

B-6-3 Quantitative In-depth Profile of Passivated Oxide Layers of GaAs by AES-SIMS - a Comparison of Thermal, Anodic and Plasma Oxidation

K.Watanabe, M.Hashiba and T.Yamashina
 Department of Nuclear Engineering, Faculty of Engineering,
 Hokkaido University, Sapporo, Japan

Introduction In order to establish the technology of GaAs devices, there have been a number of investigations recently, in which one of the most important problems may be suitable choice of passivation methods to form homogeneous native-oxide on GaAs crystal. In the present study, we will describe a comparison of the in-depth profile of surface passivated (oxide) layers prepared* by thermal¹⁾, anodic²⁾ and plasma³⁾ oxidation, by means of a simultaneous measurement of AES-SIMS with a proposed quantitative analysis for complicated oxide layers.

Experimental An Auger system(Varian) with a CMA optics with an internal electron gun and a secondary ion mass spectroscopy(SIMS) system are equipped together to a conventional UHV chamber which can be evacuated down routinely to 5×10^{-10} Torr. Further aspects of the simultaneous measurement of AES-SIMS ha been described elsewhere^{4,5)}

Quantitative Analysis of In-depth Profile Peak-to-peak height H_α from an element α in a derivative AES spectrum is considered to be proportional to atomic concentration X_α as⁶⁾

$$H_\alpha = k_\alpha X_\alpha \dots\dots\dots(1)$$

where k_α is denoted as AES sensitivity of the element α . In the present study, the AES sensitivities of Ga, As and O are determined following Pons et al⁷⁾. When the AES sensitivities are known, the atomic concentration of each element is estimated as

$$X_{Ga} = H_{Ga}/k_{Ga}, X_{As} = \delta_{As} H_{As}/k_{Ga}, X_O = \delta_O H_O/k_{Ga} \dots\dots\dots(2)$$

where $\delta_{As} = k_{Ga}/k_{As}$ and $\delta_O = k_{Ga}/k_O$, which are denoted as the relative sensitivity of As and O, respectively.

The relative sensitivities are determined on variously prepared oxide layers and summerized in Table 1. As seen in the Table, the relative sensitivities such as δ_O^{oxide} and δ_{As}^{bulk} agree well with those estimated from the literature⁸⁾, while the others significantly differ from the literature. It has been also found that the relative sensitivity in such systems as Cu-Au, Ta-O, Ta-N and Ta-C changes with concentration⁹⁾.

Table 1. AES relative sensitivity

	δ_{As}^*	δ_O^{**}
GaAs(Bulk)	2.31±0.20	—
Interface	3.42±1.09	0.19±0.07
Oxide Layer	4.25±0.45	0.36±0.02

$$\delta_{As}^* = k_{Ga}/k_{As}, \delta_O^{**} = k_{Ga}/k_O$$

Comparison of In-depth Profile of Passivated Layers By applying the relative sensitivities summerized above, quantitative in-depth profiles of each sample were

* Samples by thermal and plasma oxidation were furnished by T.Sugano's Lab.(Univ. of Tokyo) and anodic oxidation by H.Hasegawa's Lab.(Hokkaido Univ.)

determined. Fig. 1 shows a typical example of the profile of thermally oxidized GaAs (620°C, 5hr in dry air). It can be seen that As does not exist in the oxide layer and chemical composition is Ga_2O_3 .

Inside the interface (which is defined as where the amount of oxygen decreased to the half value of that of the oxide layer) a large pile-up of As was observed. It was also found that the pile-up and the thickness of the transition layer between the oxide and the GaAs bulk increased with higher temperature of the oxidation. Figs. 2 and 3 show examples of the profile of passivated layers by anodic and plasma oxidation, respectively. Characteristic common to both passivated layers is the fact that nearly ^{the} same amount of Ga and As exists in the oxide layers without any pile-up. A distinct difference between the two is content of oxygen in the oxide, the chemical composition being estimated as $GaAsO_{1.7} \sim 2.0$ for anodic oxidation and $GaAsO_{1.0}$ for plasma oxidation.

SIMS Measurement Information from SIMS measurements will be described concerning especially with the chemical constituents of the transition layers for each sample.

References 1) F.Koshiga and T.Sugano, Japanese J.Appl.Phys.Suppl.16-1(1977),465, 2) H.Hasegawa and H.Hartnagel, J.Electrochem.Soc.,123(1976),713, 3) T.Sugano and Y.Mori, J.Electrochem.Soc.,121(1974),113, 4) M.Mohri, M.Hashiba, K.Watanabe and T.Yamashina, submitted to J.Catalysis, 5) M.Mohri, H.Kakibayashi, K.Watanabe and T.Yamashina, submitted to Appl.Surface Sci., 6) R.E.Weber and A.L.Johnson, J.Appl. Phys.,40(1969),314, 7) F.Pons, J.Le Héricy and J.P.Langeron, Surface Sci.,51(1975),336, 8) P.W.PalMBERG, G.E.Raich, R.E.Weber and N.C.MacDonald, "Handbook of Auger Electron Spectroscopy", Phys.Electr.Ind.Inc.(1972), P.M.Hall, J.M.Marabito and D.K.Conley, Surface Sci.,62(1977),1

The expenses of the research were defrayed by a grant "Surface Electronics" from the Ministry of Education of Japan.

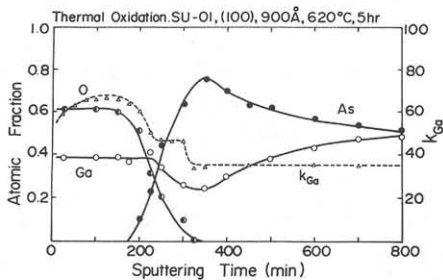


Fig.1. In-depth profile of passivated layer by thermal oxidation

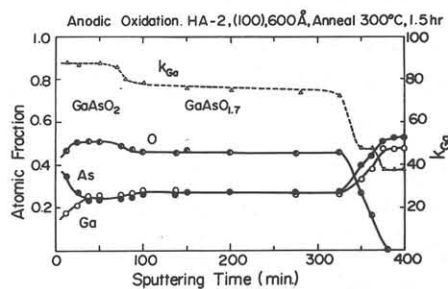


Fig.2. In-depth profile of passivated layer by anodic oxidation

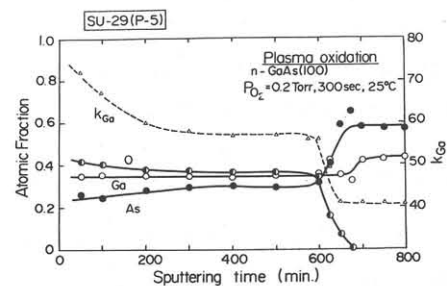


Fig.3. In-depth profile of passivated layer by plasma oxidation