MS13-1-16 Tuning the colours with one luminescent host: nitrides as promising phosphors
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Abstract
Tuning the colours with one luminescent host: Nitrides as promising phosphors
Phosphor-converted white light-emitting diodes (pc-LEDs) are emerging as an indispensable solid-state light source for the next generation lighting industry and display systems due to their unique properties.
Gallium nitride (GaN) is a key material when it comes to light-emitting diodes (LEDs) and has pushed the LED revolution in lighting and displays, triggered by the investigations of Nakamura and coworkers, being awarded the Nobel prize in 2014. The concept of down-conversion of a GaN-based blue LED offers the possibility to provide efficient generation of monochromatic, high-colour purity light resulting in a highly efficient warm-white all-nitride phosphor-converted light emitting diode (pc-LED). To cover the colour range from blue, over green and orange to red (ca. 450 to 650 nm), a combination of InGaN und AlGa(In)P is necessary nowadays.
Several challenges have to be addressed here. The decrease of the external quantum efficiency versus emission wavelength around 560 nm, is termed the “yellow gap". The immiscibility of GaN and InN leads to a reduction in performance of InGaN-based LEDs with higher InN mole fractions. The lattice mismatch between GaN, InN, GaAlN, AlGaP, different thermal expansion coefficients and the variations of the In/Al content decrease the luminescence performance tremendously.
Nitrides and nitridosilicates with their wide-ranging applicability represent an essential component in industrial and materials applications due to their intriguing structural diversity, their auspicious chemical and physical properties. In particular, Eu^{2+}-doped (oxo)nitridosilicates and SiAlONs have been amply studied as important host lattices for phosphor-converted light-emitting diodes (pc-LEDs).
Here we demonstrate the doping of bulk GaN with europium, terbium and the combination of both and the successful adsorption of Eu and Tb at the grain boundaries of bulk β-Si_3N_4 and β-Ge_3N_4 as novel and promising components of the illustrious pc-LED family.
This colour tuning proves that one luminescence host can provide three colours (red, green and orange) and that even the so called “yellow gap” could be closed with a III-nitride. The green luminescence of GaN:Tb, Tb-β-Si_3N_4 and Tb-β-Ge_3N_4 demonstrates impressively that green emitting phosphors can be also achieved with purely nitridic compounds and not only with oxynitrides (e.g., β-SiAlON:Eu^{2+}) or oxonitridosilicates (e.g., $SrSi_2O_2N_2$:Eu^{2+}) as it was up to now.
By using one material for all colours, it will be possible to overcome technical challenges in building up LED devices, which will open up new capabilities for modern highly efficient phosphors.