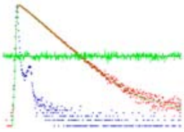


Characterising lanthanides in glasses for optical applications

Glasses are essential materials with a multitude of uses and many forms. In the area of optoelectronics there is an interest to modify the glass composition to favour the incorporation of lanthanide elements. Their stability and luminescence properties give the opportunity to fabricate optical materials, such as broadband amplifiers, lasers and non linear optical devices. A principal area of interest is that of telecommunications. Addition of heavy metal oxides assist in structural changes within the host glass for lanthanide incorporation, as well as expressing low phonon energies. However changes in composition and structure can influence the lanthanide emission and time-resolved spectroscopic methods are well suited to investigate this.

Overview

Glasses can be made and modified from many substances to provide robust and chemically durable materials. They can easily be formed into fibres which has helped the rapid progress of telecommunications. The appropriate choice of guest molecule enables the manufacture of a range of optical devices, such as laser glasses, lasing materials and optical amplifiers. The use of lanthanides as the active species holds promise. This is because of their stability, both chemically and photophysically, their well defined emission and wavelength range. Depending on the choice of lanthanide this can be from the visible to the near infrared (NIR) and is applicable for telecommunications usage.

Employing heavy metal oxides facilitates the incorporation of some lanthanides and, in the optoelectronics field, it is advantageous if the glass expresses low phonon energy. The influence of modifiers on the glass structure and the photophysical properties of the active species needs to be assessed to optimise their usage and luminescence spectroscopy plays an important role in this process.

Time-resolved study of lanthanide containing glasses

Measurements were made on glass samples, like those shown in Fig. 1. The samples were excited using *SpectraLED*s, since the expected lifetimes were on the micro- to millisecond time range.

Fig. 1. Example of sample form for different lanthanide containing glasses

As some of the samples were emitting in the NIR a *TemPro* system equipped with a NIR detector, sensitive from 950 to 1700nm, was employed (see Fig. 2). By using a mirror block coupled to the monochromator this system could be configured to also measure lifetimes in the visible using a complementary *TBX* detector, allowing a larger wavelength range to be sampled.

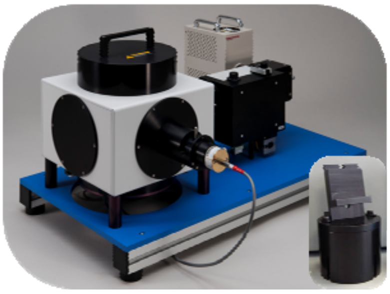
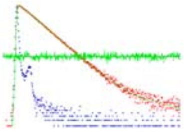


Fig. 2. *TemPro-01* with a NIR detector and a *SpectraLED* excitation source. Inset solid sample holder

Er^{3+} is an example of an ion that has emission in the visible, as well as the NIR close to 1500nm – which is well suited for telecommunications purposes. A measurement in the visible of Er^{3+} containing silver lead borate glass, using a *TBX* detector with *SpectraLED-370* excitation, showed a complex decay and time-resolved emission spectra were measured. *DAS6* analysis allowed decay associated spectra to be calculated and these, along with the sum (steady state) spectrum, are shown in Fig. 3. This shows that it is possible to obtain information concerning the individual emissions as well as the overall spectrum.



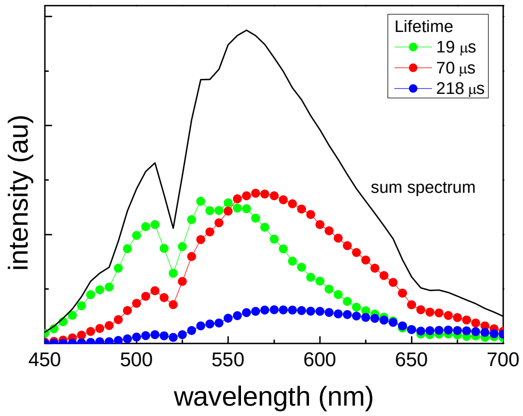


Fig. 3. Decay associated spectra for the different lifetime components as well as the calculated sum

Er^{3+} in a garnet containing glass, monitored at a single wavelength (545nm) with the same excitation was found to decay in a simpler manner as it fitted to a two exponential model. Further analysis showed that it also fitted well to one distribution, as can be seen in Fig. 4.

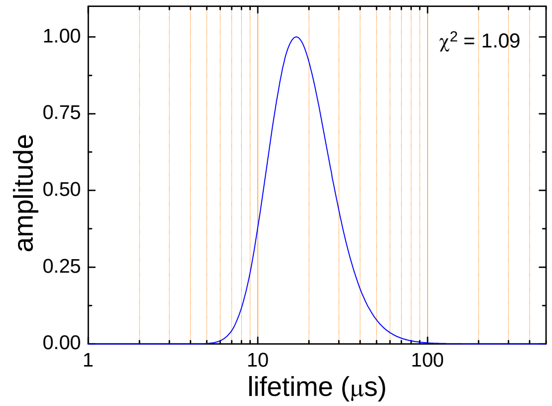


Fig. 4. Distribution analysis of Er^{3+} in a garnet containing glass. Measured using a *FluoroCube* with *S-370* excitation and *TBX* detection at 545nm. A 2-exponential fit returned lifetimes of 11 and 25µs with a similar χ^2.

Measurement of the NIR emission of Er^{3+} in silver lead borate glass at 1550nm on a *TemPro* (see Fig. 2) with SpectraLED excitation at 970nm required a two component model to fit the data. This is shown in Fig. 5 along with the steady state emission of the glass made using the same detector. It is this combination of spectral and time-resolved data that is useful in ascertaining information concerning the active species and the effect of modifiers in the glass matrix.

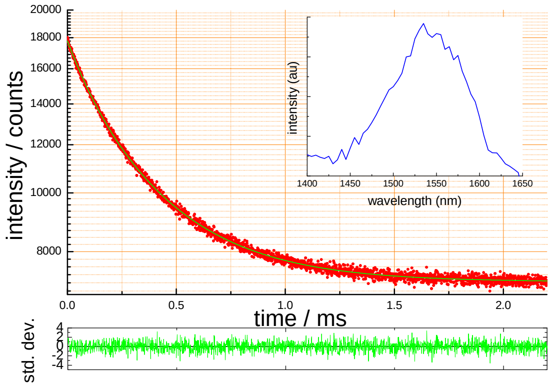


Fig. 5. Luminescence decay of Er^{3+} excited using a *S-970*, with emission at 1550nm monitored with a NIR detector. Inset, the steady state spectrum measured with the same detector

Summary

This note illustrates how different time-resolved techniques can be employed to gather information concerning these guest-host systems.

Material referenced

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