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Fluorescent Photosensitive Glass—A Novel Material for Optical Memory and Fluorescence Holography

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A new fluorescent glass with Eu and Ce has been synthesized and characterized. Absorption, excitation, and emission spectra of Eu^{3+} have been measured. The effect of Ce-coactivation on fluorescence was also investigated. Sustained irradiation by ultraviolet light leads to a persistent extinction of fluorescence. This result is discussed in terms of photoionization of Ce^{3+}. Fluorescent photosensitive glass make it possible to print fluorescent photographic images within glass samples. © 1997 Academic Press

Key Words: **fluorescent photosensitive glass; rare earths; europium; cerium.**

INTRODUCTION

In existing computers a restriction imposed by present memory technologies, such as semiconductor memories, optical disks, magnetic disks, and magnetic tape, is their 2-D nature.

To overcome this restriction, research has been seeking alternate means for storage, including 3-D optical devices. 3-D optical memory has higher theoretical capacity (6.5×10^{12} bits/cm^3) than 2-D optical memory (3.5×10^8 bits/cm^2) at the same wavelength of light (532 nm) used to access the information (1, 2).

As a result of surveying many possible materials for a 3-D optical memory, we found that fluorescent photosensitive glass could be considered for this application (3, 4).

In addition to storage, the fluorescent photosensitive materials are a subject of interest for fluorescence holography (5).

In this paper we present a description of the synthesis and characterization of fluorescent photosensitive glass.

EXPERIMENTAL PROCEDURE

In order to obtain a glass with the composition (wt%) $50Na_2O$–$49P_2O_5$–$0.5Eu_2O_3$–$0.5CeO_2$, stoichiometric quantities of $(NH_4)_2HPO_4$, Na_2CO_3, Eu_2O_3, and CeO_2 were thoroughly mixed in a ball mill. The rare earth oxides were of 99.9% grade. All other reagents were of c.p. grade. The mixture was placed in a high alumina crucible with a lid and slowly heated to 600°C. After completion of gas evolution, the mixture was heated to 1000°C for 1 h. Glass discs 1 mm thick and 12 mm in diameter were obtained.

The UV light irradiation was carried out with a 125 W Hg lamp.

For fluorescence measurements we used an Amico–Bowman spectrophotofluorometer. The optical absorption spectra were measured with a Perkin–Elmer Lambda 2S UV/vis spectrometer.

RESULTS AND DISCUSSION

The fluorescent photosensitive glass contains Ce^{3+} and Eu^{3+} ions. The optical absorption spectra before and after UV light irradiation are shown in Fig. 1. The absorption band with a peak at 310 nm is due to Ce^{3+} ions (6). Comparison between the two spectra shows the presence of Ce^{3+} ions after irradiation. Figure 2 displays the emission spectra of Eu^{3+} prior and after UV light irradiation. The spectra were obtained by excitation in the $^7F_0$–$^5D_2$ at 465 nm. All fluorescence bands are assigned to the transitions from $^5D_0$ to ^7F_j ($j = 0, 1, 2, 3, 4$) (7, 8). Upon UV light irradiation, the emissions of Eu^{3+} decrease to a very low level.

In order to develop an efficient fluorescent photosensitive glass, a good understanding of the luminiscence mechanism is very important.

Ce^{3+} in silicate glasses can be photoionized by irradiation to UV light (9, 10). The same process was investigated in fluorescent photosensitive glass. Figure 3 shows the excitation spectra for the 420 nm emission prior to and after UV light irradiation. The peak due to the Ce^{3+} can be seen around 308 nm in both spectra. A peak at 250 nm was observed after UV light irradiation. It can be assigned to Ce^{3++} as in silicate glasses (9, 11).

The electrons released from the photoionized Ce^{3+} ions produce the extinction of Eu^{3+} fluorescence.

