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Optical Behavior of ZnS:Cu Microcrystals Embedded in Porous Silica Gels

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Emission and excitation spectra of ZnS:Cu microcrystals trapped in porous silica xerogels are presented. This system is characterized by intense, long-lived green emission at room temperature. It was observed that this emission was greatly reduced after compressing the xerogel samples.

KEY WORDS: ZnS:Cu microcrystals; optical behavior; porous silica xerogels.

INTRODUCTION

ZnS:Cu microcrystals are known to be efficient luminophors characterized by intense green emission [1]. Such luminophores trapped in sol-gel glass may find application in constructing X-ray intensifying luminescent screens.

The mechanical properties of sol-gel matrices (xerogels) can be greatly improved after compression. This process leads to densification of the xerogel, closing the pores.

The purpose of the study reported here was to characterize the optical properties of ZnS:Cu microcrystals trapped in silica gel glasses and determine the influence of pressure on their optical properties.

EXPERIMENTAL

The process of synthesis involved hydrolysis of tetraethyloortosilicate (TEOS) in an aqueous acidic solution to obtain a sol and preparation of the colloid by adding aerosil to the sol and adding a powder of ZnS:Cu microcrystals. The system was then neutralized up to pH ≈6.5 by means of an ammonia solution. After liquid slip casting and gel formation, the system was dried at 500°C. We have previously described the sol-gel process applied in this work [2].

The diameter of pores of the xerogel obtained was determined by means of TEM microscopy to be 0.3 μm. The plates of xero-gel obtained were then compressed at 40 kbar and 22°C during 10 min in the nickel cell.

The emission spectra were determined with an Ocean Optics fiber spectrophotometer SD-2000. An excimer laser (Lambda Physics), argon laser, and halogen lamp were used as excitation sources.

RESULTS AND DISCUSSION

The ZnS:Cu-doped silica gel glass samples demonstrated an intense, long-lived green emission at room temperature. The sample continued to emit long after switching off the excitation source. The emission spectra of ZnS:Cu-doped silica gel glass measured at different delay times after excitation are shown in Fig. 1. With increasing time the intensity increases reaching a maximum after 60 s and then decreasing, but even after 300

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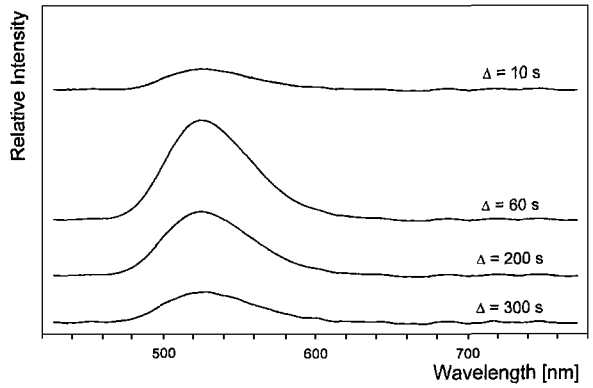

Fig. 1. Time dependence of the emission spectrum of ZnS:Cu trapped in silica xerogel. Δ = delay after excitation.

s it was still observed. The emission was recorded for several excitation wavelengths (see Fig. 2). The emission characteristics of the ZnS:Cu microcrystals trapped in silica gel glass were slightly dependent on the excitation wavelength.

We also studied the effect of temperature on the emission properties of these ZnS:Cu microcrystals trapped in the silica gel matrix. We noticed (see Fig. 3) that the intensity of the sample measured at room temperature was higher than that measured at 100 K. Moreover, the low-temperature spectra demonstrated an inhomogeneous broadening, which is most probably associated with the presence of more than one luminescent species.

The excitation spectra of ZnS:Cu microcrystals doped in xerogel are shown in Fig. 4. The absorption band maximum was centered near 380 nm.

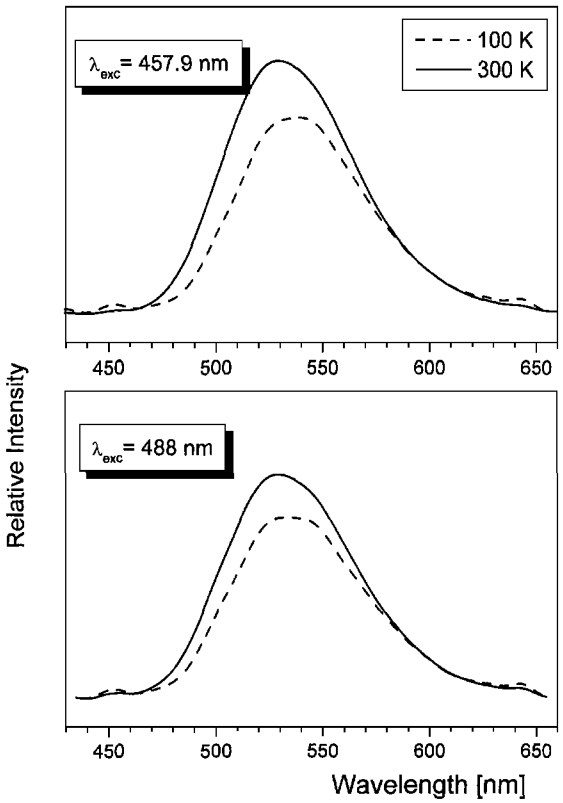

Fig. 3. Temperature dependence of the emission spectrum of ZnS:Cu trapped in silica xerogel.

