EFFECT OF CdS REPLACEMENT BY Cd-FREE BUFFER LAYER ONTO (CIS) SOLAR CELL

R.TALAIGHIL [1,2], A.IRATNI [1], N.E.H.ARABI [1], F.BENSOUISSI[1], A.SLIMANI[1]
[1] *Laboratoire Des Minéraux Et Materiaux Composites LMMC, University M'hamed Bougara, BOUMERDES*
[2]*Institute Of Electrical & Electronic Engineering, University M'hamed Bougara, BOUMERDES*

Abstract:
Cadmium Sulfide buffer layer is required in Copper Indium Diselenide solar cell to be an interface between the window layer for example: Tin oxide or zinc oxide and the (CIS) (n/p) junction. It reduces the lattice mismatch between ZnO and (CIS). But due to the cadmium toxicity, many investigations hav been done in order to replace CdS by Cd-free buffer layer. The main obligation is to keep the same properties of cdS but without Cd toxicity.
This work performs a comparative study between CIS solar cells with CdS layer and without it by introducing cd-free buffer layer like ZnS or ZnO

1. INTRODUCTION:

Buffer layers in copper indium diselenide (CIS) are really important in order to create an optimal transparent front junction to the absorber [1].
For this purpose, a large energy band gap for high optimal transmission in the visible region is required. Cadmium sulphide CdS thin films are most suitable with their gap energy E_g=2.4 eV [1].
Because of our perpetual research to optimize solar cells manufacturing, an effort is made to use non-toxic materials [2] and consequently a real thinking to replace CdS layer by another Cd-free layer is conducted [3-6].
This task is not too easy, according to some researches, many problems have been encountered especially stability and meta-stable effects [7,8].

2. COMPARATIVE STUDY:

A comparative study is performed between properties of CdS buffer layers and Cd-free buffer layers in order to understand how we can get the performance of CdS without the cadmium toxicity. The table below summarizes the required CdS properties and the alternative characteristics of Cd-free buffer layer.

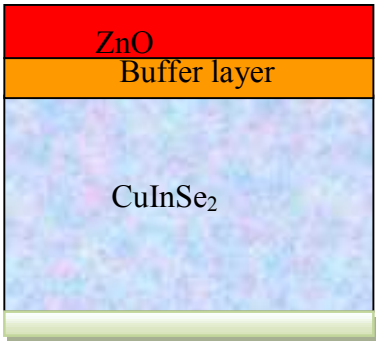

Figure 1: ZnO window layer/Buffer layer (CdS or ZnS or i-ZnO)

The table below gathers all the important data for buffer layers: CdS, ZnS, ZnO.

Buffer layers	*CdS [9]*	*ZnS [10]*	*ZnO[11]*
Thickness (μm)	0.050	0.100	0.050
Band gap (eV)	2.40	3.7	3.3
Electron affinity (eV)	4.200	4.500	4.550
Dielectric permittivity (relative)	10.000	10.000	10.000
Conduction band effective density of states (cm^{-3})	2.200×10^{18}	4.000×10^{18}	4.000×10^{18}
Valence band effective density of states (cm^{-3})	1.800×10^{19}	5.000×10^{18}	9.000×10^{18}
Electron thermal velocity (cm/s)	1.000×10^{7}	1.000×10^{7}	1.000×10^{7}
Electron mobility (cm^2/Vs)	1.000×10^{2}	1.000×10^{2}	5.000×10^{1}
Hole mobility (cm^2/Vs)	2.500×10^{1}	2.000×10^{1}	2.000×10^{1}
Shallow level density (cm^{-3})	1.000×10^{17}	5.000×10^{17}	5.000×10^{17}

3. RESULTS & DISCUSSION

Modelling and simulation has been carried out by using SCAPS dedicated thin films solar cells. The IV characteristics are represented in the figure below for CdS buffer layer and Cd-free (ZnS, intrinsic ZnO) layers.

