SUPPLEMENTARY MATERIAL FOR

Flexible white light emitting diodes based on nitride nanowires and nanophosphors

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Excitation and emission spectra of YAG:Ce nanophosphors in different media

The impact of the surrounding medium on the excitation and emission spectra of nanophosphors was analyzed. First, the wavelength of maximum absorption was determined. The excitation spectrum was measured by monitoring the fluorescence emission at the wavelength of maximum intensity while the material was excited by scanning the wavelength. The emission spectrum of the nanophosphors was measured for the excitation wavelength corresponding to the maximal fluorescence signal.

1200 nm/min scans have been performed with a Hitachi f-4500 spectrophotometer with 5 nm slits in emission and detection. The excitation and emission spectra of the nanophosphors have been measured in three different environments characterized by different dielectric constants and ionicities: PDMS, water and acetonitrile (see Fig. S1). The dielectric constant is 2.3-2.8 for PDMS, 80 for highly polar water and 37.5 for acetonitrile. The relative polarity of acetonitrile with respect to water is 0.46 resulting in an easier dispersion of nanophosphors in water than in acetonitrile.

The matrix effect of the PDMS is quite significant compared to the water and acetonitrile environment, the peak wavelength of the emission in PDMS is increased by 15 nm from 554 to 569 nm with no change of the peak FWHM. The 469 nm excitation peak of nanophosphors in water and acetonitrile is much narrower than in PDMS where several contributions seem to be superposed, one peaked around 502 nm and a second one centered at ∼450 nm. This heterogeneity is probably due to several aggregation sizes in PDMS (mass ratio YAG:Ce phosphor/PDMS=1:20) that have indeed been observed by SEM. In water and acetonitrile solvents, the aggregation and particles size is also affected by gravity settling that explains the different intensities in the emission and excitation spectra of Fig. S1 c).

The so-called Stokes shift (i.e. longer wavelengths for emission than for excitation resulting from loss of vibrational energy corresponding to the relaxations from the excited state to the ground state) is only 67 nm for PDMS compared to 85 nm for water and acetonitrile when the excitation maximum is considered. However this discrepancy is minimized when the two contributions of the excitation spectrum of Fig. S1 a) are taken into account.
Figure S1. Emission and excitation spectra of Y$_3$Al$_5$O$_{12}$:Ce$^{3+}$ (3.3 % wt.) nanophosphors (excitation and emission wavelengths $\lambda_{\text{ex}}$ and $\lambda_{\text{em}}$ are indicated in the figures) embedded in (a) PDMS (mass ratio YAG:Ce phosphor/PDMS=1:20) , (b) water and (c) acetonitrile.
Absolute quantum yield of the YAG :Ce nanophosphors

The absolute measurement of the quantum yield of phosphors (i.e. the ratio of the number of photons emitted to the number of photons absorbed by the light-emitting material) has been performed using a Quantaurus-QY setup with a Xenon lamp, a monochromator, an integration sphere and a multichannel detector. Figure S2 shows the quantum yield of the nanophosphor at different wavelengths.

![Absolute quantum yield of the YAG :Ce nanophosphors.](image)

Performance of the reference blue LED

Using a different part of the same InGaN/GaN NW wafer as the flexible white LED, a reference flexible blue LED sample has been fabricated for comparison following the same procedure as the flexible white LED but without the phosphor addition.

The JV curves of the reference flexible blue LED in decimal and log scales are shown in Figure S3. The curves have the similar profile as that of the flexible white LED. They show a diode-like behavior with an opening voltage around 3V.
Figure S3. J-V characteristics of the reference blue LED. The inset shows the same J-V curve in logarithmic scale.

The maximal values of the measured EQE of the reference blue LED (12.6%) and of the measured WPE (4.2%) can be reached under an injection current density of 14.4 A/cm$^2$. Figure S4 shows the measured EQE and WPE versus the injection current density. Starting from 14.4 A/cm$^2$, the droops of the EQE and of the WPE appear when increasing the injection current.

Figure S4. Room temperature EQE of the reference blue LED deduced from the measured optical power versus the injection current density (lower scale) and the current per NW (upper scale). The inset shows the WPE.

The reference blue LED has a similar profile as the Lambertian source. The emission intensity as a function of the emission angle is shown in Figure S5.
Figure S5. Intensity distribution diagram of the reference flexible blue LED (red) and that of a reference ideal Lambertian source (blue) as a function of the emission angle.