Characterisation of Gallium Nitride and Type IIa Natural Diamond Carrier Transport Properties

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Abstract

This research project examined the carrier transport properties; diffusion length, effective excess minority carrier lifetime and resistivity in two wide bandgap materials, GaN and type IIa natural diamond. Also, the role of the GaN/Sapphire interface was analysed with respect to these transport properties. A combination of two methods was used to obtain these transport properties. The two were optical beam induced current (OBIC) and electron beam induced current (EBIC) time of flight transient measurements. These techniques consist of measuring the current response to the drift and diffusion of generated electron-hole pair carriers created by a short-duration pulse of radiation.

Under OBIC, a short duration pulsed optical source, with an electron beam excitation pulse time much less than the transit time of the material, was used to generate excess carriers within the absorption depth of the material. The second method of excitation, EBIC involved the use of a modified SEM with a photo emission source (L-EBIC) and a high speed pulsed thermionic electron source (T-EBIC) to generate an electron beam. This electron beam was used to create a large number of electron-hole pairs at various penetration depths within the materials.

Measurements on GaN found the diffusion length was 7.84 µm with the L-EBIC and 7.78 µm with the T-EBIC. After annealing at 900°C for 30 mins., the GaN diffusion length increased to 9.89 µm (L-EBIC). These results showed that the interface did not play a significant role in the carrier diffusion process. The dark resistivity was 1.79 x 10^{10} Ω-cm, and the carrier lifetimes were 1.7 µs with L-EBIC and 3.36 and 3.9 ns with OBIC. The author believed that the L-EBIC result was a good representation of the carrier lifetime within the material, while the shorter OBIC results were due to interface intervention in the recombination processes. The diamond dark resistivity was found to be 6.14 x 10^{11} Ω-cm and the diffusion lengths were 94.1 µm and 97 µm from the L-EBIC and T-EBIC respectively. All measurements were within 10% spread.