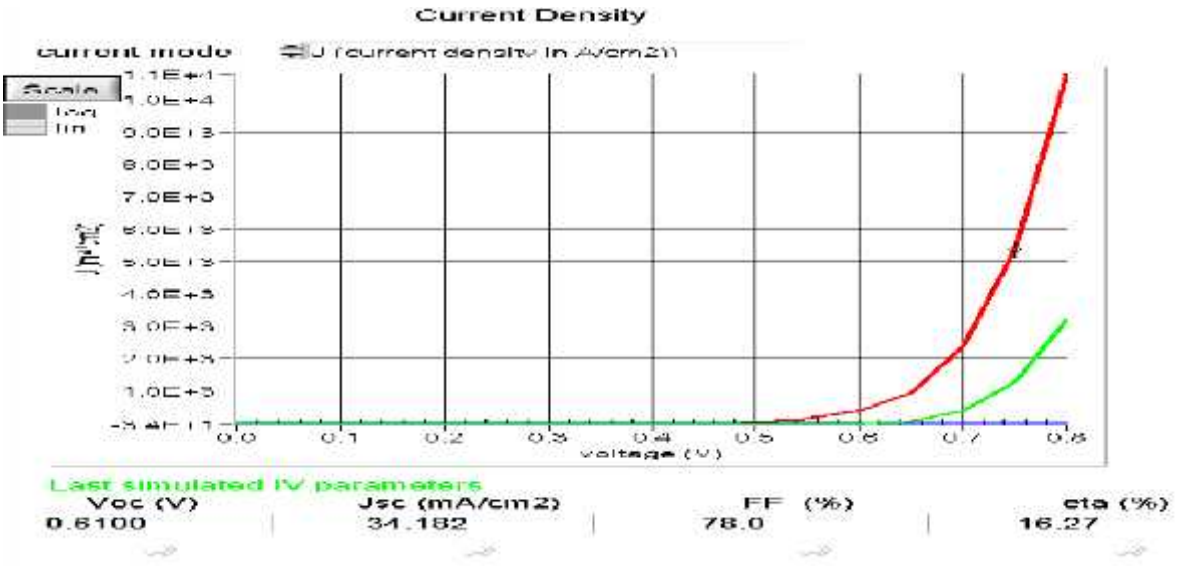

Figure 1: I(V) curve for ZnO window/ CdS buffer/ CIS solar cell

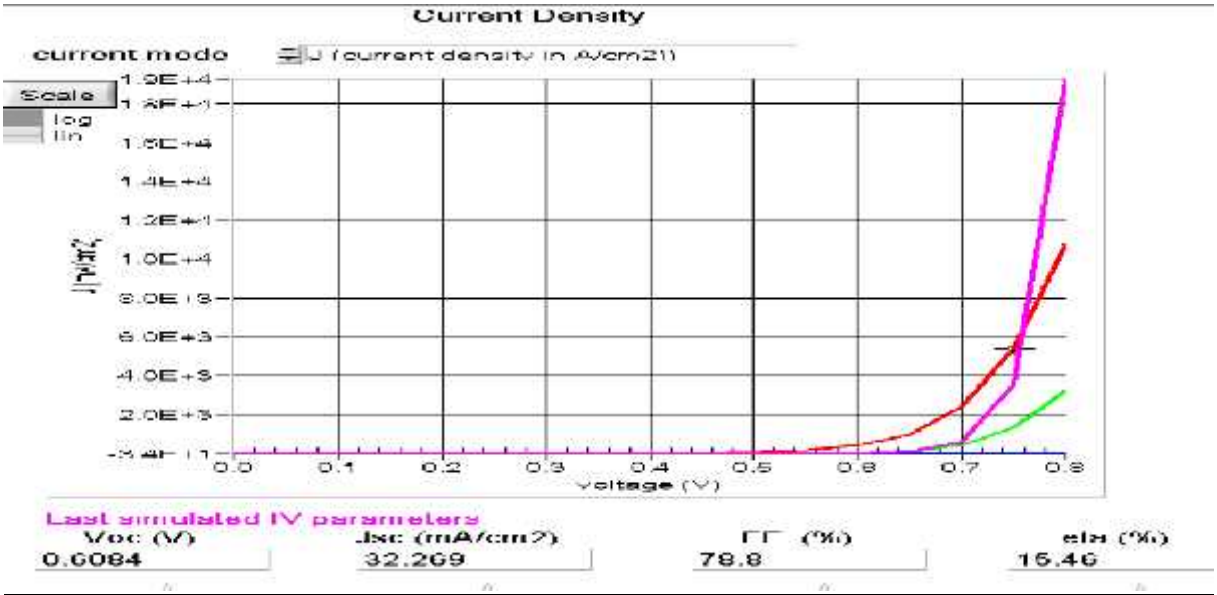

Figure 2: I(V) curve for ZnO window/ ZnO intrinsic buffer/ CIS solar cell

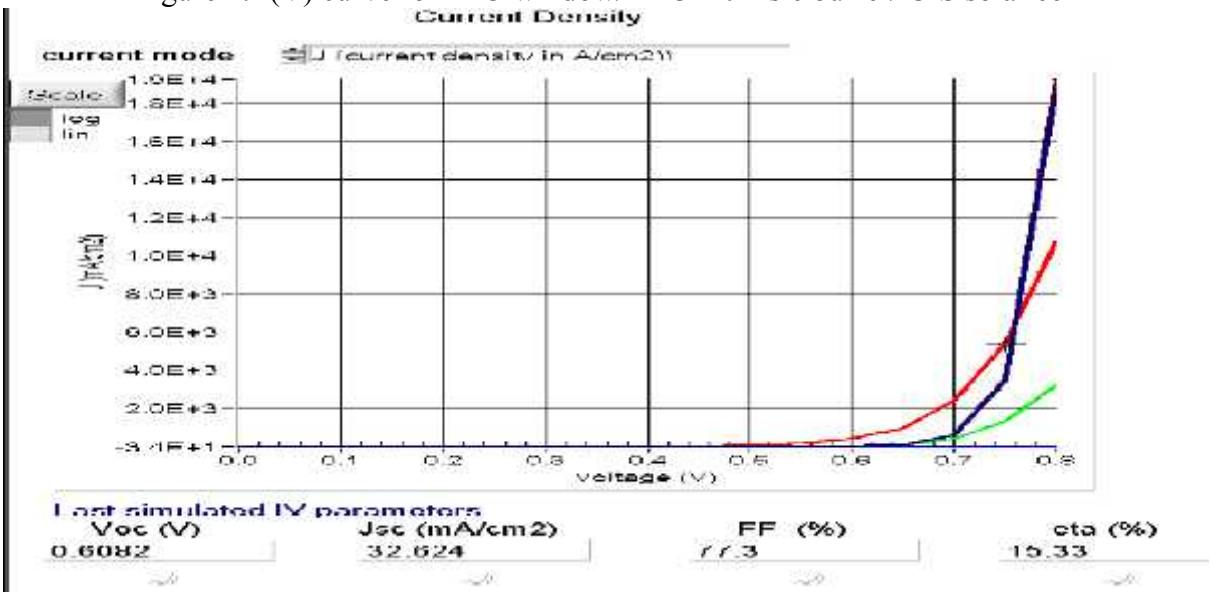

Figure 3: I(V) curve for ZnO window/ ZnS buffer/ CIS solar cell

One can remarks from figures above that conversion efficiency of CIS buffer layer is the highest value with 16.27%, followed by intrinsic zinc oxide buffer with 15.46% and finally zinc sulphide buffer with 15.33%.
A physical meaning of these results can be given according to Malm et al. [11]by the fact that the band offset of CdS is small but positive compared to Zinc sulphide and intrinsic zinc oxide buffer layers.

4. CONCLUSION

Intrinsic zinc oxide and zinc sulphide buffer layers are not so performant than cadmium sulphide buffer layer. But, because health is much more important than efficiency, deep investigations should be done to find a buffer material closer than CdS properties.

5. REFERENCES:

