Study of ZnO/InP by AES and EELS associated to CASINO simulation for use as solar cells.

A.Ouerdane[a], M.Bouslama[a], M.Ghaffour[a] A. Abdellaoui [a], C. Jardinl[b]
[a]Laboratoire Materiaux LABMAT ENSET d'Oran Mnouer 31000
[b] IUT b, 19, Rue de France, Villeurbanne France

Abstract :

In this article, we study the thin films ZnO, grown by a sputtering technical on the substrate lnP(100), by using Auger Electron Spectroscopy (AES) and Electron Energy Loss Spectroscopy (EELS) associated to the Casino Monte Carlo simulated program. We show that ZnO/lnP(100) is very stable when it is submitted to an electron beam irradiation. The X-ray intensity, computed by Casino program, varies weakly with the electron beam energy when compared to the InP one. We conclude that ZnO/lnP compound seems to be not subjected to a charge effect.

Key words:AES, EELS, CASINO, ZnO/InP.

.**E-mail:** ouerdanea@yahoo.fr

1.Introduction

ZnO is a metallic oxide largely used as transparent electrode in solar cells. Its low electrical resistivity (10^{-5}Ωcm) and high transmittance (80–90%) in the visible range give it a particular importance in the field of photovoltaic conversion as a solar cells.

In the ten recent years many researches are focused on ZnO because of the abundance of its components in nature, its non toxicity and the wide range of its electrical resistivity which can extend from 10^{4} to 10^{12}Ωcm. ZnO is an n-type semiconductor. Others authors have reported the preparation of p-type ZnO films It crystallizes in the wurtzite hexagonal structure with of wide gap equal to3.2 eV. [1,2].

In this article, we study the effects of electron beam bombardment on the thin films InP and ZnO grown on the substrates lnP (100), by using Auger Electron Spectroscopy (AES) and Electron Energy loss Spectroscopy (EELS) associated to the simulation scanning program CASINO. We find that the materials InP (100) gives rise successively to a foil of oxide when ZnO/lnP(100) seems to be unchanged. The Monte Carlo simulation Casino is used to scan the distribution and confirms these results.

2.Experimental

We use the analysis methods as the Auger Electron Spectroscopy (AES) and the Electron Energy Loss Spectroscopy (EELS) which are well appropriated to characterize the surfaces of materials using a hemispherical spectrometer operating in direct mode N (E).

The thin layer of ZnO have been grown on InP(100) by cathode RF sputtering by using Zn target of 8cm diameter. [3-6]. Finally the two samples were characterized by AES (electron beam of energy 4 keV with a current density of 10^{-3} A/cm^{2}). The incident electron beam was focused onto an area of 1mm diameter on each target. The characterization by EELS was achieved at low and high energy to distinguish the energy losses due to surface plasmons to those due to bulk plasmons. We studied at room temperature and after heating the physical structure and the chemical composition of compound surface InP or ZnO/InP previously submitted to argon ions bombardment at low energy 300eV with a current density of 2µA/cm^{2} in normal incidence on the target.

3.AES of ZnO/InP(100).

Figure 1 shows the O-KLL AES spectrum of ZnO oxide grown on InP by cathodic sputtering as describe above. The peaks which appear are located at 33eV,19.8eV,12eV and 3eV.

The formation of the ZnO grown on InP substrate by cathodic sputtering seems to be done without substrate decomposition since no trace of indium or phosphorus is revealed by auger electron spectroscopy [7-9].

4. EELS of ZnO/InP(100).

The electron energy loss spectroscopy is a good tool to characterise the material surface. As shown on fig. We have recorded EELS spectra at different primary energy. The energy loss peaks which appear are located at 4.8eV; 9 eV;18.4eV;33eV and 36eV.

The energy loss of 4.8eV and 9eV can be associated with interband transition. The large peak at 18.4eV remain unchanged in structure although the primary energy changed. The peak caused by surface plasmon is near the peak caused by bulk plasmon so that there is convolution of these two peaks. The peak intensity at33eVdepends on the primary energy Ep. It decreases when Ep decreases.

