabricated. But till now there are no commercially nano solar cells. This motivates trying to increase silicon solar cell efficiency by doping it with some elements.

II. EXPERIMENTAL WORK

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

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Results

1. ***Optical properties***

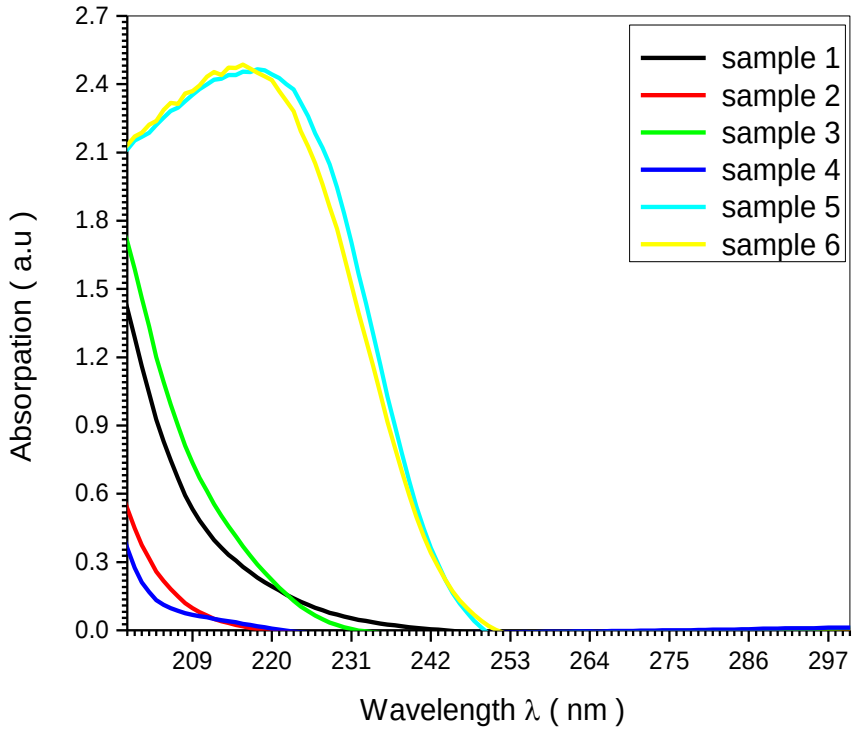

Figure (2 .a.1) Absorption versus wavelength for all samples

Sample 1: Si +Zn
Sample 2: Si +Mg
Sample 3: Si +Al
Sample 4: Si+S
Sample 5: Si+Cd
Sample 6: Si+Cu

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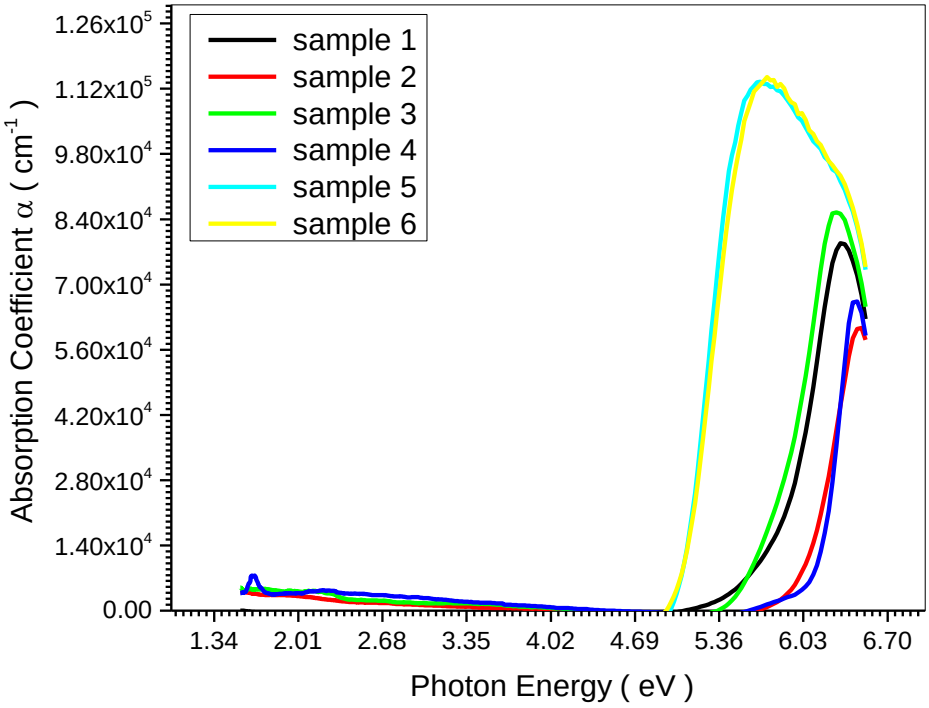