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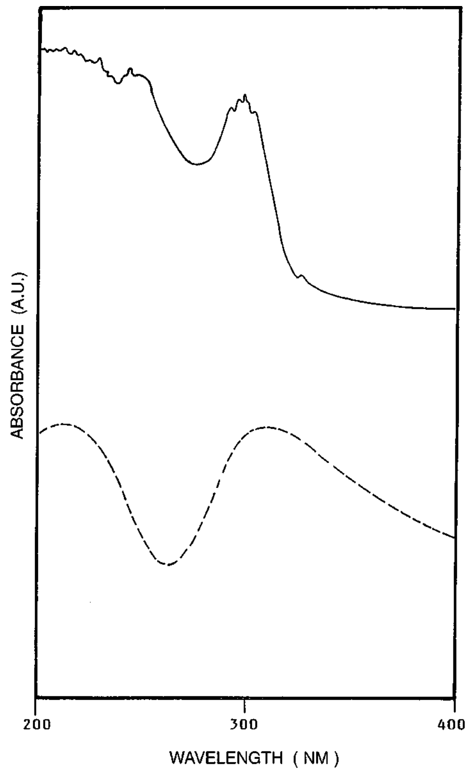

FIG. 1. Absorption spectra of fluorescent photosensitive glass before (solid line) and after (dashed line) UV light irradiation.

The information stored in UV-light-irradiated specimens exhibited excellent fading characteristics. The extinction of fluorescence is observed even 1 month after irradiation.

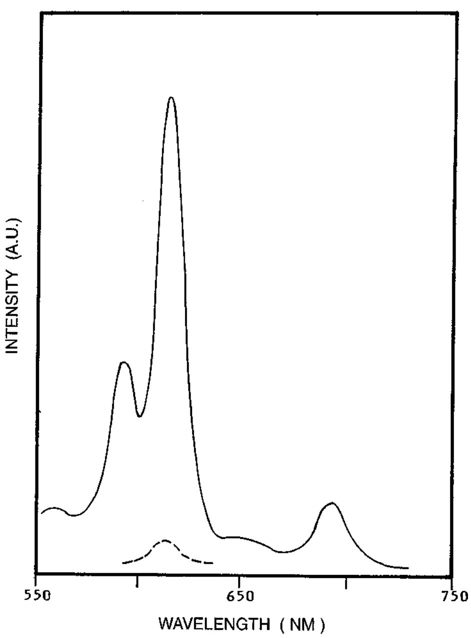

FIG. 2. Emission spectra of fluorescent photosensitive glass before (solid line) and after (dashed line) UV light irradiation ($\lambda_{ex} = 465$ nm).

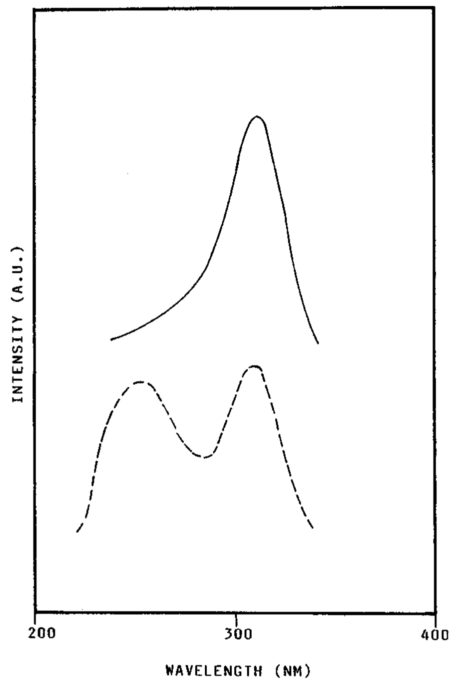

FIG. 3. Excitation spectra of fluorescent photosensitive glass for the 420 nm emission, before (solid line) and after (dashed line) UV light irradiation.

CONCLUSIONS

The fluorescence and absorption spectra of fluorescent photosensitive glass with Eu and Ce have been studied at room temperature.

A persistent extinction of fluorescence under sustained irradiation by ultraviolet light was observed.

In summary, we have developed a fluorescent photosensitive glass, which can be used for optical memory and fluorescence holography.

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