Deep levels induced optical memory effect in thin InGaN film

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An optical memory effect is found in a 20 nm InGaN film. With increasing illumination time, photoluminescence (PL) intensity of InGaN rises at first and then falls. We present that this effect is caused by carriers capture in deep levels near interfaces between GaN and InGaN. Firstly, carriers captured by deep levels near the interfaces reduces the band inclination in InGaN. This cause the rise of PL intensity. Secondly, more and more captured carriers may form anti-shielding, which enhances band inclination and results in the decrease of PL intensity. Carriers captured in previous illumination can remain for a long time after illumination is blocked, which make InGaN show an optical memory effect. https://doi.org/10.1063/1.5045811

InGaN materials are widely used as active regions in light emission devices, such as light-emission diodes (LEDs) and laser diodes (LDs).[1–3] However, due to the lack of a comprehensive understanding of their luminescence properties, some phenomena still cannot be explained very well.[4] Optical memory effect is one of these. This effect has been observed in AlN, GaN, and InGaN.[5–7] It is a phenomenon where photoluminescence (PL) intensity changes with increasing illumination time and this variation depends on previous illumination history. In InGaN, PL intensity may rise gradually to the maximum or fall exponentially within tens of seconds of an optical illumination. Such different behaviors of PL variation depends on the InGaN samples are excited by 365 nm or by 405 nm laser.[7] However, there are hardly any report of this effect in InGaN with 325 nm excitation. We have tested the PL of an InGaN film with 325 nm laser excitation and then found an interesting optical memory effect behavior. The PL intensity rises gradually to the maximum at first and then falls slowly in the range of hours rather than change monotonously.

Some researchers proposed that optical memory effect is somehow related to a blinking or quantum jump phenomenon in InGaN quantum dot.[7–9] Tsutsumi et al speculated that adsorbed molecules on the surface of the sample cause both optical memory effect and blinking.[10] However, most likely there are different mechanisms between them according to the largely different time scales of PL variation between them (most periods of blinking in InGaN are near several milliseconds, but for optical memory effect the PL rising or falling can last for more than several minutes).[10,11] More discussions about the mechanism of optical memory effect are necessary. Our analysis suggests

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