Figure (2.a.2) Absorption coefficient versus photon energy for all samples

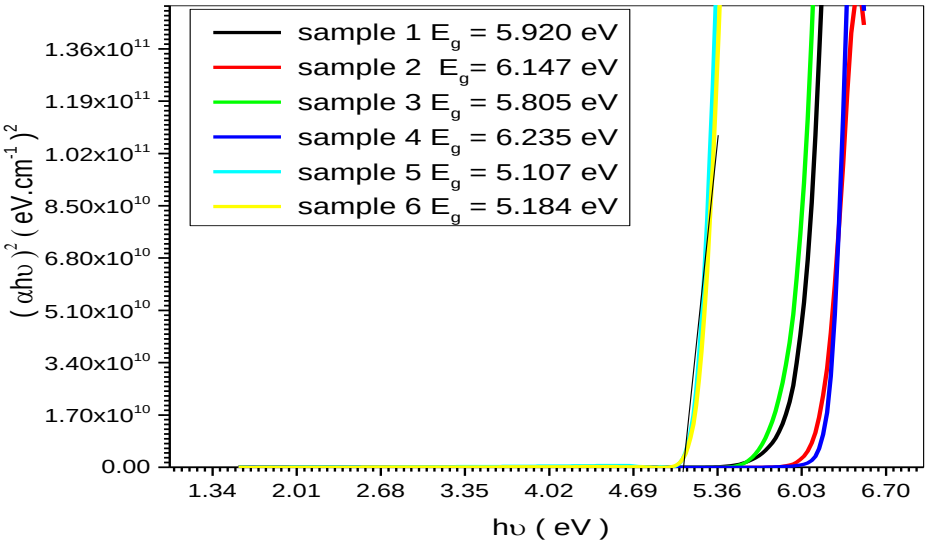

Figure (2.a.3) Energy gaps for all samples

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2. Electrical properties

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

I (mA)	V (V)
19.98549	0.0000
19.67199	0.01994
19.46299	0.03794
19.35849	0.0502
19.14949	0.06145
19.94049	0.07547
17.69231	0.09398
13.48331	0.11124
2.35994	0.12
0.00000	0.12

I ≡ Current V≡ Voltage

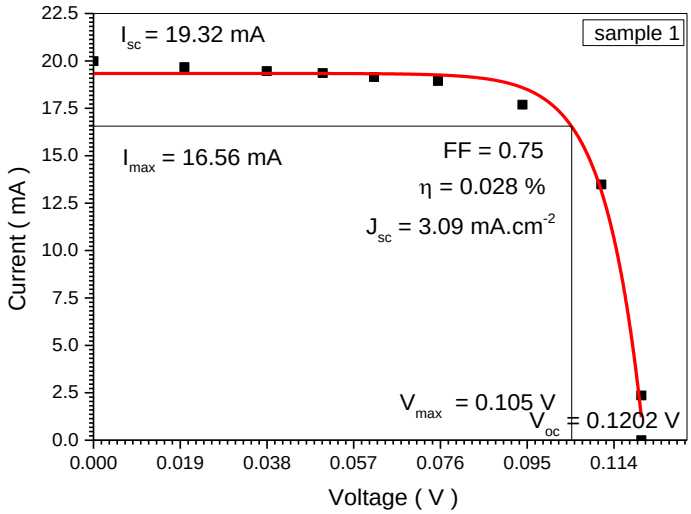

Figure (2.b.1) Relation between I and V for Zn

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

I (mA)	V (V)
6.25	21.09347
0.01711	21.09347
0.02303	21.99971
0.03327	21.13759
0.4622	21.36923
0.05535	21.41335
0.06573	21.27547
0.07949	18.94804
0.08925	13.37765
0.0955	0.00319