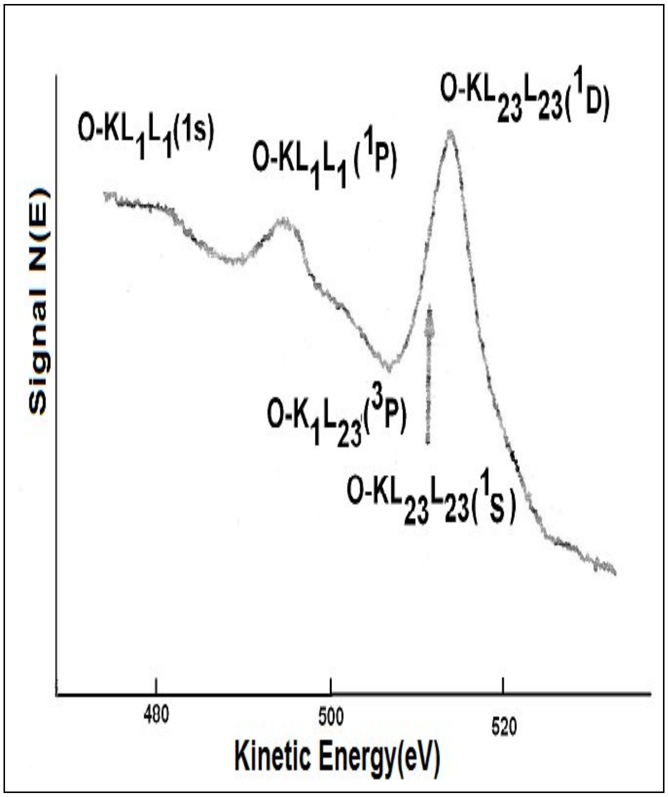

Fig.1 O-KLL AES spectrum of ZnO grown on InP by cathodic sputtering.

That peak is associated with surface plasmon, whereas the peak located at 36 eV can be associated with interband transition

AES and EELS show during cathode sputtering, the zinc has well reacted with oxygen to form ZnO on InP substrate.

5.Electron beam irradiation on InP and ZnO/InP.

By irradiating ZnO/InP (100) by the electron beam of 4 keV energy, we observe the structure and location of Auger signal 0-KLL which remains unchanged as function of applied potential to the surface as shown in figure.3. The ZnO/InP does not seem to be subjected to a charge effect. This result might be of great importance because it is known that InP (100) irradiated by the electron beam is subjected to a charge effect as shown on Figure 4. [10].

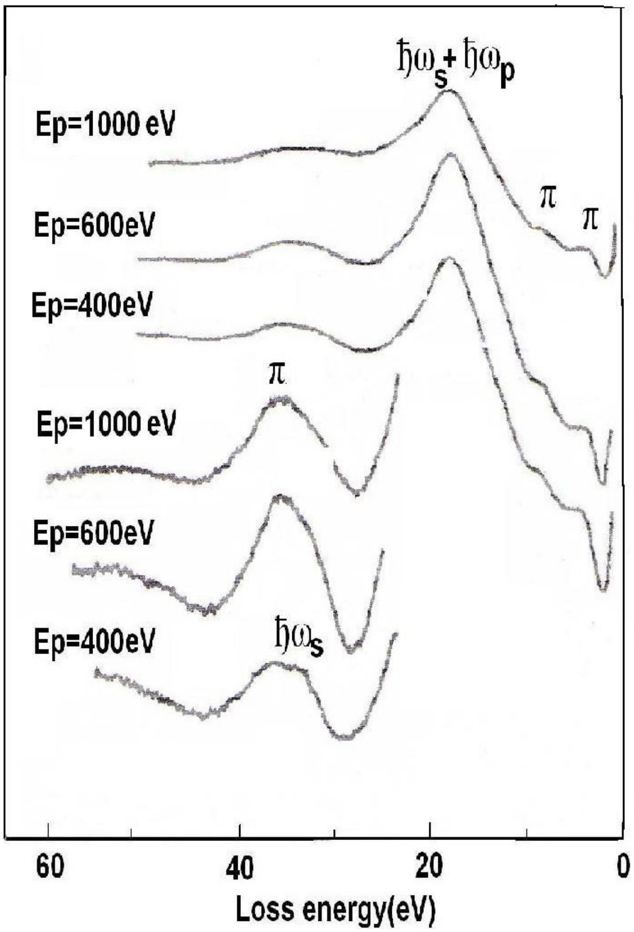

Fig.2 EELS spectrum of ZnO/InP for different primary energies (π means interband transition).

