Wider-band modulation of blue-green light-emitting diode

Taiwan researchers achieve record optical 3dB modulation bandwidth of 463MHz for an InGaN quantum well device.

Taiwan's National Tsing Hua University has claimed the highest optical 3dB modulation bandwidth of about 463MHz at 50mA for a 500nm-wavelength blue-green indium gallium nitride (InGaN) LED [Chien-Lan Liao et al, IEEE Electron Device Letters, vol35, p563, 2014].

Modulation of such 'green' light is proposed for short-haul data links using low-cost polymethyl methacrylate (PMMA) plastic optical fiber, which has a lower attenuation coefficient and less temperature sensitivity at 500nm wavelengths compared with conventional red sources emitting at 650nm. The researchers also see potential for wireless visible light communication (VLC).

The epitaxial structure for the device (Figure 1) was grown using metal-organic chemical vapor deposition (MOCVD) on c-plane sapphire. The ~90nm active region consisted of five 2.5nm InGaN multiple quantum wells (MQWs) in 14nm GaN barriers. The LED was constructed with a ring-shaped electrode on gallium-doped zinc oxide (GZO) transparent conductor.

The chip size was 380µmx380µm. The fabricated LED substrate was thinned from 425µm to 200µm to improve die singulation and thermal conductivity. The chips were mounted in TO-46 headers without encapsulation.

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Different devices with aperture diameters between 75µm and 200µm were produced. The turn-on voltage for all devices was about 2.8V. The peak wavelength was around 500nm, giving a blue-green color. The series resistance of the 75µm device was 14.5Ω and the capacitance under –5V reverse bias

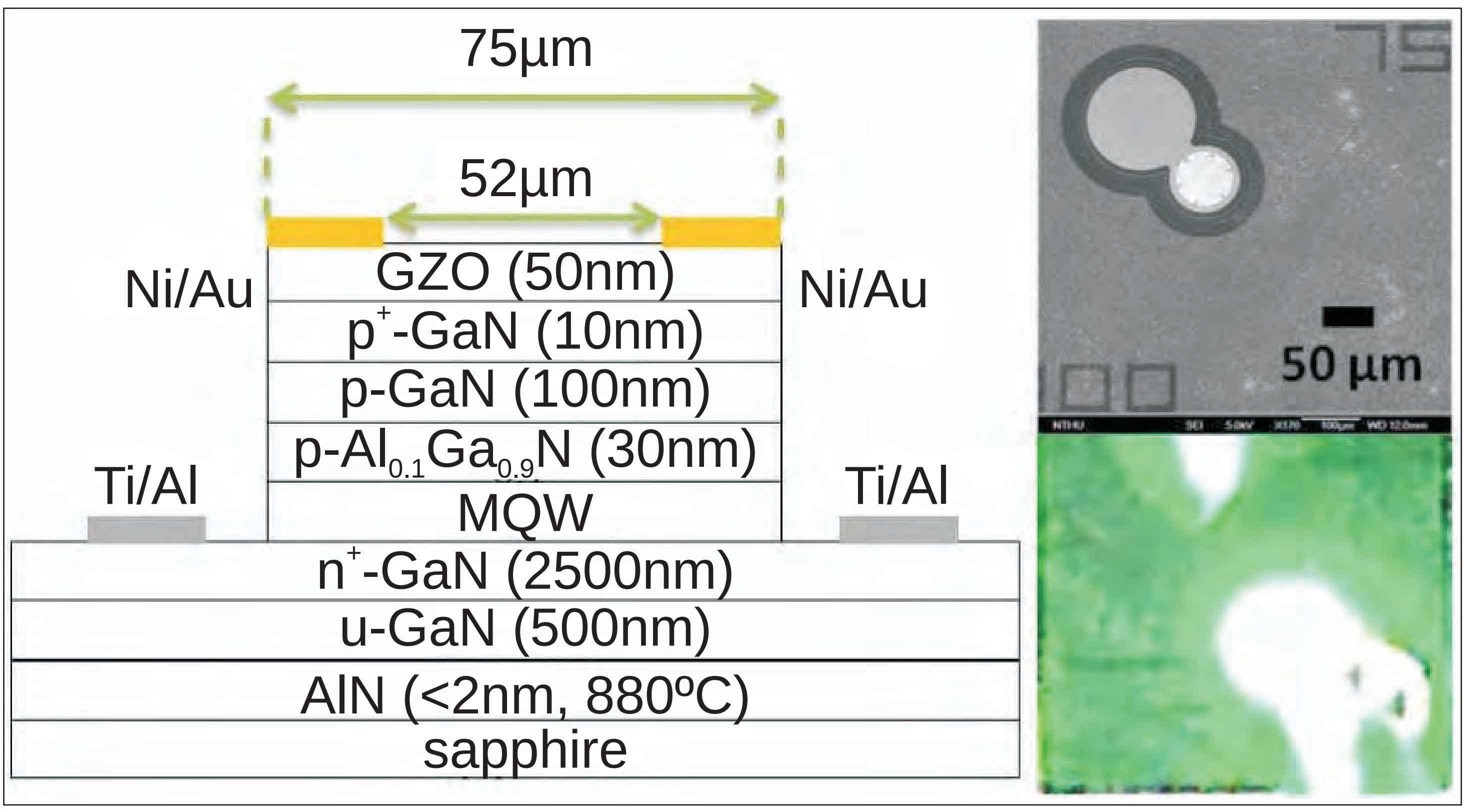

Figure 1. Green LED structure. Insets show top views of LED biased at 1mA injection current observed by field-emission scanning electron microscopy (FE-SEM, JSM-7000F) and optical microscopy.

