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Study of Heterogeneous Structure in $GaAs_{1-x}P_x$ by Anodization-Electroreflectance Technique

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Heterogeneous structures(or graded band-gaps) in semiconductor alloys are often found in electronic devices, for instance, in solar cells, epitaxial wafers, and heterojunction interfaces. It is of vital importance for the development of these devices to know the depth-profiles of the alloy composition, in other words, the band-gap energy in the heterogeneous structure.

In this report we propose a newly combined technique of the successive anodization - layer removal and electrolytic electroreflectance measurement (AE technique), and report, as an example of its application, a depth-profile of the alloy composition x in the transition layer of one of $GaAs_{1-x}P_x$ epitaxial wafers on the basis of our experimental data about the anodization of $GaAs_{1-x}P_x$ with the whole range of x.

The growth rate of $GaAs_{1-x}P_x$ determined by ellipsometry is shown in Fig.1 where the anodization was carried out by the constant current method under illumination in magnetically stirred electrolyte which was a mixture of one part of 3 % aqueous solution of tartaric acid and two parts of propylene glycol, and the current density was kept at 3.0 mA/cm^2. These data indicate that the growth rate varies linearly with the alloy composition. The ratio of the consumed thickness to the anodized layer has been found to be 2/3 over the whole range of x from talystep and interferometry measurements.

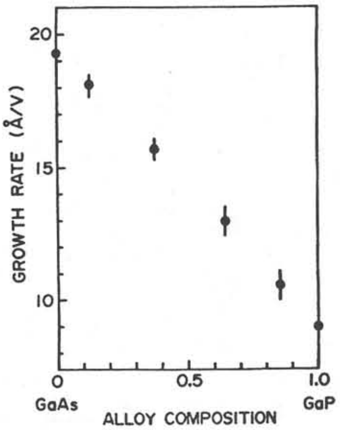

Fig. 1 Growth rate-vs-the alloy composition of $GaAs_{1-x}P_x$.

Using these data, the depth-profiles of the band-gap energy of the E_1 optical transition (open circles) and the corresponding alloy composition x (closed circles) of $GaAs_{0.63}P_{0.37}$ wafer have been obtained, as shown in Fig.2, where electrolytic electroreflectance measurements were made in the *same* electrolyte as used in the anodization, and 167 cycles of the anodization with the total forming voltage 47000 V were performed. The stripped thickness of this wafer was 52 µm. Figure 2 indicates that the width of the transition layer is 32 µm, and x varies almost linearly from $GaAs_{1-x}P_x$ epitaxial layer to GaAs substrate.

Figure 3 shows one of the electroreflectance spectra near the E_1 transition of $GaAs_{1-x}P_x$ obtained on the way of sectioning. This spectrum has been found to be represented by the low-field resonant function and to be analyzed by the use of three point method.[1)]

Applying this method to the spectrum shown in Fig.3, the energy value for the E_1 transition is estimated and indicated by an arrow, and it corresponds to the alloy composition of $x = 0.04$.

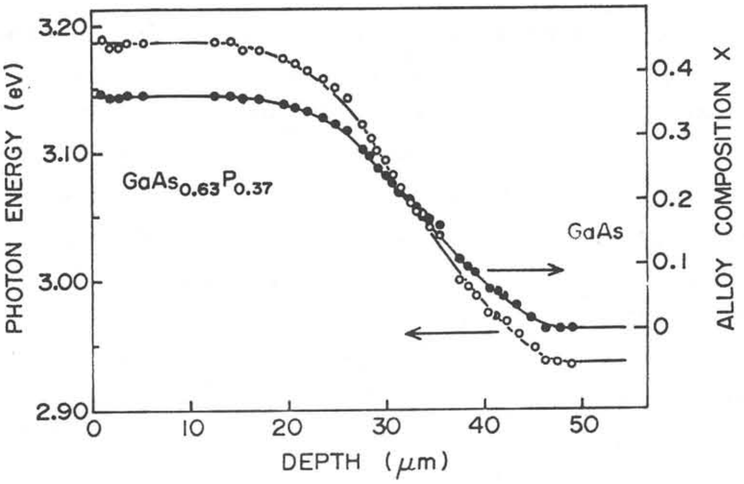

Fig. 2 Depth-profiles of the band-gap energy of the E_1 transition (open circles) and the corresponding alloy composition (closed circles) of $GaAs_{0.63}P_{0.37}$ epitaxial wafer obtained by the AE technique.

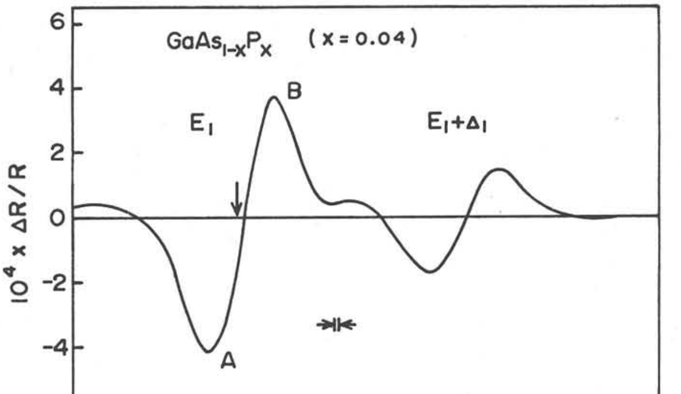

Fig. 3 Electroreflectance spectrum measured in the semiconductor-electrolyte configuration. This spectrum was taken at room temperature in the low-field condition.

1. D.E.Aspnes and J.E.Rowe: Phys.Rev.Letters 27 (1971) 183.