

การออกแบบและผลิตไบโพลาร์ทรานซิสเตอร์หัวต่อต่างชนิด GaAs/GaAlAs
ที่มีลักษณะสมบัติสมมาตร



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DESIGN AND FABRICATION OF GaAs/GaAlAs HETEROJUNCTION BIPOLAR TRANSISTORS WITH
SYMMETRICAL CHARACTERISTIC

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A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Engineering Program in Electrical Engineering

Department of Electrical Engineering

Faculty of Engineering

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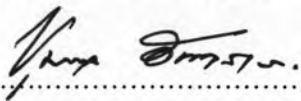
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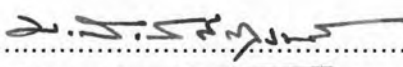
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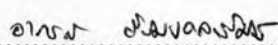
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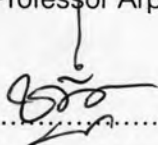
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เนเมียว ทัน : การออกแบบและผลิตไบโพลาร์ทรานซิสเตอร์หัวต่อต่างชนิด GaAs/GaAlAs ที่มีลักษณะสมบัติสมมาตร. (DESIGN AND FABRICATION OF GaAs/GaAlAs HETEROJUNCTION BIPOLAR TRANSISTORS WITH SYMMETRICAL CHARACTERISTIC)

อ. ที่ปรึกษา : รศ. ดร. ชุมพล อันตรเสน, 105 หน้า.

ไบโพลาร์ทรานซิสเตอร์หัวต่อต่างชนิดสองหัวต่อของ GaAlAs (N)/GaAs (p⁺)/GaAlAs (N) ได้รับการออกแบบและผลิต โดยเทคโนโลยีเอพิแทกซีในสถานะของเหลวเป็นตัวยังขาด ทรานซิสเตอร์มีโครงสร้างของชั้นเบสรอบนอกต่างๆ กัน ประกอบด้วย ชั้นเบสเดี่ยวปลูกใหม่ GaAs (p⁺) ชั้นเบสเดี่ยวปลูกใหม่ Ga_{0.8}Al_{0.2}As (P⁺) ชั้นเบสคู่ปลูกใหม่ GaAs (p⁺)/Ga_{0.8}Al_{0.2}As (P⁺) และชั้นเบสแพร์ซิมด้วยสังกะสี ทรานซิสเตอร์ชนิดชั้นเบสเดี่ยวและแพร์ซิมแสดงลักษณะสมบัติกระแสแรงดันไม่สมมาตร โดยมีอัตราขยายกระแสโหมคปกติ 10-40 และโหมคกลับทาง 5-18 แรงดันออฟเซ็ทอยู่ในระหว่าง 100 ถึง 600 mV สอดคล้องกับค่าความต่างที่มาก ระหว่างแรงดันหัวต่อคอลเล็กเตอร์-เบส และอิมิตเตอร์-เบส การที่มีลักษณะสมบัติไม่สมมาตรพร้อมกับแรงดันออฟเซ็ทค่าสูง เนื่องจากในโหมคกลับทาง อิเล็กตรอนจำนวนมากที่ถูกฉีดจากคอลเล็กเตอร์ในบริเวณชั้นเบสเดี่ยวรอบนอก GaAs (p⁺) จะสูญเสียไปในการรวมตัว หรือ เนื่องจากศูนย์รวมตัวที่มีอยู่มากในชั้นเบสเดี่ยวรอบนอก Ga_{0.8}Al_{0.2}As (P⁺) แล้วแต่กรณี นอกจากนั้นทรานซิสเตอร์บางตัวแสดงลักษณะสมบัติแบบ Knee-shape ในโหมคกลับทาง เนื่องจากผลของ spike ที่หัวต่ออิมิตเตอร์-เบส ในขณะที่ทรานซิสเตอร์ที่มีชั้นเบสคู่รอบนอกแสดงลักษณะสมบัติกระแสแรงดันสมมาตร ด้วยอัตราขยายกระแสเท่ากับ 18 และแรงดันออฟเซ็ท 60 mV เป็นเพราะว่าในโหมคกลับทาง ชั้นเบสรอบนอกล่าง Ga_{0.8}Al_{0.2}As (P⁺) สามารถลดการไหลของกระแสอิเล็กตรอนจากคอลเล็กเตอร์ และยิ่งกว่านั้น อัตราการรวมตัวของอิเล็กตรอนก็ลดลงในชั้นเบสรอบนอกบน GaAs (p⁺) นอกจากนี้สัดส่วนอะลูมิเนียม ซึ่งมีผลทั้งประสิทธิภาพในการฉีดพาหะ และความสูงของ Spike ที่หัวต่อทั้งสองก็ได้รับการกำหนดให้เหมาะสม สุดท้ายแรงดันออฟเซ็ทที่มีค่าต่ำมากก็ได้รับการยืนยันว่าสอดคล้องกับค่าความต่างระหว่างแรงดันหัวต่อของทรานซิสเตอร์ที่น้อย

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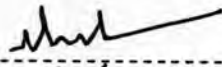

KEYWORD: GaAlAs / GaAs / HBT / DHBT / LPE / SINGLE REGROWN BASE / DOUBLE REGROWN BASE / DIFFUSED BASE / NORMAL MODE GAIN / INVERTED MODE GAIN / OFFSET VOLTAGE

NAY MYO TUN: DESIGN AND FABRICATION OF GaAs / GaAlAs HETEROJUNCTION BIPOLAR TRANSISTORS WITH SYMMETRICAL CHARACTERISTIC

THESIS ADVISOR: ASSOC. PROF. CHOOMPOL ANTARESENA, Dr. -Ing, 105 pp.

GaAlAs (N) / GaAs (p^+) / GaAlAs (N) Double Heterojunction Bipolar Transistors (DHBTs) with single regrown base (p^+ -GaAs or P^+ -Ga_{0.8}Al_{0.2}As), double regrown base (p^+ -GaAs / P^+ -Ga_{0.8}Al_{0.2}As) and diffused base have been designed and fabricated by Liquid Phase Epitaxy (LPE) super cooling technique. Most of DHBTs with the single regrown base and diffused base showed the asymmetrical (I,V) characteristics with normal mode gain of 10-40 and inverted mode gain of 5-18. The offset voltage was in between 100mV to 600mV which conformed to the large difference between the CB and EB junction voltages. The asymmetric characteristics with high offset voltage are owing to either high electron injections from the collector to the external base region under inverted mode and then loss by recombination in GaAs (p^+) regrown base or high intrinsic recombination centers in the Ga_{0.8}Al_{0.2}As (P^+) external base layer. Moreover some DHBTs with single regrown base exhibited a knee-shape characteristic in inverted mode due to influence of spike at emitter-base heterojunction. In contrary, double regrown base DHBTs showed the symmetrical characteristics with the gain around 18 and the very low offset voltage of 60mV. This is because, in inverted mode, the lower P^+ -Ga_{0.8}Al_{0.2}As regrown base layer in the double regrown base DHBTs can suppress the electron injections from the collector in the external base region and also the upper p^+ -GaAs regrown base layer can reduce the electron recombinations. In addition, the aluminum contents which relate to not only the injection efficiency but also the spike height at each heterojunction of these DHBTs were optimized. Finally very low offset voltage for double regrown base DHBTs was proved by small difference between junction voltages.

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