Persistent luminescence: traps in materials and in research

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Persistent luminescent, or glow-in-the-dark materials, have been known for centuries. Until about 15 years ago, only radioactive, hygroscopic or rather weakly emitting compounds were known. In 1996, Matsuzawa et al. [1] found that $SrAl_2O_4$, doped with both Eu and Dy, not only showed considerably higher luminance and afterglow time – up to more than 24 hours – but was also a safe and relatively stable persistent luminescent material. This discovery has opened up a wealth of possible applications, from emergency illumination to road signs and medical imaging [2].

Currently, a lot of research is devoted to optimizing brightness and afterglow time and trying to obtain colors, different from the typical blue-green of $SrAl_2O_4$:Eu,Dy. However, these developments are hampered by two effects. First of all, there exist still numerous conflicting models for the process of persistent luminescence, and the nature of the traps involved in the storage of energy is still not entirely clear [3]. Obviously, this lack of conclusive model prevents an aimed design of new materials. In the present work, we present some advanced experimental methods, including thermoluminescence spectroscopy and x-ray absorption spectroscopy (XANES and EXAFS) which allow a detailed study of the trapping (charging) behavior of persistent phosphors [4,5] and enable to exclude some of the proposed models.

The second effect complicates the development of red emitting persistent phosphors. At low light levels, the human eye sensitivity shifts towards shorter wavelengths (this is called the Purkinje effect), and the sensitivity for red light becomes very low. Thus, in order to obtain a red emitting phosphor which appears equally bright as a green or blue one, a much higher number of photons is required. Since red emission is required for both medical imaging [2] and for indicating emergency situations, there is a strong interest for developing high brightness red persistent luminescence.

Red phosphors that can be excited using visible light are scarce. It is thanks to the boosting LED business that recently several new host materials were investigated, leading to a number of efficient europium-doped nitrides and oxynitrides as stable broad band emitting phosphors. Currently, it is being explored whether these new materials can be turned into persistent phosphors by suitable co-doping or by adapting synthesis conditions. Besides this development, other methods to achieve red persistent luminescence are discussed.

References

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