Extended Abstracts of the 1992 International Conference on Solid State Devices and Materials, Tsukuba, 1992, pp. 260-262

Broad Area Electron Beam Enhanced Passivation Treatment of Sulfur Surface of GaAs

Y.C.DU, H.WANG, D.C.SUN AND F.M.LI

Department of Electronic Eng.,Tri-beams open Lab and
Department of Physics, Fudan University, Shanghai,200433,CHINA

The passivation treatment for ammonium sulfide $(NH_4)_2S$ on GaAs surface by using a broad area(<2.2KeV,50 mm i.d.) EB excitation source,Which is based on cold cathode glow discharge of secondary emission, has been performed. The results of AES data indicate that the S layer on GaAs is not one monolayer. Characteristics of XPS have shown that EB irradiation treatment(about 15-30 sec,at 2.2KeV) results in the core level shifts for As(2p) peak. This enhanced passivation with electronic excitation effects for dissociation of $(NH_4)_2S$ molecular shows that the treated GaAs surface could form S-GaAs strong bonding due to overcome a kinetic barrier.

1. INTRODUCTION

Up to now,The discovery of the passivation effects of the alkaline sulfide had led to a number of studies of sulfide treated GaAs surface [1-6]. However, it is important to provide an effective method how to passivate treatment for sulfide such as $(NH_4)_2S$ on GaAs. With respect to the choice of passivation proceduces for sulfide treated GaAs, an effective treating method for GaAs with Na_2S or $(NH_4)_2S$ would result in strong bonding between the S and GaAs under the presence of an excitation source.

In this paper, We have described a kind of method for passivation procedure for the sulfide treated GaAs by a broad area(50 mm i.d.) low energy (<3.0 KeV) electron beam irradiation , which regards as an excitation source for a strong S-GaAs bonding. This paper reports the results of characteristics of AES and XPS analysis of $(NH_4)_2S$ treated GaAs surface; AES was used to get some information of As,S,Ga species along the in- depth profile, XPS data have shown S-GaAs bonding configuration after the e-beam irradiation. The results of experiments might be explained with a model of effective passivation.

2. EXPERIMENTAL

The specimen was etched in a solution of H_2SO_4/ H_2O_2/ H_2O, after that, the wafer was placed into a solution of $(NH_4)_2S$ with different soak time (0.5-24 hr). Prior to treating chamber,the specimen capped with a thin layer of photo-resist (about less than 0.5 μm) was subjected to irradiate with a low energy (<2.2 KeV) electron beam excitation source,which was similar to one previously described [7].

3. RESULTS AND DISCUSSION

After treating the specimen in He ambient (0.5 torr) using this e-beam irradiation for 15-30 sec at lower energy of about 2.2 KeV without wafer or beam scanning.Fig.1 shows a survey spectra,Signals of oxygen and carbon species were observed on the surface, they are lower than sulfur signal.

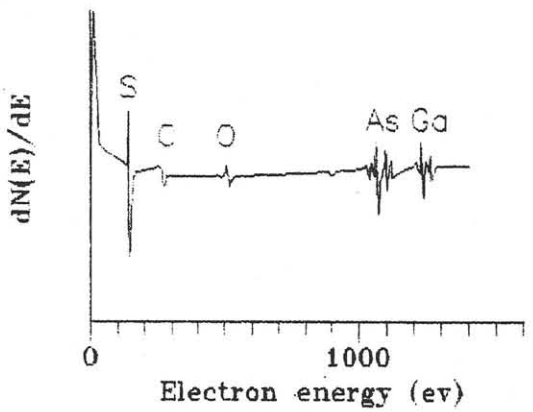

Fig.1 The AES survey spectra after EB enhanced passivation treatment.

Just as shown by Fig.2, S signal of the e-beam untreated sample is lower than that one of the treated beneath GaAs surface. The results of the EB treated sulfide GaAs indicate that the S layer on GaAs is not one- monolayer. It might be explained that EB (<3.0 KeV) bombardment of tha S-GaAs surface could induce and enhance electronic excitation effects. This is suggestive of non-chemisorption process.

As we know, In the electron energy range of 0.5-3.0 KeV, via low energy electron irradiation and secondary emission, a mechanism of electron induced and enhanced surface processes has been discussed by Kunz and Mayer [8], Again, as reported by Massies et al.[9] the adsorption of H_2S on GaAs is extremely sensitive to electron irradiation of the GaAs surface. The electron ,ion beam or substrate heating could dissociate the H_2S molecular to form the more reactive S or HS molecular.

