Figure Captions

Fig. 1.1  Lattice constant VS energy bandgap  52
Fig. 2.1  Schottky contact band diagram at thermal equilibrium.  53
Fig. 2.2(a)  Schottky contact band diagram at forward bias.  53
Fig. 2.2(b)  Schottky contact band diagram at reverse bias.  53
Fig. 3.1  The epitaxial structure of InAlP/InGaAs PHEMTs with dual delta-doping layers  54
Figure 3.2  Definition of the gate orientation relative to (100) GaAs substrate  55
Fig. 4.1 (a)  The etch profile with one step HF solution etching.  56
Fig. 4.1(b)  The etch profile with three steps wet etching.  56
Fig. 4.2 (a)  Contact resistance vs RTA temperature with Au/Ge/Ni/Au ohmic contact  57
Fig. 4.2 (b)  Contact resistance vs RTA temperature with Ge/Au/Ni/Ti/Au ohmic contact  57
Fig. 4.3 (a)  Trilayer photo-resists profile  58
Fig. 4.3 (b)  Bilayer photo-resists profile  58
Fig. 4.4  Etching depth VS etching time with CA/H2O2/H2O etching  59
Fig. 4.5.1-1  X-ray diffraction of Ti/Pt/Au annealed at different temperature.  60
Fig. 4.5.1-2  Current-voltage characteristics for Ti/Pt/Au contact annealed at different temperature.  61
Fig. 4.5.1-3  The forward bias I-V Characteristics of Ti/Pt/Au contact annealed at different temperature  61
Fig. 4.5.1-4  Schottky diode characteristics of Ti/Pt/Au contacts dependence of ideality factor on annealing temperature.  62
Fig. 4.5.1-5  Schottky diode characteristics of Ti/Pt/Au contacts dependence of schottky barrier height on annealing temperature.  62
Fig. 4.5.1-6  Reverse breakdown voltage of Ti/Pt/Au contact on InAlP annealed at different temperature.  63
Fig. 4.5.1-7  Dependence of capacitance-voltage on different  63
annealing temperature with Ti/Pt/Au contact on InAlP.

Fig. 4.5.1-8 Dependence of sheet resistance on annealing temperature for Ti/Pt/Au contact on InAlP. 64

Fig. 4.5.1-9 TEM micrograph of Ti/Pt/Au contact on InAlP structure annealed at 400°C for 30 minutes. 65

Fig. 4.5.1-10 TEM micrograph of Ti/Pt/Au contact on InAlP structure annealed at 400°C for 30 minutes. 66

Fig. 4.5.1-11 TEM micrograph of Ti/Pt/Au contact on InAlP structure annealed at 400°C for 30 minutes. 66

Fig. 4.5.1-12 EDX spectrum on EDX analysis 1 in Figure 4.5.1-11. 67

Fig. 4.5.1-13 EDX spectrum on EDX analysis 2 in Figure 4.5.1-11. 68

Fig. 4.5.1-14 EDX spectrum on EDX analysis 3 in Figure 4.5.1-11. 69

Fig. 4.5.2-1 Current-voltage characteristics for Pt/Ti/Pt/Au contact annealed at different temperature. 70

Fig. 4.5.2-2 The forward bias I-V Characteristics of Pt/Ti/Pt/Au contact annealed at different temperature. 70

Fig. 4.5.2-3 Schottky diode characteristics of Pt/Ti/Pt/Au contacts dependence of ideality factor on annealing temperature. 71

Fig. 4.5.2-4 Schottky diode characteristics of Pt/Ti/Pt/Au contacts dependence of schottky barrier height on annealing temperature. 71

Fig. 4.5.2-5 Reverse breakdown voltage of Pt/Ti/Pt/Au contact on InAlP annealed at different temperature. 72

Fig. 4.5.2-6 Dependence of capacitance-voltage on different annealing temperature with Pt/Ti/Pt/Au contact on InAlP. 72

