Electronic Supplementary Material (ESI) for Nanoscale.

Supplementary Information

Toward highly radiative white light emitting nanostructures: a new approach to dislocation-eliminated GaN/InGaN core-shell nanostructures with a negligible polarization field

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S1. Additional TEM images for planar and core-shell QWs

Fig. S1a and S1b show that cross-sectional TEM images for the core-shell InGaN SQW and the planar InGaN SQW. Due to the different growth rates of QWs on the planar and core-shell nanostructure templates, the SQWs show different thicknesses depending on the base templates. The core-shell SQW has an extremely thin thickness less than 1 nm (Fig. S1a), while the planar SQW has a thickness around 2.3 nm (Fig. S1b). Fig. S1c,d show the core-shell MQWs and the planar MQWs with their magnification images at several regions. In the case of the core-shell MQWs, the QWs grown on the pyramidal tip facet show a lower growth rate about half than the QWs on the column part. In the planar MQWs, the thick, third QW with a high In composition shows many dislocations and voids due to the enlarged strain as thickness increases.

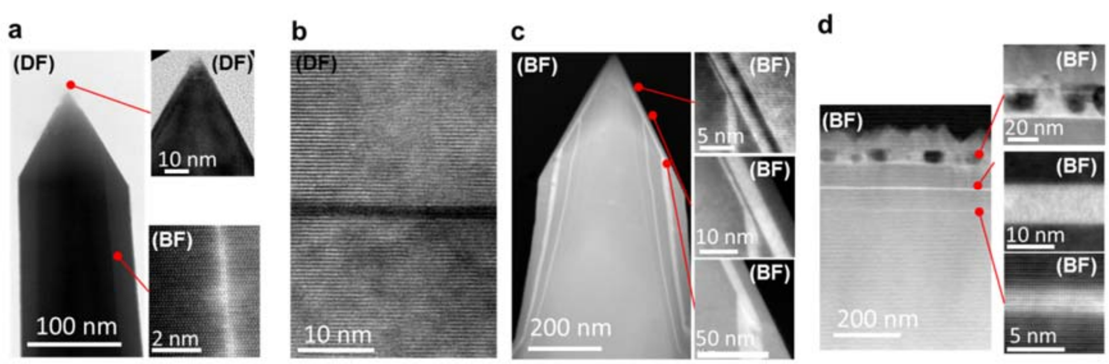

Fig. S1. (a-d) Cross-sectional high resolution TEM and scanning TEM high-angle annular dark field images: (a) core-shell SQW, (b) planar SQW, (c) core-shell MQWs and (d) planar MQWs. DF and BF indicate dark field and bright field images, respectively.

