OPTICAL SPECTROSCOPY OF Cr^{4+}-DOPED CHALCOGENIDE GLASSES

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Key words to describe the work: Optical Spectroscopy, Chromium, Chalcogenide glass

Key Results: Optical absorption, emission spectra and lifetimes were measured in Cr^{4+}-doped chalcogenides

How does the work advance the state-of-the-art?: The potential of Cr^{4+}-doped chalcogenide glasses as laser gain media has been assessed

Motivation (problems addressed): Broadband infrared laser media could have applications in optical telecommunications and gas sensing

Introduction

The infrared emission from Cr^{4+} coincides with the wavelength range used in optical telecommunications, making them interesting possibilities for active ions in optical amplifiers. Broadband amplification requires a material with a broad emission spectrum. Cr^{4+}-doped crystals are known for their use in broadband infrared laser sources. Recently there has been an interest in developing a glass host for Cr^{4+} which would be suitable for fibre-drawing. Cr was doped into a range of chalcogenides which were chosen for their suitability for fibre-drawing.

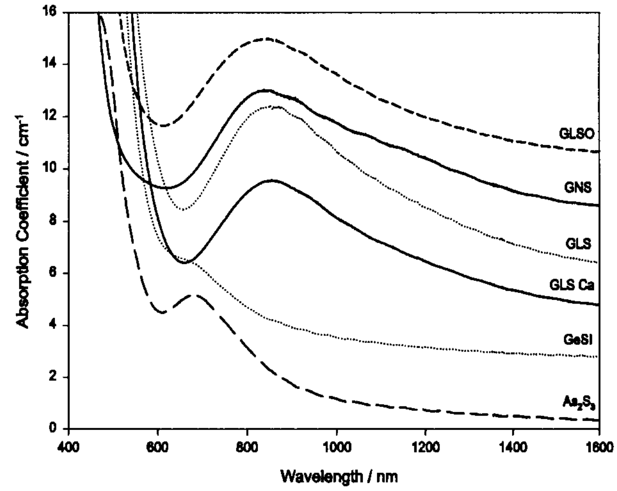

Fig 1. Absorption spectra of Cr-doped chalcogenide glasses, showing peaks at 690nm and 850nm

Results and Discussion

Bulk glass samples were prepared by melting from appropriate powders, except for As_2S_3 which was obtained as a commercial glass and remelted with Cr_2S_3. The Cr-doped samples all contained 200ppm wt. Cr.

Optical absorption spectra are shown in figure 1, and show a single broad absorption peak for each glass with a UV edge at ~500nm. The absorption peak at 700-850nm and the long wavelength tail are characteristic of Cr^{4+} absorption[1]. The GeSI and As_2S_3 glasses have peaks at 690nm compared with 850nm for the GLS-based samples, indicating that the Cr in these samples is situated in higher crystal field sites.

Room temperature emission spectra were measured by exciting the samples with a Ti:Sapphire laser at 800nm. The emission spectra in figure 2 all show single broad peaks centred around 1050-1200nm which correspond to the $^3T_2$-$^3A_2$ transition of Cr^{4+}[2].

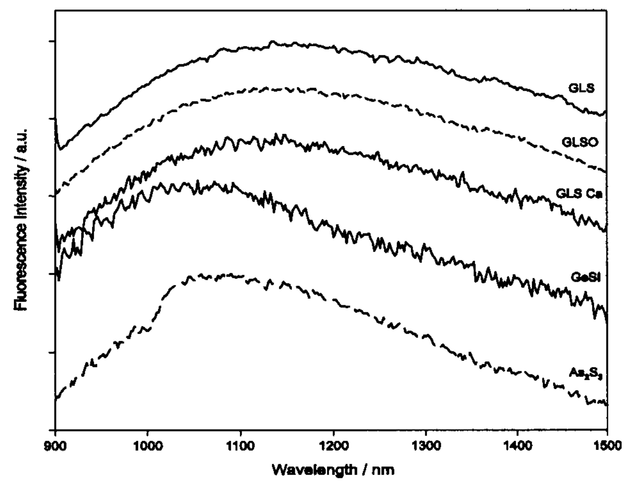

Fig 2. Room temperature emission spectra showing a single broad fluorescence in the near infrared

Emission spectra for were also measured at 70K and showed increased fluorescence intensity and a narrowing and shift to lower energy of the emission peak. Emission spectra at 4.2K were taken for the As_2S_3 and GLSO samples. These samples show a further narrowing of the emission when the temperature is decreased from 70K to 4.2K. The red-shift in emission is caused by the reduction of non-radiative decay which preferentially affects ions which emit at longer wavelengths.

Room temperature emission lifetime measurements were carried out using a PMT with sensitivity up to 1.1μm. Again the samples fell into two groups, with the GLS-based samples having longer lifetimes (0.9-1.7μs) than the As_2S_3 and GeSI samples (0.5-0.7μs). Room temperature radiative quantum efficiency measurements using an integrating sphere yielded a value of 2.5% for the As_2S_3 sample and 1.3-1.8% for the GLS-based samples.

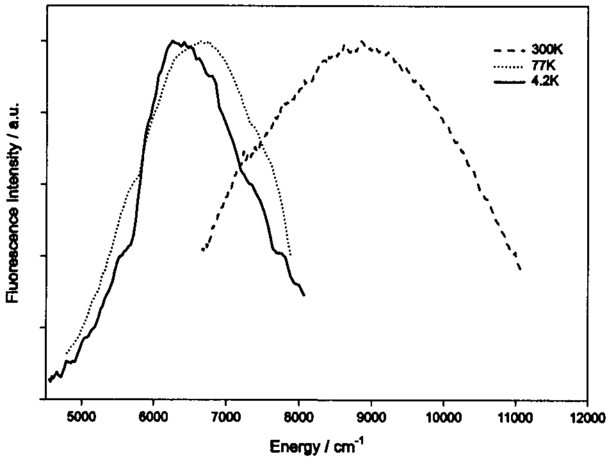

Fig 3. Temperature-dependant emission spectra, showing a shift to lower energy and a reduction of linewidth at lower temperature

Conclusions and further work

We have shown that broad near-infrared emission is exhibited by a range of Cr-doped chalcogenide glasses. Both the absorption and emission spectra are consistent with Cr being hosted in its tetravalent state in these glasses. Though the emission covers the wavelength range useful for optical telecommunications, the low radiative quantum efficiency means that these samples would not be useful for active devices. However, the strong absorption exhibited by these materials may make them useful as saturable absorbers.

The influence of glass composition and doping levels of Cr-doped GLS will be investigated further, with the aim of increasing the quantum efficiency.

[1] U. Hommerich, H. Eilers, W. M. Yen, J. S. Hayden and M. K. Aston: J. Lumin. 60-61, 119-122 (1994)

[2] R. Moncorgé, H. Manaa, G. Boulon: Opt. Mater. 4, 139-151 (1994)