Extended Abstracts of the 1999 International Conference on Solid State Devices and Materials, Tokyo, 1999, pp. 544-545 **D-13-1**

Invited

Characteristics of GaAs based HBTs

N. Pan, R. E. Welser, C. R. Lutz, J. Elliot, and J. Rodrigues
Kopin Corporation, 695 Myles Standish Boulevard, Taunton, MA 02780
Phone : 508-824-6696 Fax : 508-822-1381 email : noren_pan@kopin.com

Heterojunction bipolar transistors (HBTs) are the leading device for a variety of applications including L-band power amplifiers, high-speed A/D converters, broadband amplifiers, laser drivers, and low phase noise oscillators. They are gaining increasing acceptance for high data rate optical communication systems which require outstanding reliability.

AlGaAs emitter HBTs with adequate reliability have been demonstrated for L-band mobile phone applications, which operate at moderate current densities. For applications which require higher reliability performance operating at higher junction temperatures (>250 °C) and at higher current densities (>50 kA/cm^2), InGaP HBTs are the device of choice. The excellent reliability of InGaP HBTs has been confirmed at various laboratories. At a moderate current density and junction temperature, J_c = 25 kA/cm^2 and T_j = 264 °C, no device failures were reported out to 10,000 hours in a sample lot of 10 devices. Reliability testing performed up to a junction temperature of 360 °C and at a higher current density (J_c = 60 kA/cm^2) showed an extrapolated MTTF of 5 x 10^5 hours at T_j = 150 °C. Reliability testing was repeatedly confirmed in multiple InGaP processed lots, which indicate the reproducibility of the InGaP device material and the processing technology. The activation energy for AlGaAs HBTs was 0.57 eV and the activation energy for InGaP HBTs was 0.65 eV, which indicated a similar failure mechanism for both devices. There is increasing evidence that the large valence band offset between InGaP and GaAs may be partially responsible for the increased reliability of InGaP devices. The base current at low current densities of $Al_{0.35}Ga_{0.65}As$ emitter based HBT showed remarkably similar characteristics to that of InGaP HBT. Significantly improved temperature stability of the current gain at ambient temperatures up to 100 C was shown for both InGaP and $Al_{0.35}Ga_{0.65}As$ emitter based HBT. The improved temperature characteristic is highly attractive for the design of high performance amplifiers with improved temperature coefficients. There appeared to be no evidence, which suggested that hydrogen in the base layer is responsible for long term reliability degradation of HBT devices.

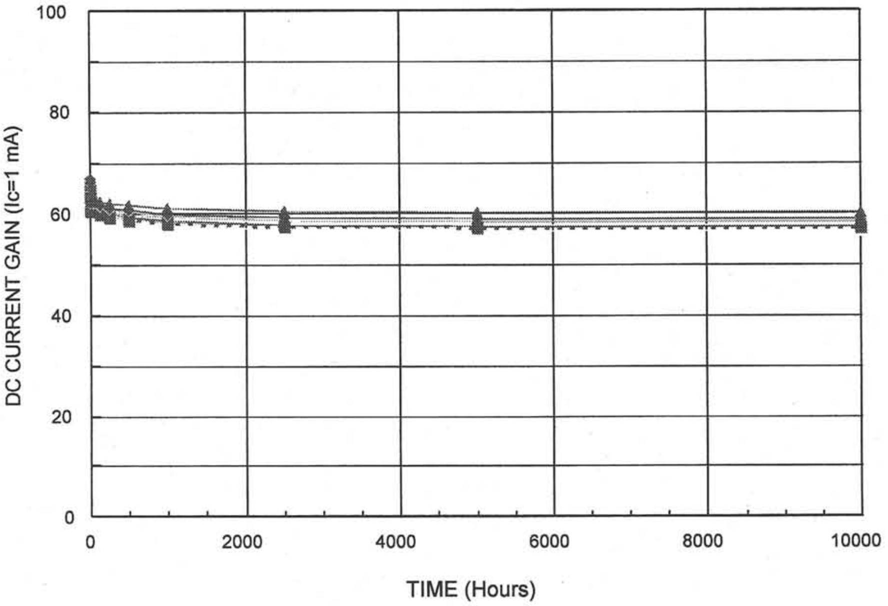

Fig. 1. Long term reliability testing of 10 devices (L = 6.4 μm x 20 μm) is shown. The test conditions were J_c = 25 kA/cm^2, V_{ce} = 2.0 V, and T_j 264 °C. The DC current gain was measured at room temperature and at a collector current of 1 mA (0.8 kA/cm^2). There was initial drop in the current gain but the current remained stable up to 10,000 hours with no device failures.

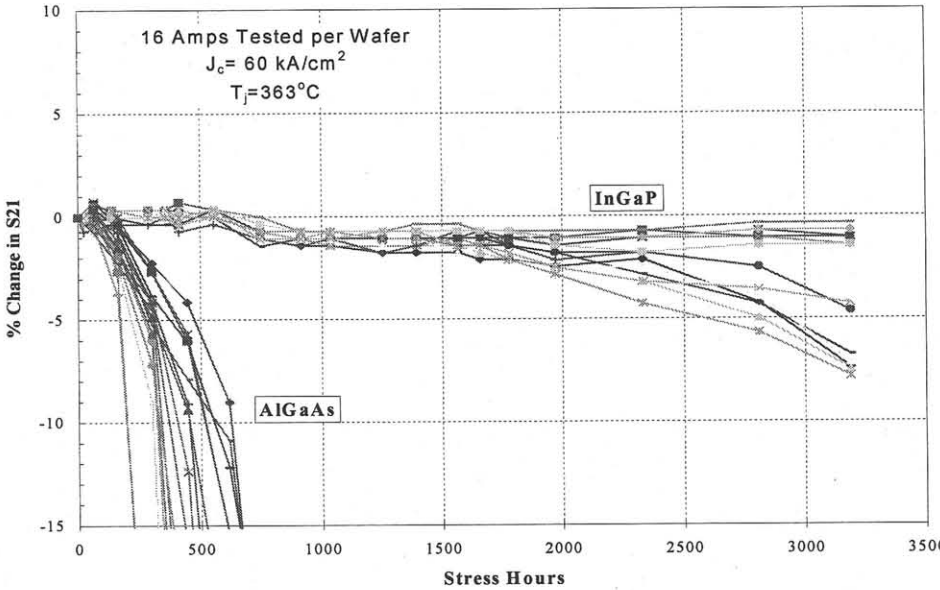

Fig. 2. Gain versus time for broadband amplifiers fabricated using both InGaP and AlGaAs HBT. 16 broadband amplifiers from each type of HBT were tested. The current density was 60 kA/cm^2 and Vce was 5.0 V and the device junction temperature was 360 C during the reliability test. All of the AlGaAs broadband amplifiers failed after 450 hours. The InGaP broadband amplifiers showed excellent reliability characteristics out to 3500 hours.