Extended Abstracts of the 22nd (1990 International) Conference on Solid State Devices and Materials, Sendai, 1990, pp. 1175-1176

LN-D-13

Ultra-High-Efficiency InGaAlP/GaAs Visible Light Emitting Diodes

H.Sugawara, M.Ishikawa and G.Hatakoshi

Research and Development Center, Toshiba Corporation,
1, Komukai-Toshiba-cho, Saiwai-ku, Kawasaki 210, Japan

Ultra-high-efficiency InGaAlP light emitting diodes (LEDs) have been successfully fabricated. The diodes are five times more efficient (1.5 %) at 620 nm (orange) than GaAlAs and GaAsP LEDs.

The wafers were grown on a (100)-oriented Si-doped GaAs substrate by low-pressure metalorganic chemical vapor deposition (MOCVD). Figure 1 shows a schematic cross-sectional view of the InGaAlP surface emission LED. The p-side electrode was formed on top of the p-GaAlAs layer which was grown on the double heterostructure layers. The Al composition in the p-GaAlAs layer was adjusted to be transparent to emitted light. Since current injected from the p-side electrode spreads through the low-resistivity p-GaAlAs layer, the emitting region in the active layer readily expands. The scribed chip (400 um X 400 um) was mounted and molded using resin. Output power was measured with a Si photo-detector.

Figure 2 shows the emission spectrum of the InGaAlP LED at an injection current of 20 mA DC. The Al composition (x) in the $In_{0.5}(Ga_{1-x}Al_x)_{0.5}P$ active layer was 0.2. Peak wavelength was 620 nm (orange) and the half width was 17.5 nm. Figure 3 shows the dependence of output power and external quantum efficiency on injection current. The output power at 70 mA was 2 mW. The external quantum efficiency and operation voltage at 20 mA was 1.5 % and 1.82 V, respectively. The diodes sre five times more efficient at 620 nm than GaAlAs and GaAsP LEDs. The output power at 20 mA is believed to correspond to a luminous intensity of about 3 cd. The wavelength dependence of external quantum efficiency for the InGaAlP LED is shown in Fig. 4, in comparison with other materials. Light emission between 570 nm and 650 nm was achieved by varing the Al composition of InGaAlP active layer. High-efficiency light emission has been achieved using InGaAlP, which has direct band-gap, as compared with that from indirect band-gap materials.

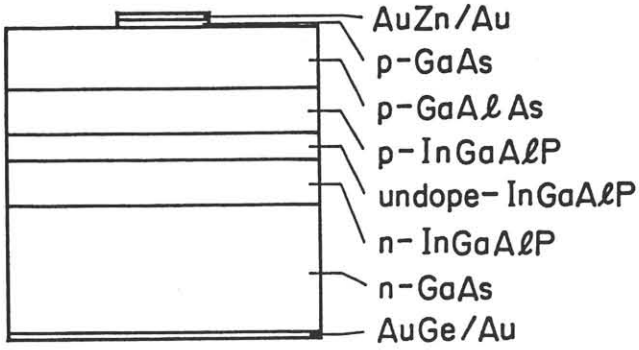

Fig.1 Schematic cross-sectional view of the InGaAlP LED

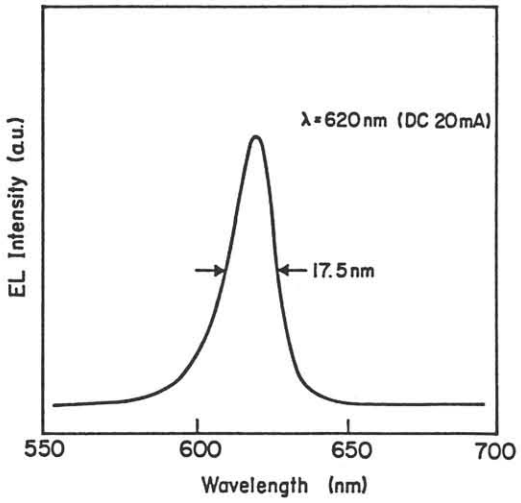

Fig.2 Emission spectrum of the InGaAlP LED

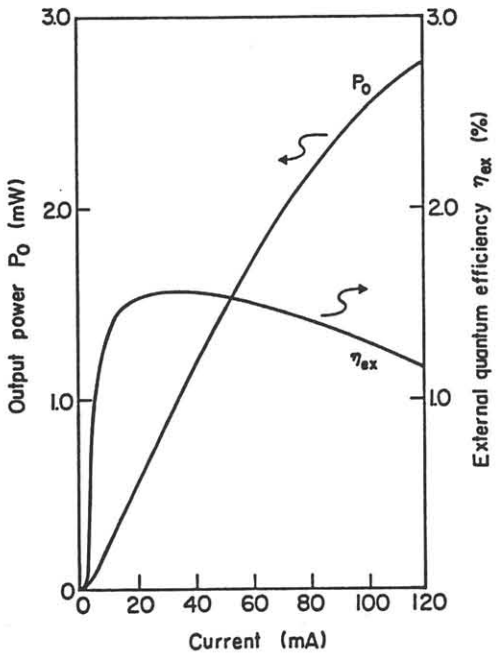

Fig.3 Dependence of output power and external quantum efficiency on injection current for InGaAlP LED

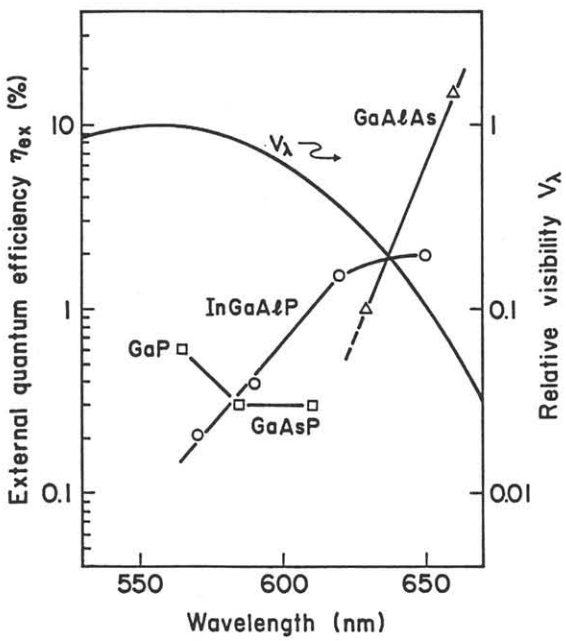

Fig.4 The wavelength dependence of external quantum efficiency for InGaAlP and other materials