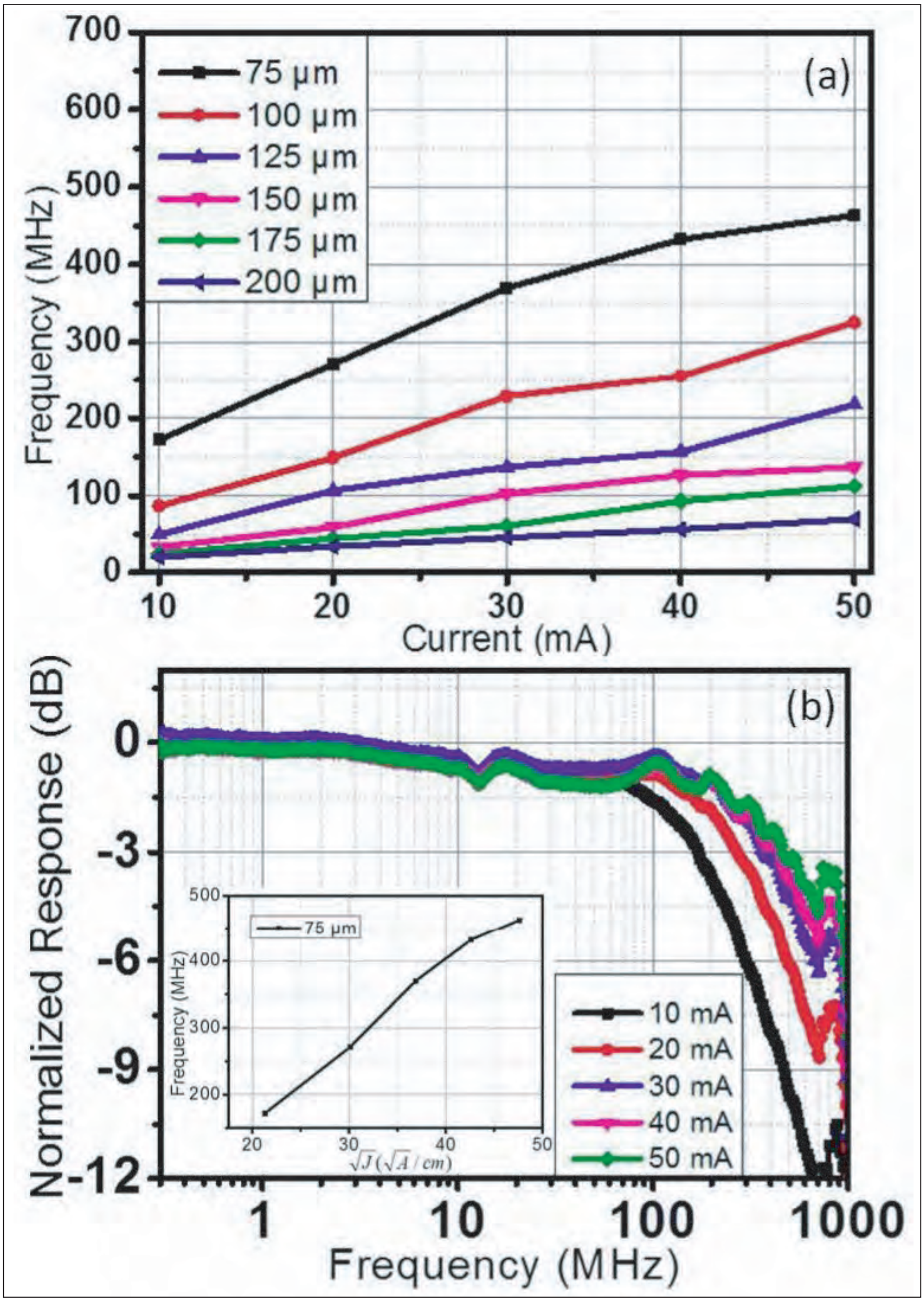

Figure 2. (a) Frequency f_{3dB} response as function of forward current for LEDs with different aperture diameters. (b) Basis for f_{3dB} measurement at different currents for the LED with a mesa diameter of 75µm. Inset shows frequency response as function of square root of current density.

was 4.8pF. The other devices had smaller series resistance but larger capacitances. For high speed, one needs low resistance and capacitance.

The light output powers at 50mA injection current varied from 1.6mW for 75µm aperture to 5.6mW for the 200µm aperture.

The 3dB modulation bandwidth (f_{3dB}, Figure 2a) was 463MHz at 50mA bias for a 75µm aperture. This reduced to 70MHz with 200µm aperture. For current biases between 10mA and 50mA, f_{3dB} was proportional to the square root of the current density for 75µm aperture (Figure 2b). The relation is more complicated with wider apertures.

These results compare with other groups that have achieved 'green' LEDs with bandwidths of 120MHz (50mA current bias, ~500nm wavelength) and 420MHz (520nm true green wavelength). ■

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