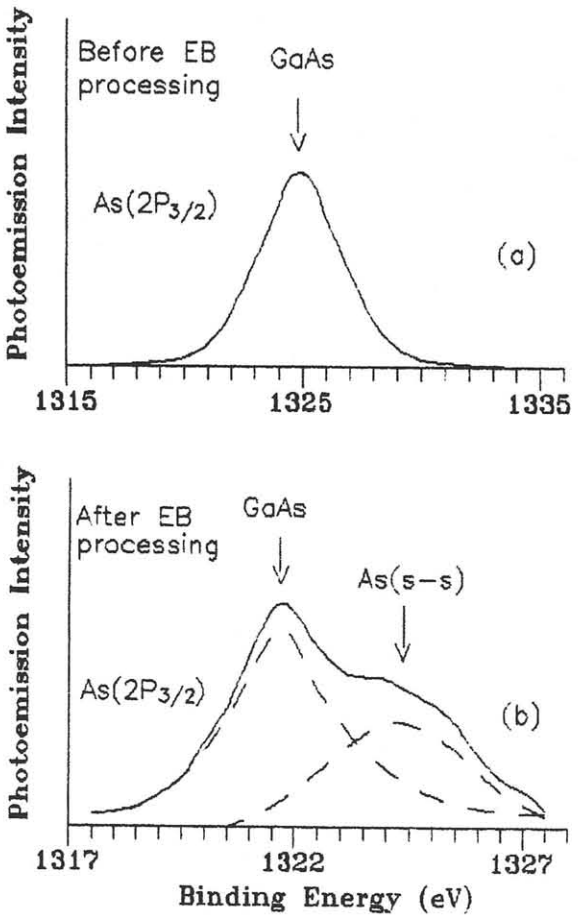

Fig.3 As($2p_{3/2}$) XPS spectra for sulfur-treated GaAs surface after broad area EB irradiation enhanced passivation for the same parameters as in Fig.2(b).

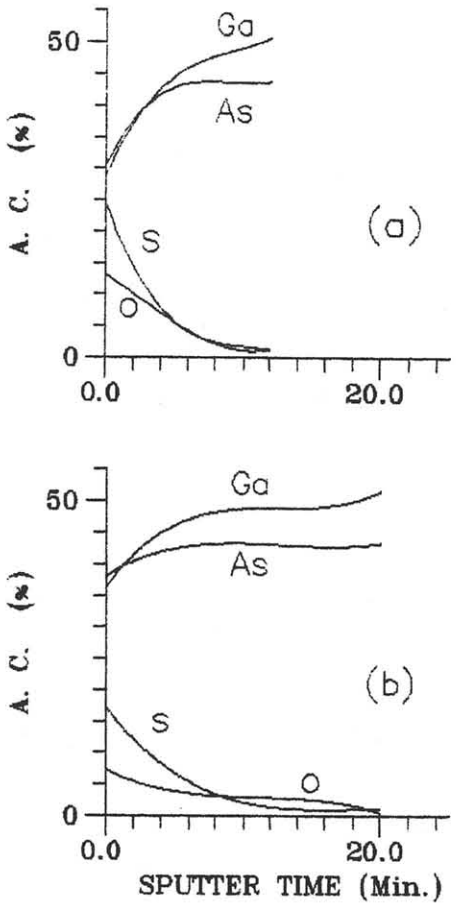

Fig.2 AES depth profile from sulfur-treated GaAs surface before (a) and after (b) the proceesing in He ambient by EB irradiation 30 s,at 2.2 KeV.

On the other hand, XPS is more suitable for identification of S-GaAs chemical reaction. Fig.3 shows representative As(2p) line for $(NH_4)_2S$ treated GaAs surface after e-beam irradiation. There is asymmetry shoulder and core level shift for As(2p) peak, XPS spectra of the sample may be decomposed into two specified Gaussian peaks, they are 1321.7 eV (GaAs) ,and 1324.5 eV (As-S-S) separately from this XPS data, it was shown that S-GaAs strong bonding, which results in XPS core level shift,could be mainly caused by a chemical reaction ,it is important to offer an excitation source for causing a chemical reaction, which breaks back bonds of the substrate and overcomes the kinetic barrier if an energy source such as electron,heat or light could be used.[10]

4. SUMMARY

This paper has briefly demonstrated some aspects of characteristics of XPS and AES for this kind of passivation treatment for ammonium sulfide on GaAs by the low energy broad area e-beam excitation source. As explained by a model proposed which includes a kinetic barrier to S-GaAs chemical bonding and requirement of an excitation source for the effective passivation treatment, the analysis with this enhanced passivation shows that the treating GaAs with sulfide ($(NH_4)_2S$) could form S-GaAs strong bonding due to overcome a kinetic barrier.

5. REFERENCES

1) J.Sandrof,N.Nottenburg,C.Bischoff and R.Bhat,Appl.Phys Lett.51(1987) 33.
2) N.Notteenburg,J.Sandrof,A.Humpgrey,H.Hollen beck and R.Bhat,Appl.Phys.Lett.52(1988) 218.
3) J.Skromme,J.Sandrof,E.Yablonovitch and T.Gmitter Appl.Phys. Lett. 51(1987) 2022.
4) S.Carpenter,R.Melloch,S.Lundstrum and P.Tobin Appl.Phys.Lett. 52(1988) 2157.
5) R.Iyer,R.Chang,A.Dubey and L.Lile, J. Vac. Sci.Technol.B6(1989) 1174.
6) R.Lunt,G.Santangero and S.Leiws,J.Vac. Sci.Technol.B9(1991) 2333.
7) Y.C.Du,H.Wang,G.B.Jiang,D.C.Sun,Z.Q.Yu and F.M.Li,Thin Solid Films,163(1988) 349.
8) R.R.Kunz and T.M.Mayer,J.Vac.Sci. Technol.B5(1987) 427.
9) J.Massies,F.Dezaly and T.Linh,J.Vac. Sci.Technol.17(1980) 1134.
10) J.Shin,M.Geis,W.Wilmsen and Z.Lil-liental-Weber,J.Vac.Sci.Technol.A8 (1990) 1849.