[1] I.Konovalov, thin solid films 451-452 (2004) 413-419
[2] A.Goetzberger, C.Hebling, H.W.Schoch, Materials Science & Engineering R 40(2003) 1-46
[3] Y.Ohtake, A.Yamada, M.Konagi, Jpn.J.Appl.Phys.37(1998)3220
[4] Y.Ohtake, T.Okamoto,A.Yamada, M.Konagi, K.Saito, Solar Energy Materials & Solar Cells 49(1997) 269
[5] Y.Ohtake, K.Kushiya, M.Ichikawa,A.Yamada, M.Konagi, Jpn. J. Applied Physics 34 (1995) 5949
[6] Y.Ohtake, M.Ichikawa, T.Okamoto,A.Yamada, M.Konagi, K.Saito, Proceedings of the 25th PVSC, Washington DC, 1996, p 793
[7] C.Platzer-Bjôrkman, J.Lu, J.Kessler,L.Stolt, Thin solid films 431-432 (2003) 321
[8] N.Naghavi, S.Spinering, M.Powalla, B.Cavana, D.Lincot, Progress in Photovoltaics Research Applied 11(2003) 437
[9] M.Burgelman, P.Nollet and S. Degrave, " Modelling polycrystalline semiconductor solar cells", Thin solid films 361-362 (2000) pp 527-532.
[10] M.M. Islam, S.Ishizuka, A.Yamada , K.Sakurai, S.Niki, T.Sakurai, K.Akimoto; Solar EnergyMaterials&SolarCells93(2009)970–972
[11] U.Malm, J.Malmström, C.Platzer-Bjôrkman, L.Stolt, Thin solid films 480-481 (2005) 208-212