THE EFFECT OF SINGLE VOLTAGE PULSING ON GaAs AND GaN LIGHT-EMITTING HETEROSTRUCTURES

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Semiconductor components that make up spacecraft and aircraft may be sensitive to electromagnetic interference (EMI) caused by electrostatic discharge, lightning or nuclear explosion [1]. Exposure to EMI results in pulsed voltage across semiconductors, thus, EMI resistance is commonly assessed using single voltage pulses (hereinafter referred to as pulses). Voltage pulses can affect critically important components of electronic systems due to outflow of electrical and time parameters beyond the norm, thyristor effect, secondary thermal breakdown, formation of point defects, and melting and shorting of local regions in semiconductors. Investigation of the consequences is an important applied task contributing to the development of microwave electronics, aviation, and space technologies [1–3]. The relevance of this task is defined by the increased sensitivity of modern electronic systems to EMI due to miniaturization and increased functional complexity [1].

The effect of pulses on silicon devices has been most studied: diodes, MOSFETs, and bipolar transistors [1, 3]. In the past two decades, the focus of research has shifted towards GaN, SiC, and GaAs devices (high-voltage diodes, HEMTs, power transistors, etc.) [4–6], however, the effect of pulses on light-emitting heterostructures remains insufficiently understood. Meanwhile, simultaneous measurement of the electrical and optical characteristics of such structures can yield additional insight into the processes activated during and after semiconductor devices exposure to pulsing. Therefore, the purpose of this work is to study the effect of single voltage pulses on light-emitting heterostructures fabricated from GaAs and GaN.

The samples under study are industrial quantum well LEDs fabricated from GaN and GaAs with electroluminescence (EL) wavelengths of 530 and 850 nm. To simulate EMI exposure, single voltage pulses of negative and positive polarity with an amplitude no more than 100 V and a duration of 30 ns were supplied. The samples were in active state with direct constant current of 0.5 to 20 mA during pulsing. To monitor the condition of the samples, the oscillograms of current-measuring resistor voltage, photodiode's resistor voltage and EL spectra were recorded simultaneously. Volt-ampere characteristic of light-emitting diodes was also measured before and after pulsing.

It has been found that actions of pulses with positive and negative polarity are significantly different (Fig. 1). Pulse with positive polarity leads to intense EL flash and after that there is decrease in EL intensity.

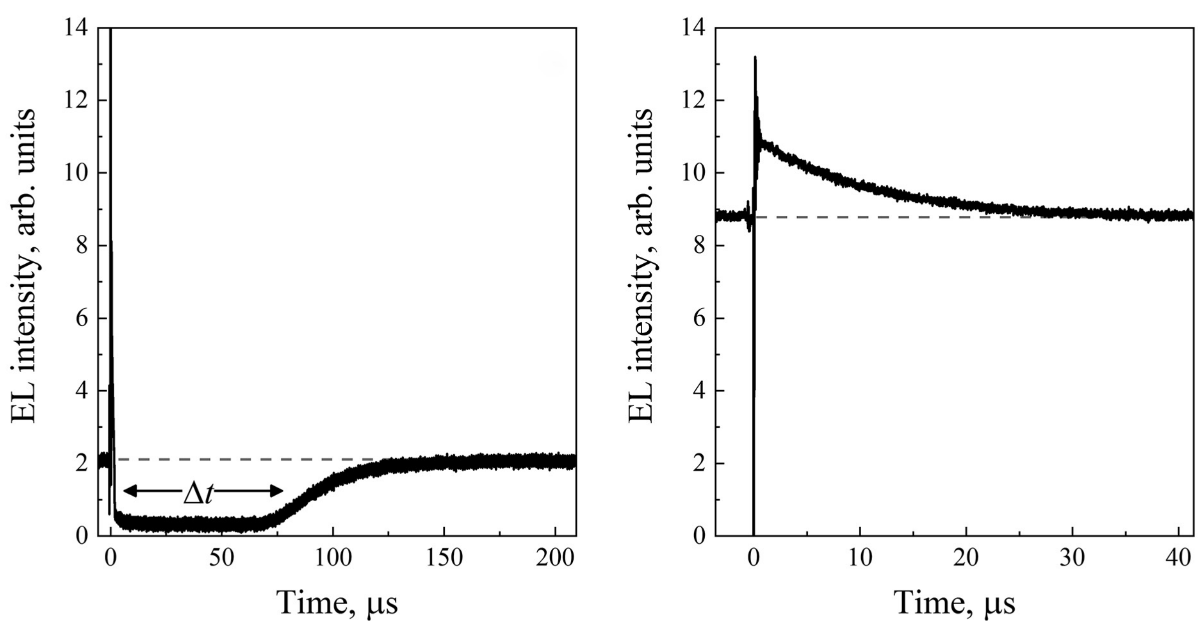

Fig. 1. Typical dependence of EL intensity on time after pulse with positive (*a*) and negative (*b*) polarity

Furthermore, during about 1–100 μs after pulsing, the value of EL intensity is of the order of magnitude lower than before pulse. The loss time of the LEDs, Δt, decreases with digital current flow increase. Pulse with negative polarity causes short EL intensity decrease and then the flash with duration about 10 μs that is substantially greater than minority carrier lifetime in quantum well. Peak wavelength of the flash is 530 nm and corresponds to optical transitions in quantum well.

Analogous EL flash of GaN- and GaAs light-emitting structures was observed during exposure to ionizing radiation [7]. The authors relate the flash with injection of minority carriers generated by ionizing radiation in quantum well. Measurements of volt-ampere characteristics evidence that pulses amplitude is enough to cause electric breakdown so the flash may be due to nonequilibrium charge carriers generated by the breakdown.

It is also worth to mention that a persistent alteration in the volt-ampere characteristics of the LEDs was observed within the low-voltage region (compared to the diode opening voltage) when the amplitude of negatively polarity pulses is elevated. These changes accumulate with the increasing number of individual pulses applied to the sample.

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