6.Casino simulation

In this section we use a code simulating the trajectory of electrons in a solid. It is known that the excess energy due to the electron beam bombarding a material target is released in the form of electromagnetic radiation (X-rays) or kinetic energy to the bulk atomic electrons.

The inelastic interaction gives rise to a wide variety of signals such as X-rays; the secondary electron emission. CASINO is specially designed for low beam interaction in a bulk and thin foil.

Casino program can be used to generate many of the recorded signals (X-rays and backscattered electrons) in a scanning electron microscope. [11].

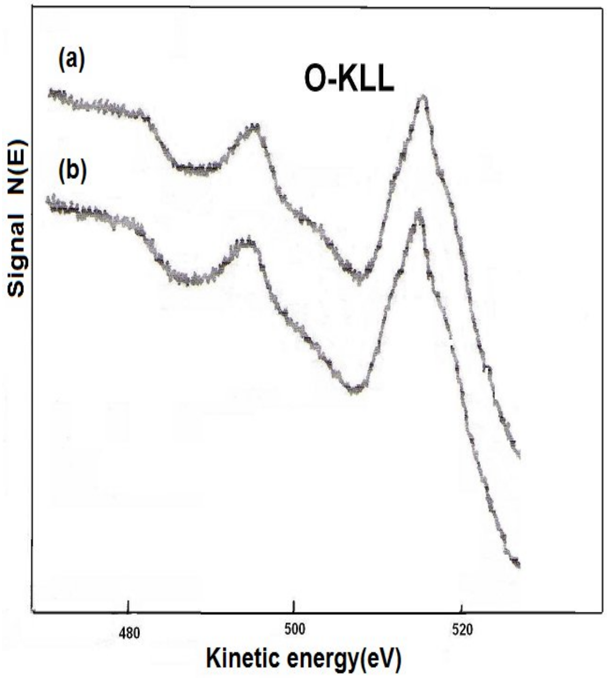

Fig.3 AES signal 0-KLL unchanged as function of applied potential to the surface (a) U=-90V and (b) U=0V

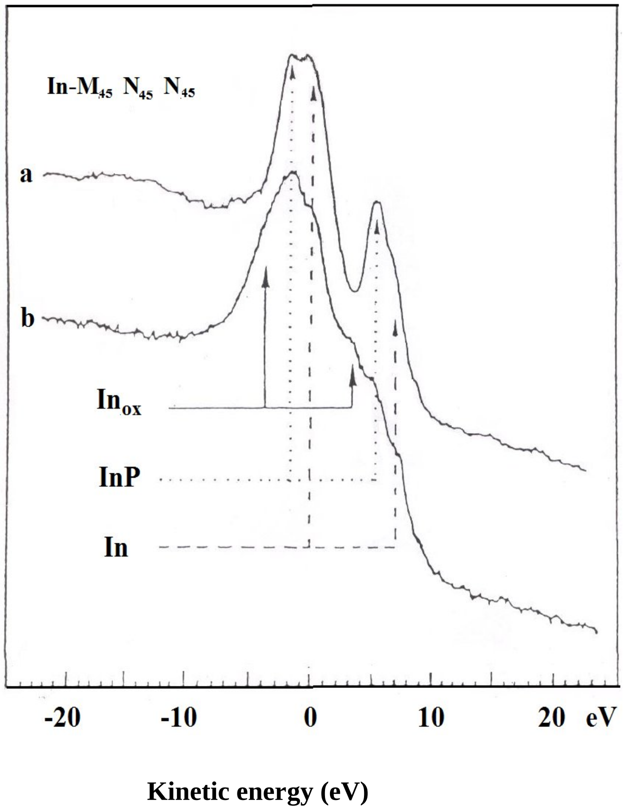

Fig.4 AES signal In-MNN (a) elemental In and (b) oxidized In.

Other result of the beam electron bombardment is the carrier screening of the internal electric field commonly named the space charge effect. On figure 5 we record, for the compound In_20_3/ InP the variation of the absorbed intensity as function of the electron beam energy. Figure.6 shows that the X-Ray intensity of In_20_3/ InP varies strongly, with the incident electron beam energy while the X-Ray intensity of ZnO/InP does not seem one.

