A STUDY OF Zn DIFFUSION IN InP AT LOW TEMPERATURE

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Abstract

The diffusion of Zn in InP at low temperature is investigated. The experiment is accomplished in an evacuated and sealed quartz ampoule using Zn$_3$P$_2$ as the source of Zn.

The electrical characteristics of the diffusion samples obtained by the isothermal process and the two-temperature process have been compared. It is found that with the two-temperature process one can obtain a smooth, damageless and high-concentration surface layer. This process has been applied to fabricate InGaAsP/InP light emitting diodes, and the diodes obtained have an output power of ~1mW with a series resistance of 2—5Ω. The behaviors of Zn diffusion in InP are discussed.

I. Introduction

With the development of optical communication systems operating in the wavelength range of 1—1.6 μm, the InGaAsP/InP double heterostructure light emitting diodes, semiconductor lasers and detector devices have received extensive attention. The diffusion of Zn into InP is an important technique. A number of reports have been published on this aspect recently[1—8].

In order to fabricate InGaAsP/InP DH LED, the diffusion of Zn into InP at low temperature is investigated. In this report, the two-temperature zone diffusion method at low temperature has been examined. A smooth as well as homogeneous concentration distribution in Zn, reproducible and damageless high-concentration surface layer can be obtained by this process. The diffusion behaviors of Zn in InP will be discussed.

II. Experimental Procedure

The InP was single-crystal material cut in a (100) orientation. It was n-type Sn-doped with a carrier concentration of 5×10$^{18}$cm$^{-3}$. The slice of InP was chemically polished. Small pieces were placed in a 10m$^{-3}$ ampoule along with Zn$_3$P$_2$ and P, evacuated to 3×10$^{-5}$ torr and then sealed off[8].

After diffusion, a bar was cleaved from each sample and stained with a solution of K$_3$Fe(CN)$_6$. The junction depth was measured by the microscope, scanning electron microscope or electrochemical C—V method[16]. The results obtained by these methods are in good agreement with each other. For carrier concentration measurements the Van der Pauw technique and electrochemical C—V method were used.
III. Results

1. Relation of the $x_j - \sqrt{t}$

The relation of the depth of $p$-$n$ junction versus the square root of the time is shown in Fig. 1. From the results shown in Fig. 1, it is found that the $x_j - \sqrt{t}$ is obviously linear, if the diffusion is accomplished at the same temperature. Fick’s law is adequate to describe this diffusion process. At the same time, $x_j$ increases rapidly as the diffusion temperature increases. The relation of $x_j$ versus $\sqrt{t}$ in the isotemperature process and the relation of $x_j$ versus $t$ in the two-temperature process (source temperature is 30 — 40°C higher than the sample temperature) are identical.

The front of $p$-$n$ junction was observed by SEM, and shown in Fig. 2. The result seen in Fig. 2 indicates that the front of $p$-$n$ junction is smooth and plain. The scanning analysis carried out by Auger electron spectroscope found that the content of Zn is uniform in the diffusion layer.

![Fig. 1 Relation of junction depth vs. square root time](image1.png)

![Fig. 2 The front of $p$-$n$ junction](image2.png)

2. $C_s - \frac{1}{T}$

The reciprocal of the diffusion temperature versus surface acceptor concentration, $C_s$, is plotted in Fig. 3. The results seen in Fig. 3 exhibits that $C_s$ increases as $\frac{1}{T}$ decreases. The linear relation is very good in the temperature range of 500 — 700°C. It can be expressed as: $C_s = (C_s)_0 \exp\frac{-Q}{k_T}$ where $Q = 1.86$eV, $(C_s)_0 = 1.058 \times 10^{10} \text{cm}^{-8}$. 