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Characterization and Improvements of Metal-p Type ZnSe Interfaces

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Surface and interface characteristics of metal-p type ZnSe system has been studied by resonant Rutherford Back Scattering (RBS) and X-ray Photoelectron Spectroscopy (XPS) techniques in connection with the metal contact properties. These experiments have revealed the surface oxide layer which mainly consists of SeO_x (x=2). The surface layer is found to correlate with an extraordinarily large potential barrier observed in the metal (Au)- p type ZnSe interface. A new simple etching process with a saturated bromine water (SBW) is proposed to improve the potential barrier of Au-p ZnSe electrical contacts.

1.Introduction

Striking progress in the development of II-VI wide bandgap semiconductor heterostructure optical devices, coupled with seminal advances in conduction-type controlling[1-2], has led the demonstration of blue-green laser diodes at low temperature[3]. A great deal of efforts has been continued to improve the qualities of the laser diodes and heterostructure crystal films, and at present stage, a continuous room temperature operation has been obtained[4]. At the same time, a series of this research has revealed an existence of substantial issues in order to attain a practical application of these laser diodes at room temperature. A major issue which can now be identified is its small lifetime, which can reflect (i) an extraordinarily large potential barrier in unohmic metal contact to p-type ZnSe top layers, and (ii) uncontrolled macro- and micro-defects[5] in the p type layer and the heterostructure interfaces.

This paper addresses in part of the first issue; characterization of p type ZnSe surfaces and metal-interfaces, and the improvements in the electrical contact properties.

2. Experimental

The samples used in this study are active nitrogen doped p type ZnSe films on GaAs substrates, grown by a conventional molecular beam epitaxy (MBE). Metal(Au) -p type ZnSe interfaces are examined by resonant Rutherford Back Scattering (RBS) using high energy particle (7 MeV ^4He), specially focussing on detecting oxygen atoms in the interfaces (Fig.1). Crystal surfaces are traced by X-ray Photoelectron Spectroscopy (XPS) technique in combination

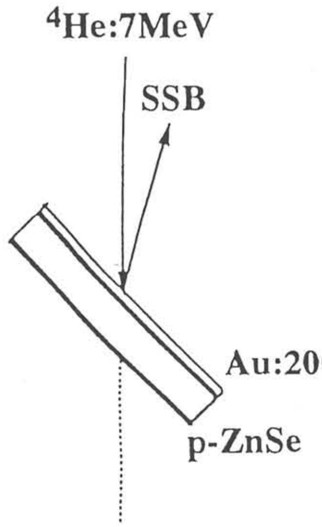

Fig.1 Configuration of RBS experiment

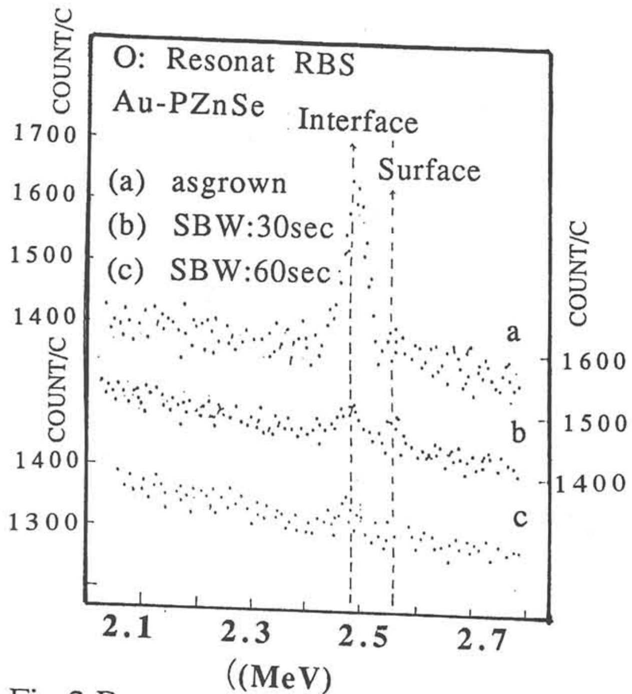

Fig.2 Resonant RBS spectra for interface Oxegen in Au (200 Å) -p ZnSe contacts

with the RBS results. Electrical properties of Au electrode to p ZnSe is studied by monitoring the current-voltage (I-V)characteristics. In order to improve the contacts electrical properties a surface treatment is carried out using a saturated bromine water (SBW) etching solution.

3. Result & Discussion

Figure 2 shows RBS spectra for Au-p type ZnSe interfaces. Clear RBS signals on interface oxygen atom (at 2.48 MeV) are detected for the interface without SBW treatment. The oxide layer thickness is evaluated as 20-50 A. After SBW treatment RBS signals from the interface are found to decrease, which are shown by spectrum b and c in Fig.2.

