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B—6—7 Electrical Properties of Mo/III-V Compounds Schottky Barriers

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Because of the advent of using high power III-V MESFET devices, the need for a high reliability metallization technology becomes more crucial. The electrical characteristics of Schottky barrier contacts are generally very sensitive to the interdiffusion of constitutents in the vicinity of the metal-semiconductor interface. Therefore, a preferred approach for improving the reliability of Metal-Semiconductor contacts is to utilize systems that are metallurgically non-reactive. In recent years, many transition metals are considered and investigated metallurgically as possible candidates for III-V Schottky barriers. Due to the large difference of electronegativity and thermal expansion coefficient between these metals and III-V compounds, interdiffusion, compound formation and lack of adhesion are existed.[1] For these reasons it is interesting to find and investigate new Schottky barrier structures with near-ideal electrical properties. The early transition metal, Mo, which has the relatively small electronegativity[1] and thermal expansion coefficient closed to that of GaAs.[2] It prompts us to prepare the Mo/III-V compounds contact and study the Schottky barrier properties of these contact systems.

The (100) III-V compound semiconductors used are n-type with the carrier concentration in the range of $5\times10^{16}-10^{17}$ cm^{-3}. The 88:12 weight parts Au-Ge eutectics are evaporated and annealed for back surface ohmic contact formation. The 0.1 μm Mo is electron-beam evaporated at a rate of 3Å/sec in the background pressure less than 7×10^{-7} torrs to reduce oxidation. After the Mo evaporation at different substrate temperature, the samples are annealed for 10 minutes in the dried N_2 gas and the temperatures varied from 200°C to 600°C. The electrical properties and interface of Schottky barriers are assessed by I-V, C-V, DLTS and Rutherford Backscattering (2MeV He^+, $\theta_s = 160^\circ$), respectively.

All the forward log I-V characteristics of as deposited Mo/III-V Schottky barrier systems are linear over five decades. The values of ideal factor are 1.03, 1.10 and 1.06 for GaAs, $GaAs_{0.8}P_{0.2}$ and $GaAs_{0.6}P_{0.4}$, respectively. And the reverse saturation current densities are in the order of 10^{-8} A/cm^2. It means the Mo/III-V Schottky barriers have the good diode performance.

The Schottky barrier height (Φ_{B1}) is calculated from the extrapolation of the forward current plot to the intersection with the current axis (J_s) by the expression $J_s = A^*T^2 \exp(-\Phi_{B1}/KT)$

where the effective Richardson constants A^* are the calculated values obtained from the relation,[3]

$$\frac{A^*(GaAs_{1-x}P_x)}{A^*(GaAs)} = \frac{m^*(GaAs_{1-x}P_x)}{m^*(GaAs)}$$

and

$$m^*(GaAs_{1-x}P_x) = (1+0.5x)m^*(GaAs)$$

And it is also deduced from the C-V analysis and J_s/T^2 vs 1/T plot for Φ_{BC} and Φ_{B2}, respectively. The results are shown in Fig. 1 and Fig. 2. Fig. 1 shows the Φ_{BC} vs mole fraction of $GaAs_{1-x}P_x$ and it increases linearly with the increasing of the mole fraction. This phenomenon can be attributed to the linear relation of band gap with the mole fraction of $GaAs_{1-x}P_x$ in the direct band gap. In Fig. 2

the variation of Φ_B with the thermal annealing temperature is presented. The barrier height deduced from C-V is larger than that deduced from I-V. This difference may be arised from the interface state or native oxide existed in the interface of metal-semiconductor.[4] The heat treatment appreciably degrades the apparent barrier height about 0.2 eV after 500°C or above temperature annealing, whereas the ideal factor increases about 0.05-0.1. Such degraded values of Φ_B could be interpreted as being caused by the physical irregularities at the interface as a result of interdiffusion. In order to conform this consideration, the RBS and DLTS are performed. Fig.3 shows the Rutherford backscattering spectra of 1000Å Mo on $GaAs_{0.6}P_{0.4}$ in the 200°C as deposited state and after 600°C annealing. It can be seen the Mo has penetrated into the $GaAs_{0.6}P_{0.4}$ about 160Å after the heat treatment. By the DLTS analysis, it has found and corresponds with the RBS result that the hole trap, Ev+1.0eV, exists in the samples annealed above 500°C temperature. This deep level increases the generation current, so the reverse saturation current degrades about 3 orders. From the RBS and DLTS results, it can be tentatively considered that Ev+1.0eV is as a Mo acceptor level in $GaAs_{0.6}P_{0.4}$. Further systematic studies are considering and performing.

References

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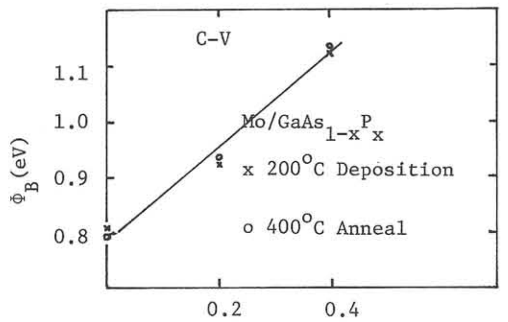

Fig. 1 X, Mole Fraction of $GaAs_{1-x}P_x$

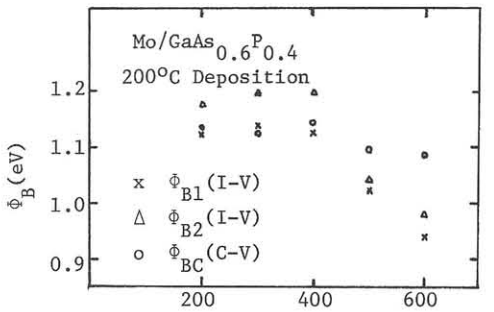

Fig. 2a Anneal Temperature (°C)

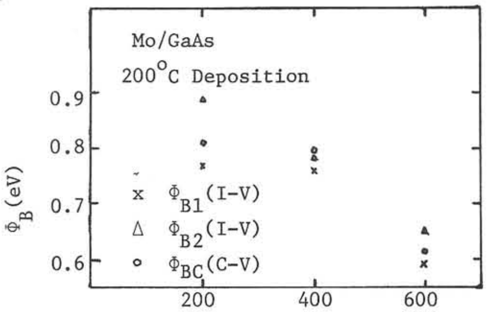

Fig. 2b Anneal Temperature (°C)

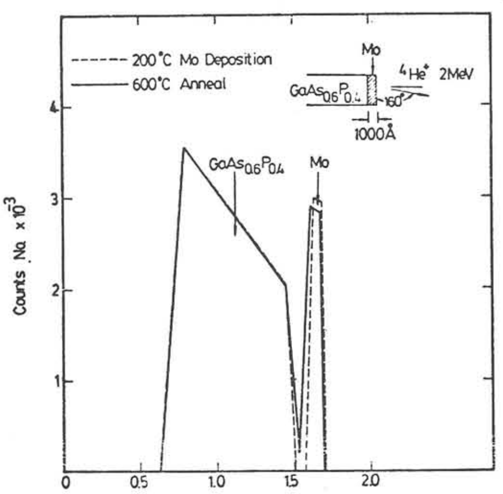

Fig.3 Backscattered Energy (MeV)