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Summary

Synthesis and optical studies of $Y_3Al_2Ga_3O_{12}:Cr^{3+}$ persistent phosphors and ceramics doped with Rare Earth ions (RE^{3+})

Zhengfa Dai

Persistent luminescence (PersL) is a type of luminescence that can be observed for several minutes or even hours after the removal of the excitation sources. This unusual property is caused by the specific mechanism of charge carrier trapping and de-trapping process in the persistent phosphors. Persistent phosphors may be widely applied in many fields, such as decoration, security display, bio-imaging. Red or NIR persistent nano-phosphors are still unique and have already proven their superiority over other candidates due to their deep tissue penetration and high signal-to-noise ratio when applied as luminescent probes. However, compared to the widely studied and applied blue and green persistent phosphors, both the development and application of red and NIR persistent phosphors are still insufficient. Moreover, until now, the detailed mechanism of the PersL remains an open question.

For the purposes of this dissertation, $Y_3Al_2Ga_3O_{12}$ garnet was selected as the host matrix, and Ce^{3+}, Cr^{3+}, Pr^{3+} and Nd^{3+} were used as dopants and emitting centres to realise red and/or NIR persistent luminescence. Nanosized phosphors with a narrow particle size distribution were synthesized using the Pechini and co-precipitation methods. The effect of annealing temperature on the morphology and properties was systematically investigated. It was found that the particle size and luminescence intensity, as well as energy transfer efficiency from Ce^{3+} to Cr^{3+} and Pr^{3+} increased with increasing temperature. The influence of surface states and defects on the energy transfer and charge carrier trapping and de-trapping process was studied. Persistent luminescent ceramics were fabricated by using hot isostatic pressing method and the influence of air-annealing treatment on their properties was also investigated. It was found that after this post-treatment annealing, the number of oxygen vacancies became less and the intensity of PersL decreased. These results prove that such defects may act as traps in the PersL process. The PersL mechanism, charge carrier trapping and de-trapping model, was updated and applied to explain the PersL of studied materials based on the obtained results.