An XPS experiment is done to determine the oxide compound at the interface layer. Figure 3 shows XPS spectra of p type ZnSe surfaces on the Se 3d electron before and after surface etching. Before SBW treatment, a new signal peak (at 59 eV) can be observed in lower energy region of the Se 3d main peak. This peak signal is always detected for both MBE and MOVPE grown p ZnSe surfaces without surface treatment, and the chemical shift from main Se 3d peak ranges from 58 eV to 60 eV. With the

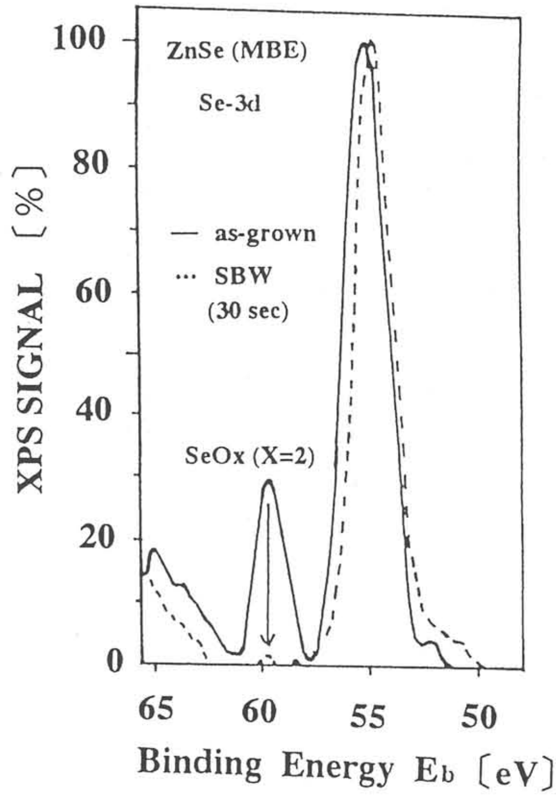

Fig.3 XPS spectra for as-grown and SBW treated surfaces of p type ZnSe

RBS experimental results the origin of this new peak is assigned as SeOx (x=2). After SBW treatment for 30-60sec, this peak was completely disappeared. The SBW etching effect on XPS signal is consistent with those obtained in the RBS experiment shown in Fig.2. These results strongly suggest that the surface(or interface) of p ZnSe is covered with insulating Se oxide layer which can cause large potential barrier in metal-ZnSe contacts.

Interface potential barrier (V_b) observed in Current-voltage(I-V) characteristics of Au contact to p type ZnSe films(on s.i GaAs) is shown in Fig. 4 as a function of effective carrier (N_a-N_d) concentrations. In this experiment the I-V curves are measured in two separated Au electrode (distance L=2 mm) on the p ZnSe surface. From Fig.4 interface potential barrier is large and depends on the carrier concentration. In case of highly doped p type ZnSe (N_a-N_d=$1x10^{18}cm^{-3}$), the interface barrier becomes small (V_b=3-5V). Potential barrier V_b is found to markedly decrease by the SBW treatment for 60 sec, which is also shown in Fig.4. The effect of the SBW treatment is very clear in low carrier concentration sample. This results, together with the XPS and RBS experiments, indicates that the origin of extraordinarily large potential barrier in the Au-p ZnSe contacts is mainly caused by an insulating oxide layer (20-50 A) of as grown p ZnSe crystal surfaces. Therefore, it is possible to realize a practical electrical contacts to p type ZnSe top layers of blue-green laser diodes by carrier high doping technique and optimum surface treatment like the present SBW etching.

4. Summary

Surface and interface have been studied of MBE grown p type ZnSe and metal(Au)-p type ZnSe contacts using RBS and XPS techniques.

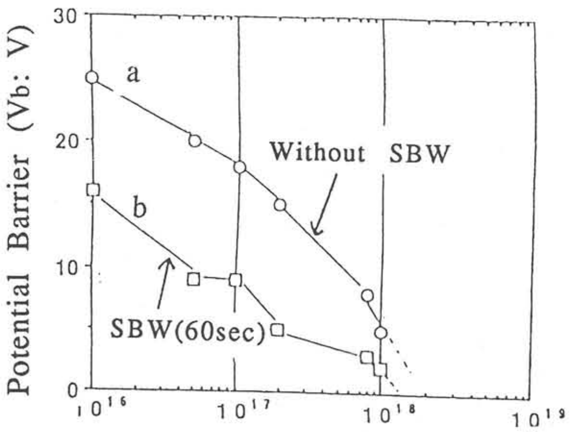

Fig.4 Observed potential barrier of Au-p ZnSe contacts (a:without SBW, b:with SBW treatment)

It is found that the surface of as grown ZnSe is covered with insulating SeO_2 layers which cause an abnornally large potential barrier in the Au-p ZnSe contacts. A new simple and effective surface treatment using SBW etching solution is propopsed, which is found to improve an electrical contact property drastically.

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