We determined the luminescent lifetimes of ZnS:Cu polycrystals and ZnS:Cu microcrystals trapped in xerogel. The lifetime in the first case was determined to be

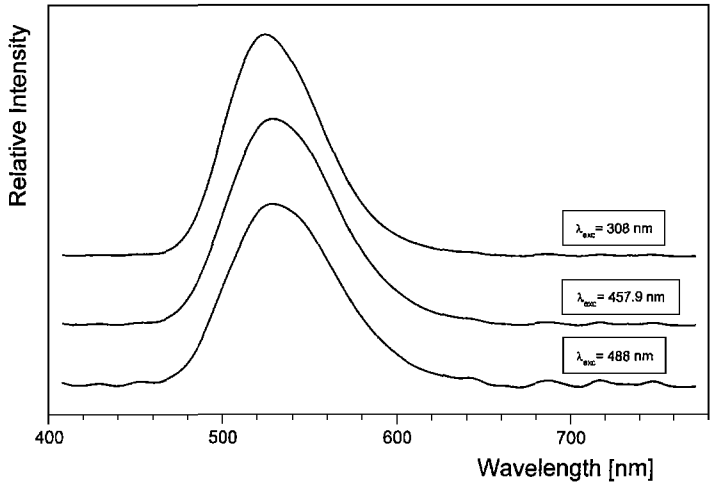

Fig. 2. Excitation dependence of the emission spectrum of ZnS:Cu trapped in silica xerogel.

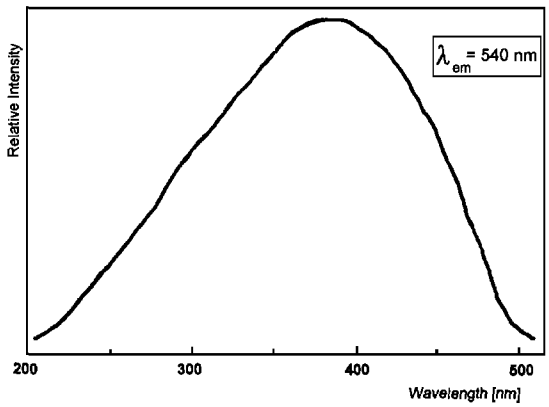

Fig. 4. Excitation spectra of ZnS:Cu trapped in silica xerogel.

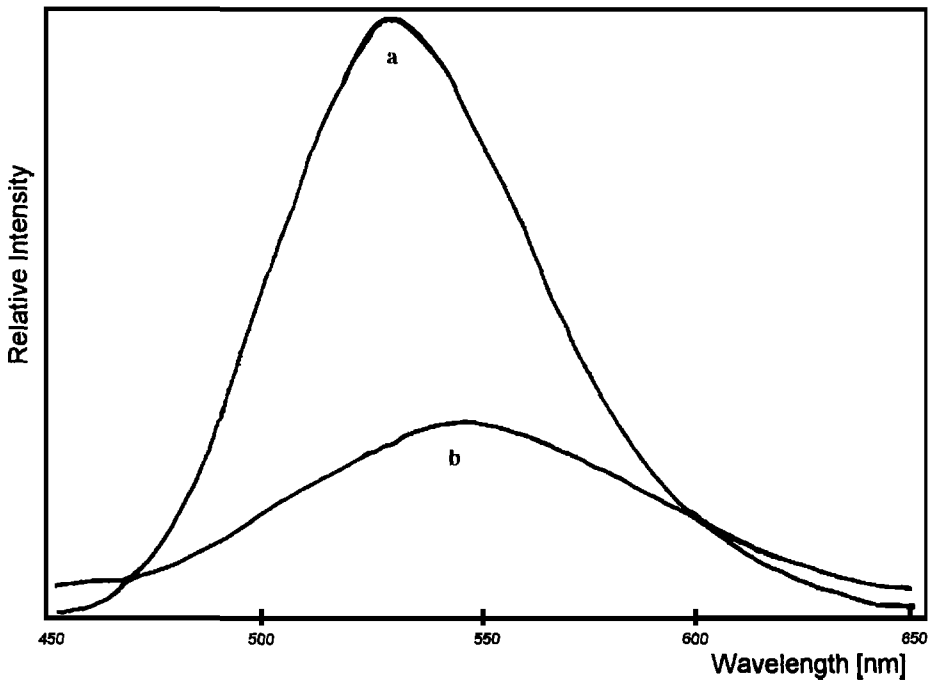

Fig. 5. Pressure effect on the emission spectrum of ZnS:Cu trapped in silica xerogel.

38 s, whereas for the second case it was slightly increased, to 39 s.

We observed that the sample which was compressed exhibited a severalfold lower intensity than an uncompressed one (Fig. 5). In addition, the peak emission was slightly shifted to the red. The emission liftetime of the compressed sample was determined to be less than 0.1 s.

Activation of solid matrices with phosphor crystals is usually accompanied by their partial destruction due to structural or chemical interactions caused by their compression. This may lead to degradation of the luminescent characteristics of the ZnS:Cu microcrystals.

ACKNOWLEDGMENT

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REFERENCES

1. M. Aven and J. S. Prener (Eds.) (1967) *Physics and Chemistry of II–VI Compounds*, North-Holland, Amsterdam.
2. G. E. Malashkevich, E. N. Poddenezhny, I. M. Melnichenko, and A. A. Boiko (1995) *J. Non-Cryst. Solids* **188**, 107.