White-light up-conversion emission in transparent sol-gel derived glass-ceramics containing rare-earth doped YF_3 nano-crystals

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Transparent nano-glass-ceramics containing YF_3 nanocrystals doped with luminescent rare-earth ions, such as Yb^{3+}, Er^{3+} and Tm^{3+} and combinations of those ions, were obtained under adequate heat treatment of precursor glasses synthesized by room-temperature sol-gel processing. Thus, precursor silica glasses with composition $90SiO_2$-$10YF_3$ co-doped with 0.3 Yb^{3+}- 0.1 Er^{3+}, with 0.3 Yb^{3+}- 0.1 Tm^{3+}, and triply-doped with 0.3 Yb^{3+}, *x* Er^{3+} and 0.1 Tm^{3+} with *x* ranging from 0.025 to 0.1 (in mol%), were obtained by sol-gel method as described in [1,2] and subsequently heat-treated to achieve controlled precipitation of YF_3 nano-crystallites. Hence we report the sol-gel route for obtaining rare-earth doped YF_3 nanoparticles dissolved in silica glasses, alternative to reported conventional high-temperature melting techniques for these nano-composites [3,4]. Upconversion luminescence features confirm the effective partition of luminescent ions into precipitated nano-crystals. The dependence of the overall emitting colour has been analyzed, as a function of doping ions and respective concentration and heat treatment temperature of precursor glasses, and quantified in the CIE standard chromaticity diagram. Moreover, tuneability colour has been achieved with varying rare-earth ions concentration. In particular, very bright and efficient upconversion emission, almost matching the standard equal energy white light illumination point of the CIE diagram, was obtained in the 675 ºC-treated 0.3 Yb^{3+}- 0.05 Er^{3+}-0.1 Tm^{3+} nano-glass-ceramics, showing up as promising candidate materials for potential applications in photonic integrated devices and infrared tuneable phosphors.

References:

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Figures:

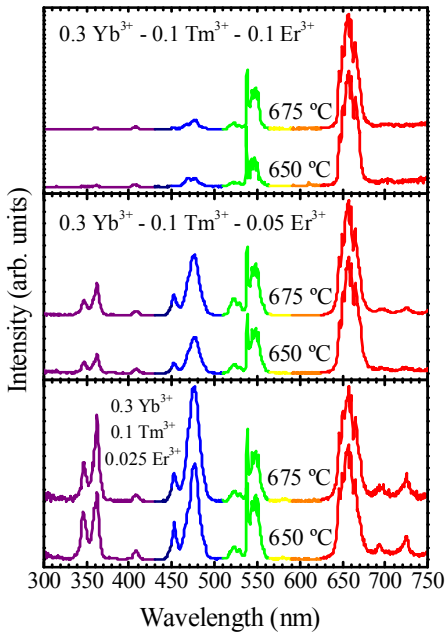

Figure 1. Up-conversion emission spectra in $90SiO_2$-$10YF_3$ triply-doped with 0.3 Yb^{3+}, *x* Er^{3+} and 0.1 Tm^{3+} (in mol%), where a) *x* = 0.1, b) *x* = 0.05, c) *x* = 0.025, under 980 nm excitation at 200 mW pump power as function of heat treatment temperature of the samples in the range 650-675 ºC. Spectra have been normalized to the maximum of the 660 nm emission band.

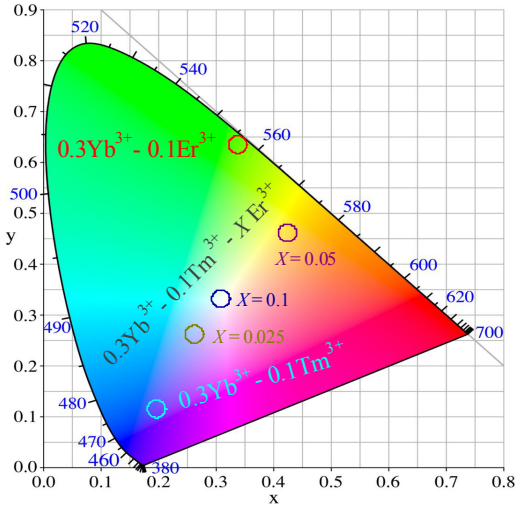

Figure 2. CIE standard chromaticity diagram including coordinates of $90SiO_2$-$10YF_3$ co-doped with 0.3 Yb^{3+}- 0.1 Er^{3+}, 0.3 Yb^{3+}- 0.1 Tm^{3+}, and 0.3 Yb^{3+}- *X* Er^{3+}, 0.1 Tm^{3+} (in mol%) with *X* = 0.05, 0.025, respectively, heat-treated at 675 ºC under 980 nm excitation at 200 mW pump power.