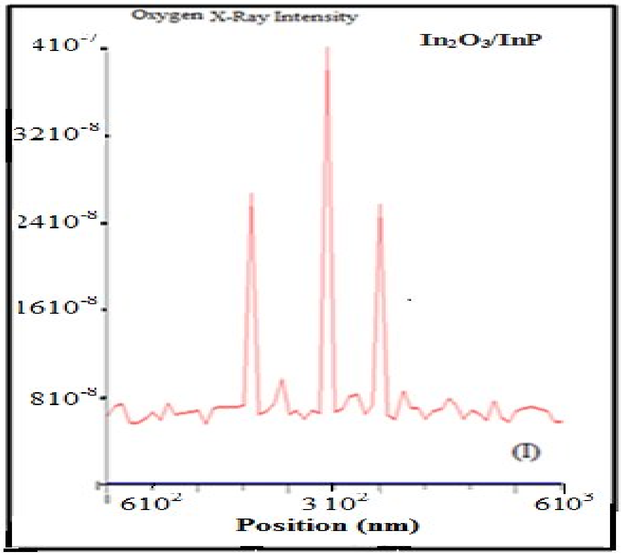

Fig.5 Casino oxygen X-Ray intensity as function of electron beam position on In_2O_3 oxide detected on InP substrate.

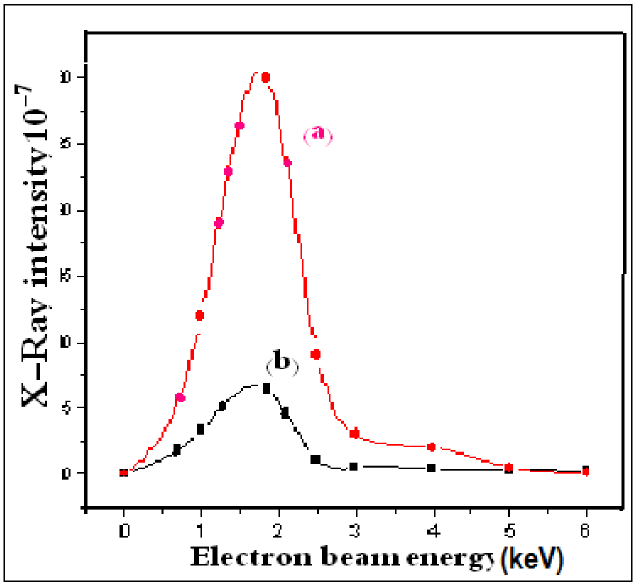

Fig.6 X-Ray intensity variation as function of electron beam energy on oxides: (a) In_2O_3/InP and (b) ZnO/InP.

7. Conclusion

In this work we have used AES, EELS and Casino simulated program to study the thin film ZnO grown on InP(100) by cathodic sputtering method. The growth of ZnO has been done without interdiffusion of elements Indium and Phosphorus. Further, ZnO does not seem to be subject to a charge effect in AES.

References

[1] K.Ogata,K.Koike,S.Sasa,M.Inoue,M.yano Applied Surface Science 254(2008)7708.

[2]J.C.Fan,Z.Xie, Applied Surface Science 254(2008) 6358.

[3] J.P.Kar,S.W.Lee,W.Lee,J.M.Myoung Applied Surface Science 254(2008) 6672.

[4] Shoubin Xue, Xing Zhang,Ru Huang Huizhao Zhuang Applied Surface Science 254(2008) 6766.

[5] M.H.Weber,F.A.Selim,D.Solodovnikov,K.G. Lynn Applied Surface Science 254(2008) 68.

[6].M.Bouslama,M.Ghamnia,C.Jardin, M.Bouderbala, B.Gruzza Vacuum 47(1996)1353

[7E.Vasco,O.Bohme,E.Roman J.Phys.Chem.C,111(2007) 3505

[8] A. V. Bulgakov, A. B. Evtushenko, Yu G. Shukhov, I. Ozerov, W Marin Quantum Electronics 40 (2010)1021.

[9] V.Consonni,G.Rey,I.Benaime,N.Karst,B.Doisneau, H.Roussel,,S.Renet,D.Bellet Applied Physics Letters 98(2011)111906

[10].A.Ouerdane,M.Bouslama,M.Ghaffour, A.Abdellaoui, K..Hamaida, Z.Lounis, Y.Monteil, N.Berrouachedi, A.Ouhaibi Applied Surface Science 254 (2008) 7394.

[11] D. Drouin, A.R. Couture, D.Joly, X.Tastet, V.Aimez, R Gauvin, Journal Scanning Electron. 49 (2007) 92

.