2-5 Effects of Nonuniform Conductivity on the Velocity-Field Characteristics of GaAs

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The velocity-field characteristics is the most fundamental curve to analyze operations of the Gunn and related effects due to valley-transfer of hot electrons in GaAs. There have been so many experiments on the velocity-field characteristics using various methods. But those results were highly conflicting. Several speculative possibilities to interpret such conflicts would be inhomogeneities in samples, hole generation suggested by Copeland (1), impact ionization and differences between measuring methods.

We investigated effects of nonuniform conductivity on the apparent v-E curve using the microwave-heating technique (2). Various nonuniformities were introduced by a serial irradiation of 1.5 MeV electrons on a localized portion (0.5 mm wide) near the middle of the sample of several mm long. The profile of the nonuniform conductivity was measured by scanning of a potential probe. Fig. 1 shows a typical result. As the nonuniformity is increased, the threshold field, peak velocity and negative differential mobility decrease. The initial negative differential mobility is 1660 cm^2/volt·sec, but after the second irradiation it decreases down to 920 cm^2/volt·sec. This result can explain a poor efficiency of Gunn oscillators containing nonuniformity, and, moreover, agrees with the fact reported by Gunn (3) that the apparent threshold fields would appear to decrease as the sample length is increased.

In addition, we studied effects of mobility and temperature on the v-E curve of GaAs. Mobilities were changed with uniform

electron irradiation of samples. A decrease of carrier density due to the irradiation would not affect the v-E curve. With decreasing mobility peak velocity and negative differential mobility decreased but threshold field increased. The temperature dependence of the v-E curve was understood essentially by taking effect of mobility into account. When temperature was lowered, peak velocity and negative differential mobility became higher because electron mobility increased with decreasing temterature.

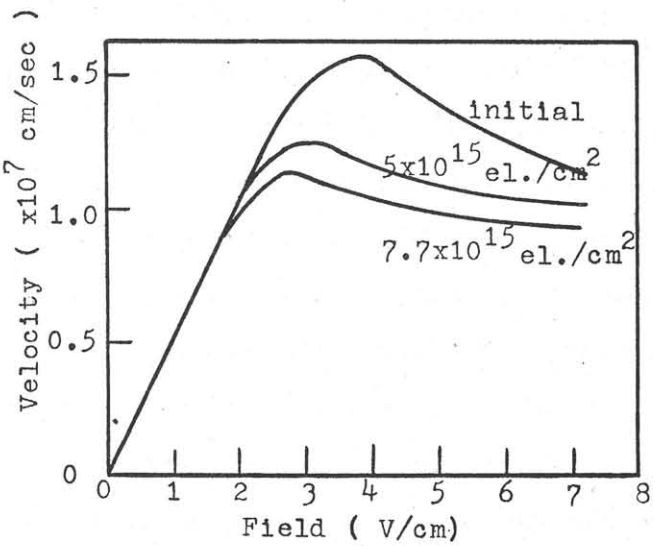

Fig. 1 Effect of nonuniform conductivity on the v-E curve

In some samples with negative differential mobility as low as 500 cm^2/volt·sec, the current-field characteristics measured by d.c. pulse showed a current breakdown at fields slightly above the threshold for Gunn oscillation. From this one of possible mechanisms causing low negative differential mobility would be an impact ionization. But in this case a decrease of the threshold field would not appear.

(1) J.A. Copeland, Phys. Letters 24A, 9 (1967).

(2) C. Hamaguchi et al, Phys. Letters 24A, 500 (1967).

(3) J.B. Gunn, IBM J. Res. Develop. 8, 141 (1964)