Fig. 4.5.2-7 Dependence of sheet resistance on annealing temperature for Pt/Ti/Pt/Au contact on InAlP. 73

Fig. 4.5.2-8 TEM micrograph of Pt/Ti/Pt/Au contact on InAlP after annealing at 400°C for 30 minutes. 74

Fig. 4.5.2-9 EDX spectrum on EDX point 1 in Figure 4.5.2-9. 75

Fig. 4.5.2-10 EDX spectrum on EDX point 2 in Figure 4.5.2-9. 76

Fig. 4.5.2-11 EDX spectrum on EDX point 3 in Figure 4.5.2-9. 77

Fig. 4.5.2-12 TEM micrograph of Pt/Ti/Pt/Au contact on InAlP after annealing at 400°C for 30 minutes. 78

Fig. 4.5.2-13 TEM micrograph of Pt/Ti/Pt/Au contact on InAlP 78
after annealing at 400°C for 30 minutes.

Fig. 4.5.3-1 X-ray diffraction of W annealed at different temperature.

Fig. 4.5.3-2 Current-voltage characteristics for W/Ti/Pt/Au contact annealed at different temperature.

Fig. 4.5.3-3 The forward bias I-V characteristics of W/Ti/Pt/Au contact annealed at different temperature.

Fig. 4.5.3-4 Schottky diode characteristics of W/Ti/Pt/Au contacts dependence of ideality factor at different annealing temperature.

Fig. 4.5.3-5 Schottky diode characteristics of W/Ti/Pt/Au contacts dependence of Schottky barrier height at different annealing temperature.

Fig. 4.5.3-6 Reverse breakdown voltage of W/Ti/Pt/Au contact on InAlP annealed at different temperature.

Fig. 4.5.3-7 Dependence of capacitance-voltage on different annealing temperature with W/Ti/Pt/Au contact on InAlP.

Fig. 4.5.3-8 Dependence of sheet resistance on annealing temperature for W/Ti/Pt/Au contact on InAlP.

Fig. 4.6.1 The Ids-Vds curve for the InAlP/InGaAs PHEMT.

Fig. 4.6.2 The I_D-V_G curve and G_M-V_G curve. The drain voltage is 1.5V and the gate length is 0.4um.

Fig. 4.6.3 The gate-to-drain breakdown voltage of InAlP/InGaAs PHEMT.

Fig. 4.6.4 The Ids-Vds curve of the Enhancement-mode InAlP/InGaAs PHEMT.

Fig. 4.6.5 The I_D-V_G curve and G_M-V_G curve of Enhancement-mode InAlP/InGaAs PHEMT. The drain voltage is 1.5V and the gate length is 0.5um.

Fig. 4.6.6 Schottky diode characteristics of Enhancement-mode InAlP/InGaAs PHEMT.

Fig. 4.7.1 Dependence of the I-V characteristics with [0-1-1] and [0-11] oriented devices.

Fig. 4.7.2 Dependence of the transconductance characteristics with [0-1-1] and [0-11] oriented devices.

Fig. 4.8.1 Transfer characteristics at Vds=1.5V of typical 0.6um gate length InAlP/InGaAs PHEMT with Ti/Pt/Au
contact preannealed and annealed condition.

Fig. 4.8.2 Transfer characteristics at Vds=1.5V of typical 0.6 um gate length InAlP/InGaAs PHEMT with Pt/Ti/Pt/Au contact preannealed and annealed condition.

Fig. 4.8.3 Transfer characteristic at Vds=1.5V of typical 0.6 um gate length InAlP/InGaAs PHEMT with W/Ti/Pt/Au contact preannealed and annealed condition.
Table Captions

Table 4.1  Characteristics with Ti/Pt/Au contact  94
Table 4.2  Characteristics with Pt/Ti/Pt/Au contact  94
Table 4.3  Characteristics with W/Ti/Pt/Au contact  94
Table 4.4  Dependence of characteristics on different oriented devices.  95