Fabrication of blue LEDs on big chips

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In this paper, the GaN based epitaxial wafer is fabricated on big 1 mm×1 mm chips, and packaged with a special technology. At working current 350 mA and working voltage 3.74 V, the full viewing angle, the axial brightness and the output integral power of the 465 nm LED can reach 125°, 210,000 cd/m^2 and 1.5 lm, respectively. The LED with such good performances has promising application potential in the fields of display, traffic and the development of solid-state white light source.

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In the last few years, the solid-state white lighting has become one of the research hotspots in semiconductor field. Along with the appearance of new materials InGaAlP and InGaN, and with the continuous development of semiconductor techniques, the new applications, such as full color display, large fluorescent display and solid-state lighting, have come out[1]. For the applications of display and lighting, traditional 3- or 5-mm LEDs packaged with small chips have to be integrated in large scale. This makes the system complicated and causes large quantity of energy waste. To solve so pressing a problem, we made blue LEDs using big chips (1 mm ×1 mm ×90 μm) which were from GaN based epitaxial wafer[2,3], and plated aluminium reflection layer on the sapphire substrate to enhance the light-extracting efficiency (Fig. 1). To realize the area emission lighting source in order to substitute the traditional point emission source the ohmic contacts of the chip were comb-shapely arrayed (Fig. 2). In making the LED, we used a bowl heat sink (Fig. 3(a))[4] and side winglike electrodes, thus the bottom of the heat sink could deal with the problem of heat dispersion. For the connection between the chip electrodes and the outside electrodes, an electrode transition board (Fig. 3(b)) was adopted, which was embedded firmly around the heat sink. Besides, a concave lens was designed to obtain brighter light. For the sake of batch production we made a corresponding injection mould of the lens (Fig. 3(c)).

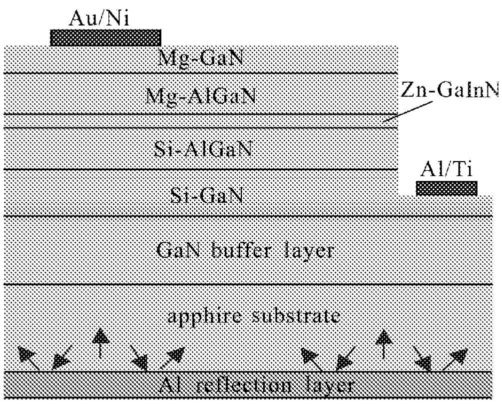

Fig. 1. Chip structure with aluminium reflection layer (side view).

After all the former preparations, we assemble the LED, that is, fix the electrode transition board and chip on heat sink, connect ohm contacts to outside electrodes by supersonic soldering technique and finally to package the whole LED in its envelop. Figure 3(d) shows the cross section of a packaged LED.

We measured some of the primary parameters of the LEDs.

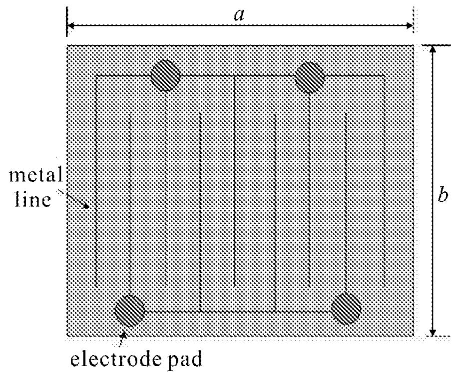

Fig. 2. Ohm contacts of big chips ($a = b = 1$ mm, top view).

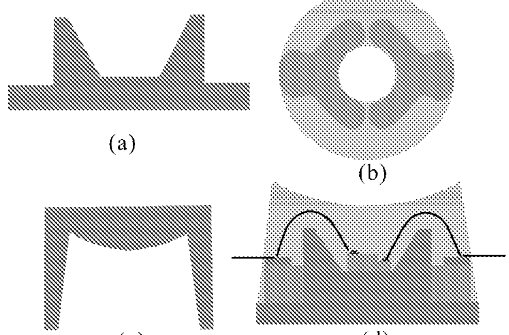

Fig. 3. (a) Bowl heat sink for the chips (side view); (b) Electrode transition board (top view); (c) Injection mould of the concave lens (side view); (d) Cross section of the concave LED (side view).

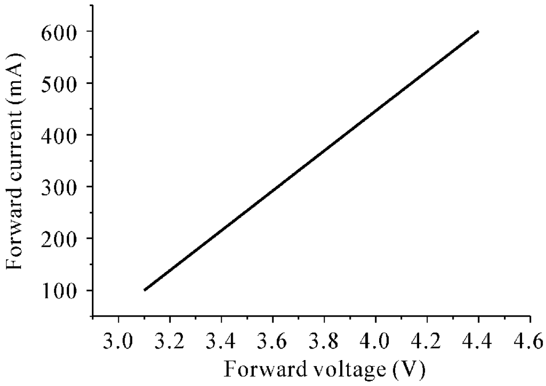

Fig. 4. I-V curve of the LED.

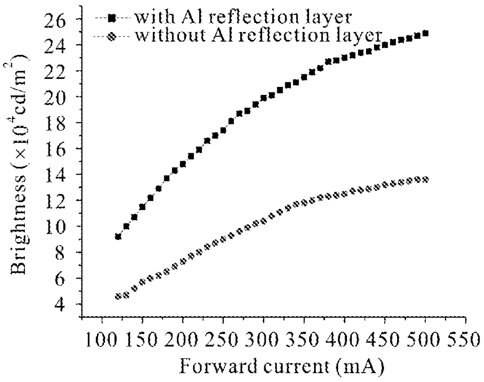

Fig. 5. Brightness-current curves of the LEDs with and without AL RL.

Table 1. Comparison of Primary Parameters for LEDs with and without Al RL (the Values are the Average of Four Samples)

Measured Parameters (350 mA)	Maximal Intensity of Light (mcd)	Output Integral Power (mlm)	Light Extracting Efficiency (lm/W)	Full Visual Angle (deg.)
LED without Al RL	300.0	598.0	0.45	134.0
LED with Al RL	790.0	1500.0	1.30	125.0

The I-V curve of LED with Al reflection layer (Al RL) was measured. Figure 4 shows that the I-V characteristic is steady.

We also made a comparison between the LED with Al RL and that without Al RL under the same forward current of 350 mA (Table 1, the values are the average of four samples).

At the same time, we made a curve of brightness versus forward current (Fig. 5).

From above measured results, we can see that at 350-mA forward current and 3.74-V forward voltage the brightness of the LED with Al RL layer reaches 210,000 cd/m^2, almost twice the brightness of that of the LED without Al RL. It is true the full viewing angle of the LED with Al reflection layer becomes smaller owing to the redistribution of the output light, it still reaches 125°. However, the maximal light intensity, the output integral power and the light-extracting efficiency reaches 790 mcd, 1.50 lm and 1.3 lm/W, respectively. The LEDs with such good performances have unexceptionable application potential in the fields of large fluorescent display and traffic[5]. Especially, white solid-state LEDs can be achieved by adding proper YAG fluorescent powder to the blue chips, that means we may realize LED-solid-state white lighting in the near future.

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