Development of down converting stable and efficient materials: Silver diffusion in glass

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Abstract

Luminescent devices are significant part of daily life (e.g., LEDs). In this work new stable luminescent glass materials for down converting UV light to visible/NIR light were synthesized. Noble metal clusters are known to be able to confer photoluminescence to glasses and are expected to display high luminescence quantum yields when synthesized with different emissive ions. [1] Control of the size and shape of the small particles is imperative to increase the colour range and external quantum yields (EQY) of luminescent glasses, thus demanding investigation of the metal ions reduction mechanisms, nanoparticles formation and diffusion in glass.
In a first step silver in different concentrations was introduced in soda-lime silicate glasses. An ion exchange technique was used by immerse a glass piece in a solution containing silver, e.g. in a molten salt mixture of AgNO3/NaNO3, allowing the formation of homogeneous films in glass surfaces doped with silver clusters and/or larger nanoparticles (NPs), taking in consideration that oversized NPs may quench luminescence. The ion metal reduction was achieved by chemical agents present in the glass matrix. After silver diffusion and reduction, formation of metal clusters or NPs with controlled sizes was induced by heating at different temperatures, for different times. After annealing at 400 °C the samples were pale-yellow and transparent, yet when excited at 360 nm photoluminescence was observed with an emission band around 650 nm, consistent with Ag clusters as light emitting centres. Annealing at higher temperatures, c.a. 500 °C, lead to larger nanoparticles and a more intense yellow colour, however with same characteristic photoluminescence.

Different experimental techniques were used, namely XRF combined with the ion beam based spectrometries PIXE, RBS and NRA, to characterize the elemental glass compositions and depth distributions of the incorporated atoms, as well as absorption and emission spectroscopy to characterize the optical properties.

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