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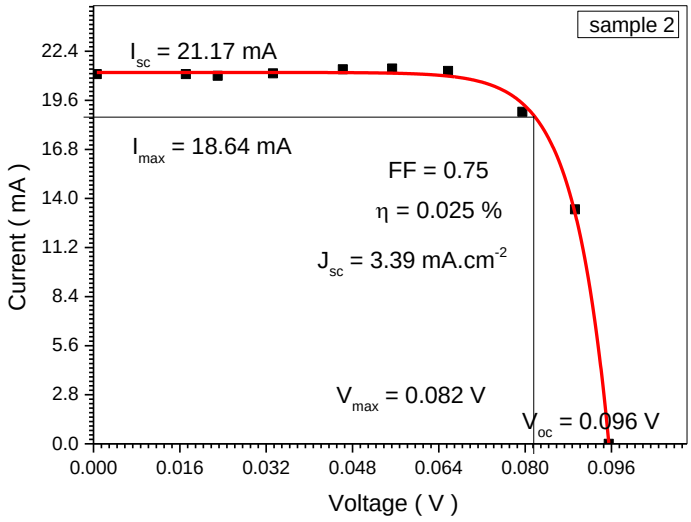

Figure(2.b.2) Relation between I and V for Mg

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

I (mA)	V (V)
50.83019	0.0031
49.90566	0.01698
49.26415	0.02898
49.96226	0.03822
49.73585	0.04909
49.90566	0.05995
49.73585	0.07173
47.71698	0.08929
27.71698	0.10269
0.09434	0.11286

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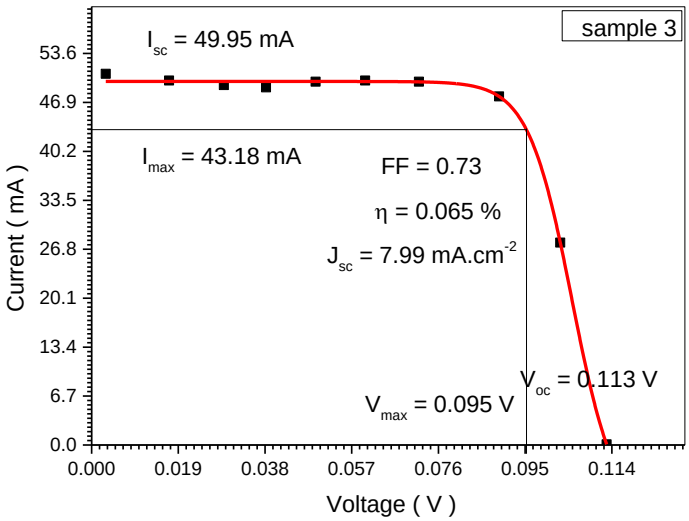

Figure (2.b.3) Relation between I and V for Al

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

I (mA)	V (V)
0.51959	0.13316
3.98113	0.13144
9.49347	0.12918
20.08708	0.12093
32.19594	0.11069
37.70827	0.09107
39.98113	0.06863
41.06531	0.0345
41.60087	6.52921

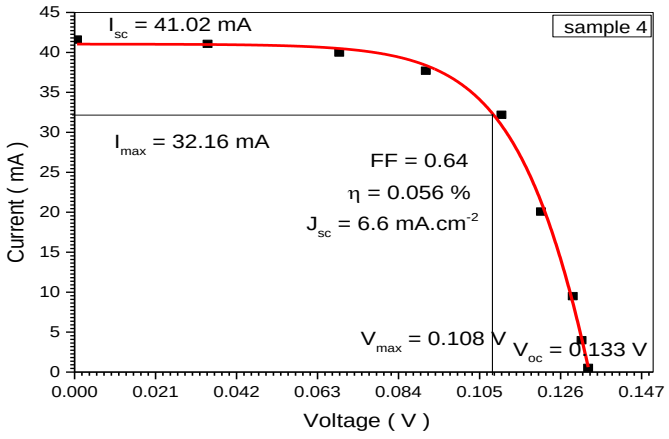

Figure (2.b.4) Relation between I and V for S

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Impact Factor: 4.116
CODEN: IJESS7

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

I (mA)	V (V)
55.83019	0.0016
55.5283	0.02036
55.0566	0.03338
56.5	0.049
55.83019	0.06835
52.09434	0.08263
36.32075	0.09778