S2. CL experiment for core-shell SQW

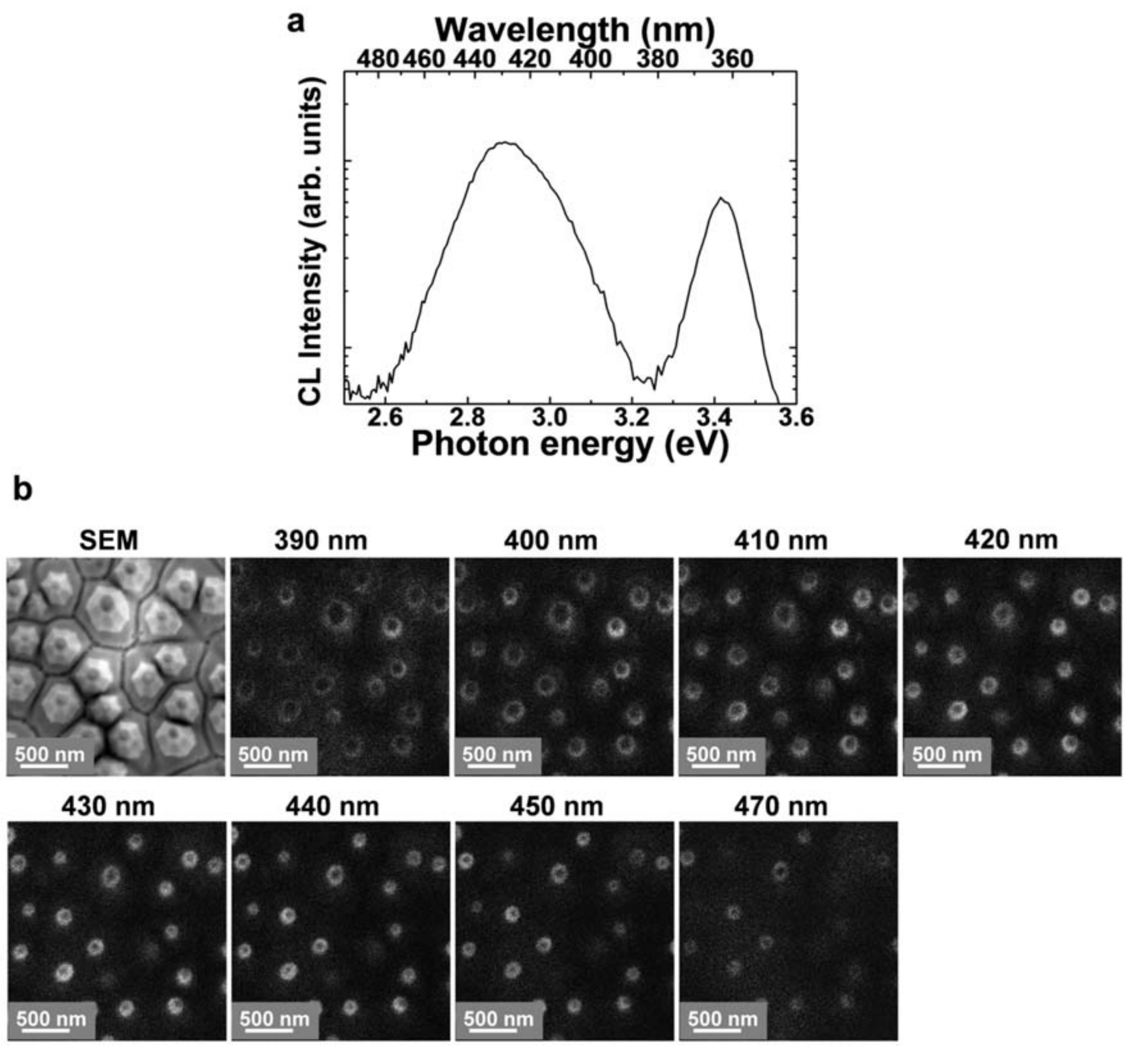

Fig. S2 (a) CL spectrum of core-shell SQW measured at room temperature with an acceleration voltage of 5 kV. (b) SEM and monochromatic CL images at various wavelengths for the core-shell InGaN SQWs.

S3. Commission internationale de l’éclairage (CIE) color space

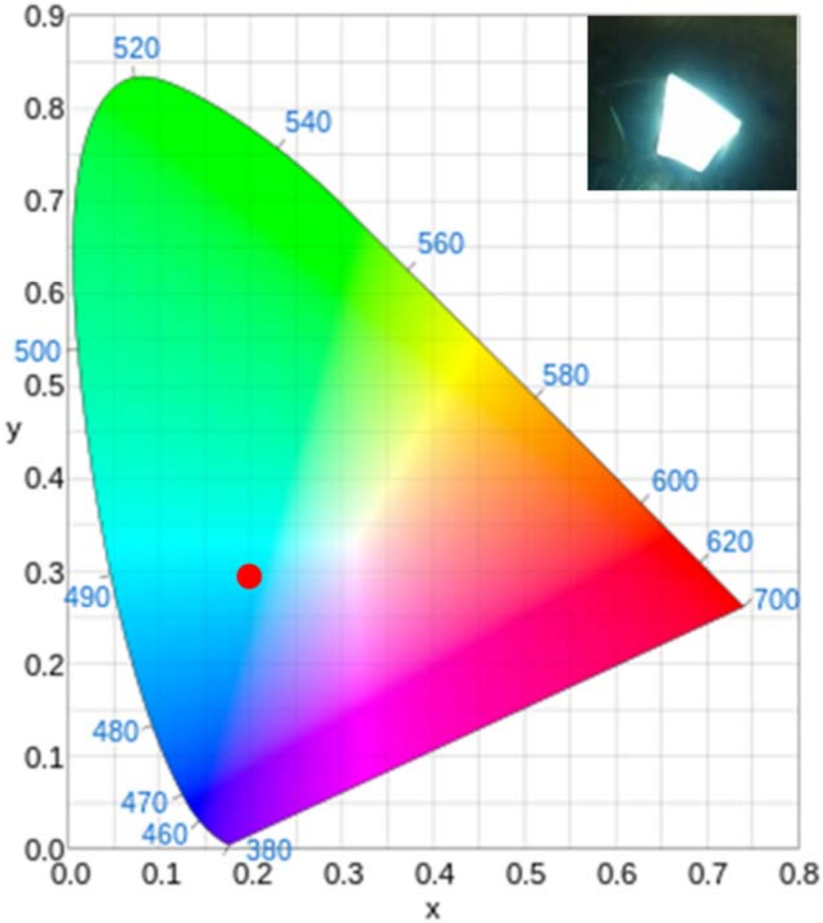

Fig. S3. CIE color space for CIE coordinate (0.2, 0.29) for core-shell InGaN MQWs.

