

## Sym. B : Compound Semiconductors for Electronic & Photonic Devices

### GaN & RELATED MATERIALS-II

#### D-THU-18

INTERFACIAL REACTIONS AND THERMAL STABILITY OF (Ti,Al,Au) METALLISATION SCHEMES TO n-GaN, H.K. KIM, J.S. JANG, I.S. CHANG, T-Y. SEONG, S.H. LEE, S-J. PARK

(Department of Materials Science and Engineering, K-JIST Kwangju. 506-712, Korea )

Ti(50nm), Al(50nm), Ti(50nm)/Al(100nm), and Ti(50nm)/Au(100nm) thin films were deposited on n-type GaN substrates ( $\sim 10^{18} \Omega \text{cm}^{-2}$ ) by electron beam evaporation under high vacuum condition ( $5 \times 10^{-7}$  torr). After the metal deposition, all the samples were subsequently annealed in  $\text{N}_2$  atmosphere for 30s at temperatures of 500°C and 600°C. Auger electron spectroscopy (AES) and x-ray diffraction (XRD) have been used to characterise interfacial reactions and thermal stability of (Ti,Al) metallisation schemes to n-type GaN. It is shown that both TiN and AlN phases are formed at the interface between the Ti/Al film and the GaN layer. For comparison, Ti/Al and Ti/Au contacts are investigated. AES and XRD results show that the TiN phase is more effective diffusion barrier for Ga atoms than the AlN phase. Based upon structural and chemical data, a model is presented to describe possible mechanisms for the interfacial reactions between the Ti- and Al-based alloys and the GaN layers.

#### D-THU-19

DEVELOPMENT AL-FREE OHMIC CONTACT TO n-GaN, DAE-WOO KIM, JOON SEOP KWAK, HONG KOO BAIK (Dept. of Metallurgical Eng. Yonsei University, Seoul, 120-749, Korea), CHA YEON KIM, SUNG WOO KIM (LG Corporate Institute of Technology, 16 Woomyeon-Dong, Seocho-Gu, Seoul 137-140, Korea)

III-V nitrides are promising materials not only for optical devices in the blue region of visible spectrum, but also for high speed electronic power devices. A problem to overcome in achieving high performance of GaN-based devices is the realization of good reliable ohmic contact. Up to the present, Ti/Al system have been widely used as n-type ohmic contact. Although Ti/Al based contacts have the lowest contact resistance, these show the poor surface morphology and poor thermal stability because of low melting point of Al metal. In this study, we investigated the electrical properties and interfacial reactions of the Si/Ti based ohmic contacts to n-GaN layers grown by metal organic chemical vapor deposition (MOCVD) and the electrical properties were related with the material reactions. Contact resistance was evaluated using the transmission line method. In order to obtain the required current path, mesas were etched by reactive ion etching (RIE) and TLM pattern was prepared by standard metal lift-off technique and photolithography. Si/Ti based ohmic contacts showed very good ohmic characteristics after annealing at 700°C for 3min. According to the results of material reaction analysis, the good ohmic characteristic of Ti-Si base contact was due to Ti Silicide, which has low work function.

## Sym. B : Compound Semiconductors for Electronic & Photonic Devices

### II - VI & RELATED MATERIALS

#### D-THU-20

Cathodoluminescence and Photoluminescence of Zinc Oxide Single Crystals Grown by a Flux method

N.Ohashi, T.Sekiguchi\*, T.Ohgaki, Y.Wada\*\*, H.Haneda\*\*, T.Tsurumi, J.Tanaka\*\*

Dept. Inorg. Mater., Tokyo Inst. Tech., Tokyo 152-1552 Japan

\*Inst. Mater. Res., Tohoku Univ., Aoba, Sendai 980 Japan

\*\* Nat. Inst., Res., Inorg., Mater., Namiki, Tsukuba, 305 Japan

Zinc oxide is applicable to optical devices in ultraviolet region because of its wide band gap, 3.3 eV, and large exciton binding energy, 60 meV. Further more, zinc oxide single crystal is considered to be suitable substrate for the formation of GaN thin film devices. In the present study, single crystals of ZnO have been grown by a flux method using  $\text{PbF}_2$  and their properties, especially defect related photo emission, was studied by measuring photoluminescence, cathodoluminescence, electron spin resonance and secondary ion mass spectra. The grown crystal had hexagonal platy shape and was typically  $25 \text{ mm} \phi \times 0.5 \text{ mm}^t$  in size. A nominally pure single crystal never gave defect related emission and only ultra violet emission was found. In the doped single crystal, defect related emission was found in visible light region and the profile of light emission spectra was varied with kind of doped elements and thermal treatment. In this paper, three possible assignment for the visible light emission of zinc oxide are proposed.

#### D-THU-21

PHASE EQUILIBRIA WITH VAPOR IN THE Cd - Ge - As SYSTEM, George D. NIPAN

(Kurnakov Institute of General and Inorganic Chemistry Russian Academy of Sciences, Leninsky pr. 31, Moscow, 117907, Russia).

Phase equilibria with vapor in the Cd - Ge - As semiconductor system were investigated in the 800 - 1200 K temperature and 0.1 - 100 kPa pressure ranges by static tensimetric method with quartz Bourdon manometer. The existence of metastable phase  $\text{Cd}_4\text{Ge}_3\text{As}_5$  was confirmed. It was detected that the stable phase  $\text{Cd}_2\text{GeAs}_4$  is actually the solid solution based on  $\text{CdGeAs}_2$ , which dissolves up to 30 mol.%  $\text{CdAs}_2$  and has the polymorphous transition at 820 - 830 K. The  $p, T$  coordinates and the composition of melt in the six nonvariant equilibria "three crystal phases - melt - vapor" were determined. The partial pressures of  $\text{Cd}$ ,  $\text{As}_4$  and  $\text{As}_2$  molecules in the vapor, the vapor composition  $X_v$  at fixed temperatures in the mono- and nonvariant equilibria and the enthalpy of formation  $\Delta_f H^\circ(\text{CdGeAs}_2, \text{cr.}, 298.15) = -(4.5 \pm 3.0) \text{ kJ/mol}$  for stoichiometric  $\text{CdGeAs}_2$  were calculated. The  $(p, T, x, y)$  phase diagram for the Cd-Ge-As system from static tensimetric, XRD and DTA data was mapped out.