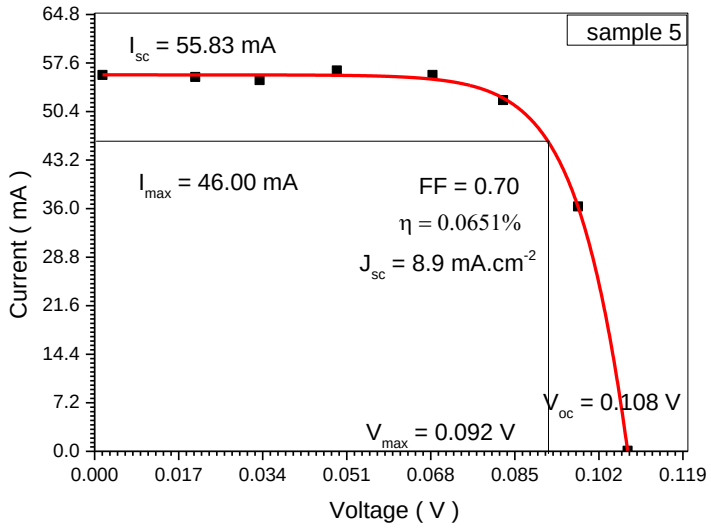

Figure (2.b.5) Relation between I and V for Cd

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

I (mA)	V (V)
17.31736	8.87183
17.41115	0.01288
17.0474	0.02317
17.54501	0.03128
14.8566	0.03885
12.35849	0.04205
9.54717	0.0436
5.98491	0.04408
0.9283	0.04461

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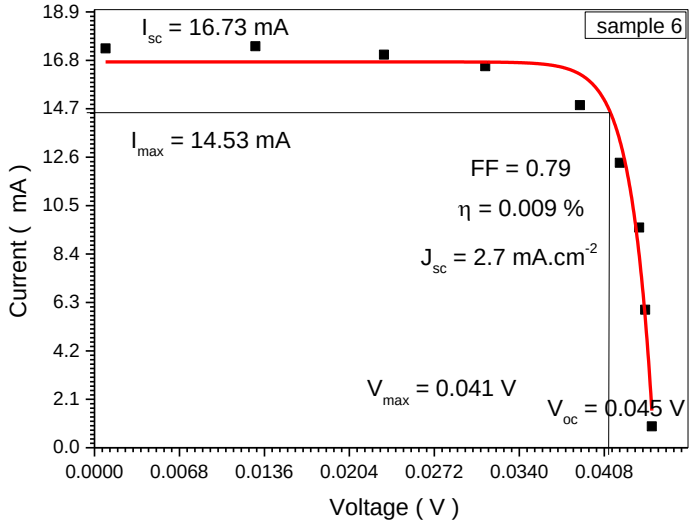

Figure (2.b.6) Relation between I and V for Cu

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
2	21.17	18.64	0.096	0.080	3.39	0.0960	0.75	6.147	12	Mg
3	49.95	43.18	0.113	0.095	7.99	0.0650	0.73	5.805	13	Al
4	41.02	32.16	0.133	0.108	6.60	0.0560	0.64	6.235	16	S
6	16.73	14.53	0.046	0.041	2.70	0.0090	0.79	5.184	29	Cu
1	19.32	16.56	0.1202	0.125	3.09	0.0280	0.75	5.920	30	Zn
5	55.48	46.00	0.108	0.092	8.90	0.0651	0.70	5.107	48	Cd

III. DISCUSSION

The effect of the change of the atomic number Z of the elements which are used to dope Si shows some interesting features. In view of table (1) which relates the solar cell efficiency η to the atomic number Z, it is clear that η change with Z. For Mg, Al, S and Zn with Z = 12, 13, 16, and 30 , the increase of Z decreases the efficiency. This may be related to the fact that increasing Z increases atomic radius which decreases atomic density of free carriers, which in turn decreases output current which decreasesη. However the situation is different for Cu and Cd which have Z = 29 and 48 respectively, where the Z number is more than twice than the first group (Z = 12, 13, 16) . Here the energy gap E_g decreases up on increasing Z. This may be related to the fact that the role of the atomic radius r becomes important where Thus increasing Z increases r which in turn decreases E_g . Again for Cu and Cd the decrease of E_g increases the efficiency η which is explained in the first group discussion. The behavior of Zn is peculiar. This may be related to the fact that ZnO act as a semiconductor.

IV. CONCLUSION

The efficiency of silicon solar cells are highly affected by the atomic number. Thus silicon solar cell performance can be improved by doping

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