S4. PL excitation (PLE) experiment

We performed the PLE experiment at 10 K to confirm that the PL emission at 2.3 eV in the core-shell MQWs originated from InGaN QW, not from the yellow defect band. We used a quasi-monochromatic light from a xenon lamp dispersed by a monochromator as an excitation source. The PLE curves were measured at the various QW energies (3 eV, 2.6 eV, and 2.25 eV) and they showed broad absorption edges (3.3 eV, 3.1 eV, and 2.7 eV) with a large Stokes'-like shift. The broad and large Stokes' like shift is related to the large potential fluctuation and the strong localization effect of exciton.[1] In the case of yellow defect bands, it is related to the GaN defects. Therefore, they have a strong intensity drop at the excitation energy below the GaN bandgap near 3.5 eV.[2]

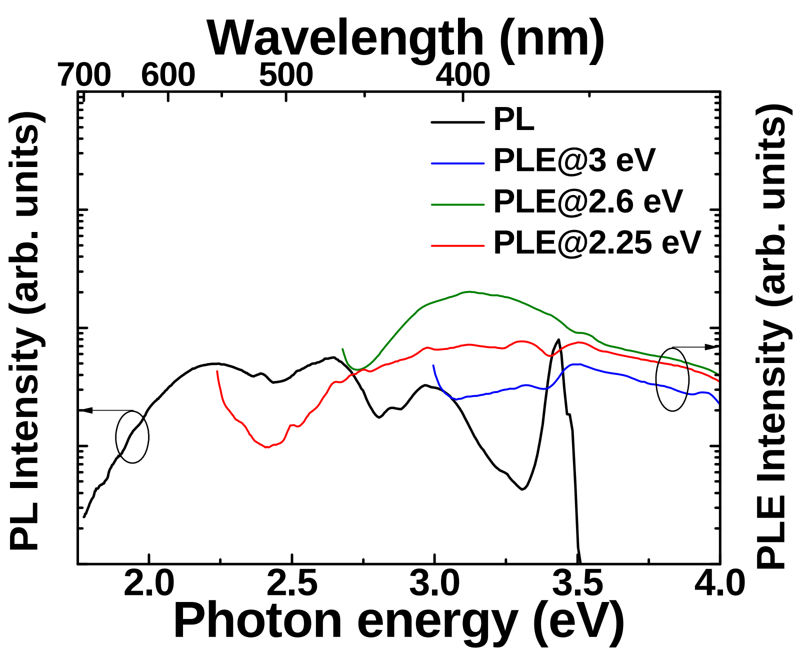

Fig. S4 . PL and PLE curves for core-shell InGaN QWs.

S5. Carrier recombination dynamics of planar InGaN QW

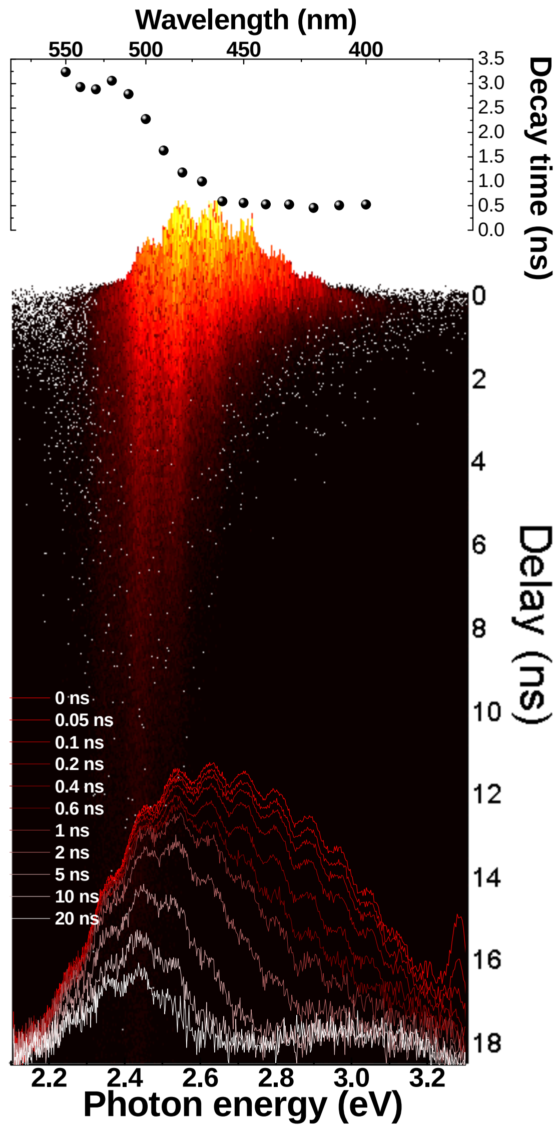

Fig. S5 Streak images at 15 K for the planar InGaN SQW shown in Fig. S1b. Decay time constants at different wavelength and time evolution of PL emission (log-scale) after pulse excitation are also shown above and below streak images, respectively.

References

1 R. W. Martin, P. G. Middleton, K. P. O'Donnell, W. Van der Stricht, *Appl. Phys. Lett.* 1999, **74**, 263.

2 Y.-H. Cho, J. J. Song, S. Keller, U. K. Mishra, S. P. DenBaars, *Appl. Phys. Lett.* 1998, **73**, 3181.