EFFECTS OF Eu IMPLANTATION ON RED LIGHT EMISSION OF GROUP III-NITRIDES

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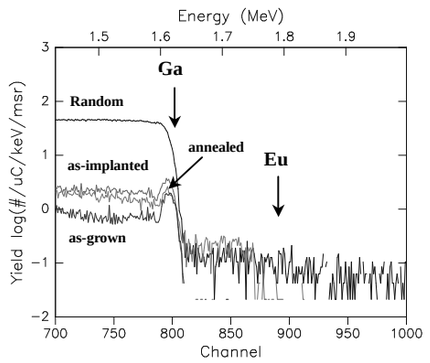
Recently, it has been reported that rare earth ions such as Eu act as an effective luminescence center in GaN. Since Eu may takes the position of Ga site in GaN and create isovalent traps, where electrons and holes should be captured and excite the 4f core electrons, although new trap levels are created by irradiating high energy particles, this excitation process in 4f core electrons causes strong radiation hardness of luminescence via 4f-4f core level transitions of Eu. To improve the luminescence efficiency of Eu implanted GaN, the local symmetry around the Eu should be reduced by co-doping or alloy composition[1]. In this work, we have implanted Eu ions into GaN, $In_xGa_{1-x}N$ and $Al_yGa_{1-x}N$ and investigated the crystalline quality of implanted samples by Rutherford backscattering spectroscopy and the luminescence properties.

GaN, $In_xGa_{1-x}N$ and $Al_yGa_{1-x}N$ epitaxial layers were grown on sapphire (0001) substrate by organometallic vapor phase epitaxy(OMVPE). Al composition were changed from 3 to 10 % and In composition was 15 %. Eu ions were implanted into these epitaxial layers with the dosage of 10^{13} ~8 x 10^{15} cm^{-2}. After the Eu implantation, the samples were annealed at 1050 °C for 30 min in 33 % NH_3 diluted N_2 to avoid decomposition of nitrides.

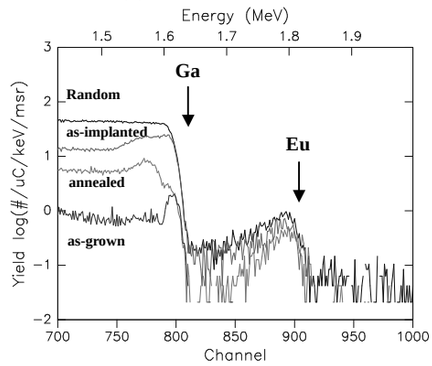
Fig. 1 (a) and (b) show RBS spectra of Eu dose of 10^{14} and 10^{15} cm^{-2} implanted GaN, respectively. From these figures, the implantation damage seems to be greater with the higher dosage of Eu and after the annealing process, the damage becomes to be reduced in both samples. Fig. 1 (a) indicates that χ_{min} is 1.7 %, which is close to that of as grown sample. Fig. 1(b) shows that Ga peak is accumulated under the Eu implanted layer due to the knock on effect by high energy Eu implantation and 40 % of Eu atoms are located at substitution site. Fig. 2 shows room temperature PL spectra of Eu implanted samples. We found that in the case of Eu implanted $Al_yGa_{1-x}N$ strong and narrow red emissions at 621 nm and this peak corresponds to the transition between $^5D_0$ and $^7F_2$ states in Eu^{3+}. The intensity is almost same compared with the magnitude of band-edge emission of GaN and this Eu-related emission indicates very small thermal quenching. The experimental results suggest that the implanted Eu ions can be effectively activated by the annealing around 1000 °C, and it is very useful for fabricating a light emitter for high temperature operation.

References

1. H.J. Lozeykowski and W.M. Jadwisienczak, Appl. Phys. Lett. 74, 1129 (1999)



(a) Eu dose : $10^{14}cm^{-2}$



(b) Eu dose : $10^{15}cm^{-2}$

Fig 1. RBS spectra of Eu implanted GaN.

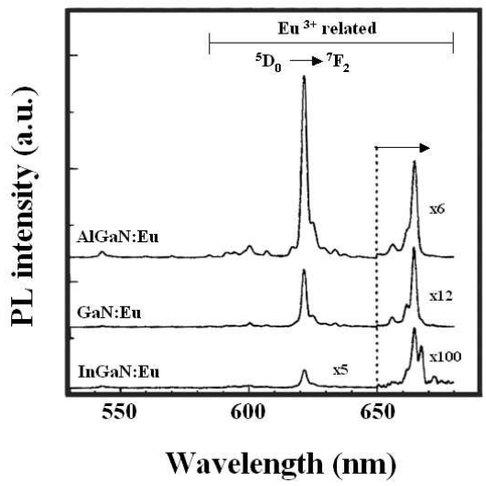


Fig 2. Room-temperature PL spectra of Eu doped samples with different alloy composition.