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LOW TEMPERATURE TRANSIENT OF DEEP CENTRE Zn IN GaN

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Kinetics of the photoluminescence emitted from GaN:Zn was studied at temperature 2K. A typical life-time of 300ns is reported for the blue GaN:Zn emission peaking at about 2.89eV. The decay of PL intensity corresponds to a hyperboric curve approximately and it is well described by the Becqueral type of relation.

1. INTRODUCTION

GaN is a wide-gap (3.5eV) direct semiconductor and thus gives luminescence over the entire visible spectrum by suitable doping. Zn dopants give rise to a broad blue luminescence bands in GaN, but the nature of the deep center responsible for these bands is not well established, nor is the mechanism involved[1].

In this work we report the detail analysis of the low temperature transients at different time range, the results show that the nature of 2.89eV blue luminescence is due to the radiative recombination between photoexcited electrons in conduction band and holes bound at the Zn_{Ga} acceptor taking into account some perturbations.

2. EXPERIMENTAL

The photoluminescence measurements were performed at 2K, using a standard liquid hulium bath cryostat (THOR CRYGENICS). A pulse nitrogen laser (LAMBDA PHYSICS M1000) was used as excitation source (3371A). Its pulse-width was 5ns and the average excitation intensity was 200kW in the pulse. The emission from the sample was focused on a 0.85m double grating monochromator (SPEX 1404) and detected with an S11 or S20 photomultiplier. The decay was measured by a wave-form (BIOMATION), a transient recorder (DL 906) and a signal averager (NICOLET 1170) while the time-resolved spectra were recorded with a boxcar averager (PAR 162).

The GaN samples were prepared by vapour phase epitaxy and a typical layer thickness is 50μm. For moderate Zn doping levels ($Zn \doteq 10^{18} cm^{-3}$) the broad blue-violet emission band dominates. Its PL peak centered at 2.89eV and the D-A pair emission at 3.26eV were observed in some samples.

3. RESULTS

The transient of 2.89eV band is shown in Fig. 1a, where the initial fast decay induced by the system response to the laser. It is followed by a rather well defined approximately exponential decay, which differs from that of D-A pair (Fig.

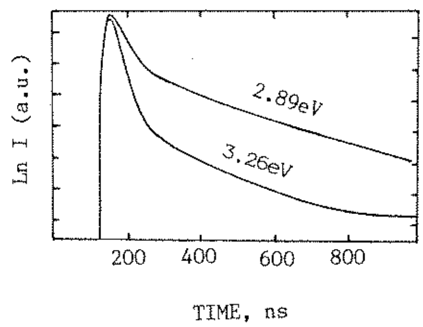

FIGURE 1
Transients of 2.89eV PL (a) and 3.26eV D-A (b).

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1b). The lifetime turns out to be 300ns at 2K and slight faster at 77K, in accordance with the rerult obtained from the time-resolved spectra (Fig. 2).

However, the decay curve of long-peroid (40µs) is unexponent, fitting the Becqural type of relation. The intensity of luminescence is basically given by the expression $I=I_0/(1+bt)^\alpha$ and we have obtained $\alpha=1.8$ from the experimental curve (Fig. 3). It demonstrates that the luminescence is interpreted as a bimolecular mechanism rather than a monomolecular kind.

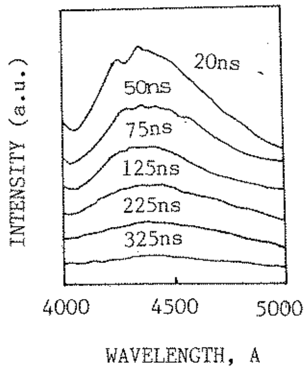

FIGURE 2
Timeresolved spectra of 2.89eV band for GaN:Zn.

4. DISCUSSION

The nature of the radiative transition is of considerable interest for GaN:Zn. The process, which originates from the recombination between a free electron and a hole bound at a deep acceptor Zn_{Ga}, is supposed to dominate and can be described as follows:

$$-\frac{dP_A}{dt} = -C_n n P_A$$

where C_n is a capture coefficient of electrons and n is the concentration of free electrons. We may assume $n \gg P_A$ and n is a constant. In this case

$$P_A(t) = P_A(0)e^{-C_n n t}$$

i.e. the population P_A of the acceptors decays exponentially with a time constant $\tau = 1/C_n n$.

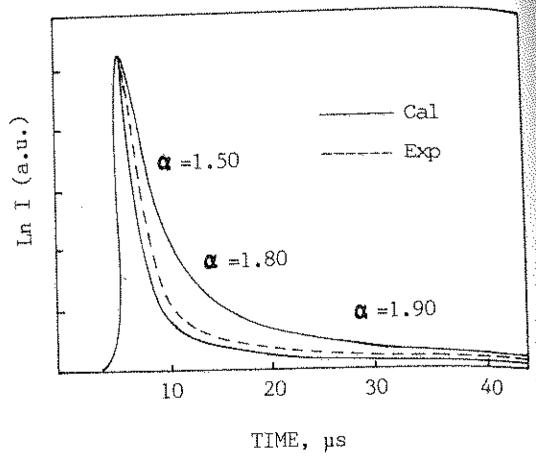

FIGURE 3
Decay curve of long-period for 2.89eV band

The PL intensity obviously appears the same decay so that lifetime of 300ns well-defined and it is shorter than that of GaN:Cd[2].

We can discuss further the increasing unexponential transient when $t \gg 1\mu s$ (Fig. 3), its decay corresponds to a hyperbolic curve. This result shows that Zn is a complex center. Zn in GaN forms not only a deep acceptor, but also causes other deep levels and the nonradiative recombination. We have measured the temperature dependence of 2.89eV luminescence and have observed the rapid drops of PL effeciency above 160K, which is responsible for compteting nonradiative transition[3]. It is proposed that the PL of 2.89eV is due to some perturbation-assisted the radiative recombination between photoexcited electrons in conduction band and holes bound at the Zn_{Ga} acceptor.

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