AlGaInP light-emitting diodes with metal substrates fabricated by wafer bonding

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High-efficiency light-emitting diodes (LEDs) operating in the wavelength region from red to green lights have been recently employed by the AlGaInP alloy system grown on GaAs substrate. However, the problem of joule heating existing in the conventional LEDs has limited the light output performance. To achieve higher light output performance, AlGaInP LEDs with metal substrate (MS LEDs) using the wafer bonding technology is proposed in this study. First, the Ta/TaN layers were deposited on the host Cu substrate as barrier and adhesion layers. Next, the AlGaInP LED/GaAs was bonded to the Cu substrate by thermal treatment at 400°C for 30 min. Following the bonding process, the GaAs substrate was removed by chemical etching. Samples were mesa etched to generate 250 × 250 μm^2 devices. Au/AuGe dots were then deposited onto the GaAs layer as shown in Fig. 1.

In this work, the high-efficiency, high-reliability operation of wafer-bonded AlGaInP LEDs was demonstrated. Figure 2 presents the current versus voltage (*I-V*) of the MS LED. The device exhibited normal *p-n* diode behavior with a forward voltage of less than 2.1V at 20 mA. The result indicated that the wafer-bonding process did not affect I-V characteristics of the MS LED. Furthermore, the experimental results indicated that bonding a Cu substrate to an AlGaInP LEDs could be operated in a higher injection forward current. Such bonding enhanced the device performance significantly (Fig. 3). The joule heating exhibiting in the conventional LEDs was eliminated because the copper substrate provided a good heat sink. Thus, the thermal property of the conventional LEDs was improved.

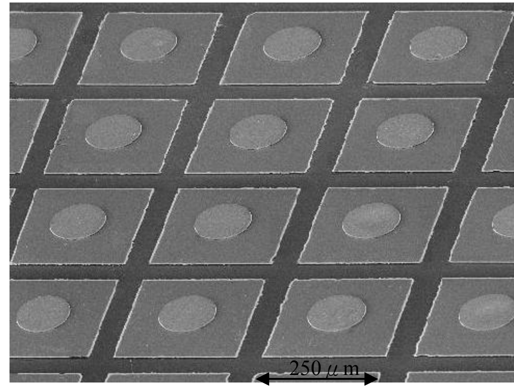

Fig. 1 Surface morphology of the MS LED with device area 250 μ m× 250 μ m.

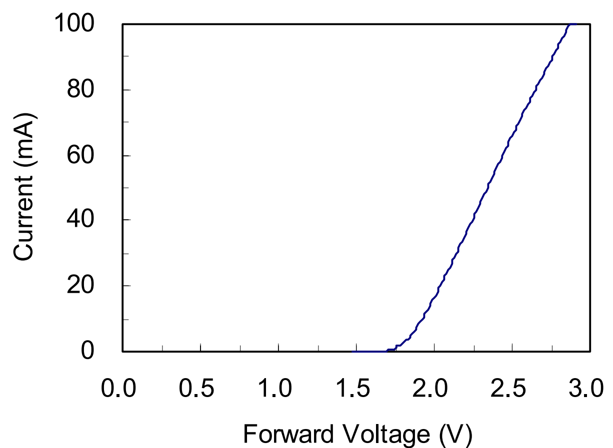

Fig. 2 Typical *I-V* characteristic of the MS LED fabricated by wafer bonding technology.

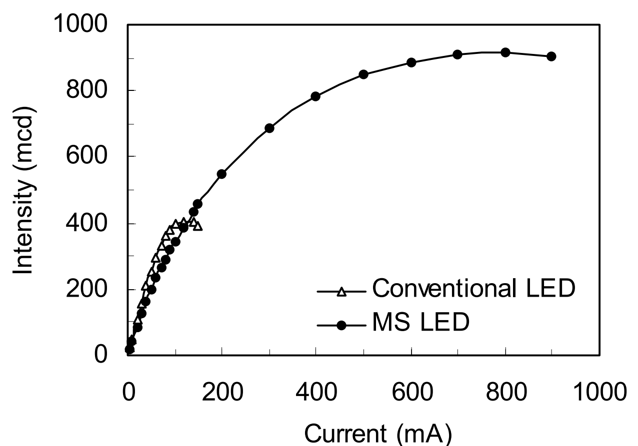

Fig .3 Intensity versus current curves for MS LED and conventional LED.