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Magneto-optical investigations of radiation defects in cerium-doped fluorozirconate glasses

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Abstract

Measurements of the magnetic circular dichroism of the optical absorption (MCDA) on X-irradiated Ce-doped fluorozirconate glass showed an increased paramagnetic band in the range from 300 nm to 700 nm and a new paramagnetic band peaking at 570 nm. Electron paramagnetic resonance (EPR) detected in these MCDA bands yielded two different defect centres having resonances at $g = 1.90$ and $g = 1.98$, respectively. © 2000 Elsevier Science B.V. All rights reserved.

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1. Introduction

Activator-doped fluorozirconate glasses are possible candidates for application as X-ray storage phosphors [1]. For the understanding of the energy storage in these glasses upon X-irradiation it is necessary to investigate the created defect centres (electron and hole centres). It is known from other X-ray storage phosphors that Ce^{3+} acts as a very efficient hole trap centre being converted to Ce^{4+}. Assuming that the diamagnetic Ce^{4+} is the hole trap centre magnetic resonance methods allow the investigation of the complementary electron trap centres.

2. Experimental details

The investigations were carried out on Ce-doped fluorozirconate glasses (53% ZrF_4, 20% BaF_2, 20% NaF, 3% AlF_3, 1.5% LaF_3, 1.5% YF_3 and 1% CeF_3). The X-irradiation was done at room temperature (tungsten anode, 50 kV, 30 mA, several hours).

3. Results

The magnetic circular dichroism of the optical absorption (MCDA) of 1% Ce-doped fluorozirconate glass showed a strong paramagnetic band peaking at 285 nm and a second one between 300 and 550 nm with its maximum at 310 nm having

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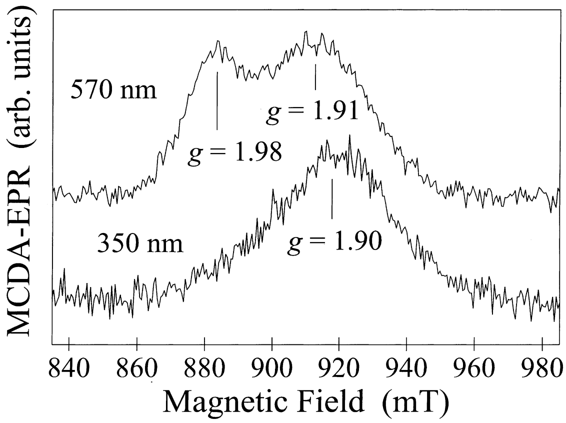

Fig. 1. MCDA-detected EPR of 1% Ce-doped fluorozirconate glass, detected at 570 nm and 350 nm, respectively, recorded at 1.5 K after X-irradiation at room temperature applying 24 GHz microwave frequency.

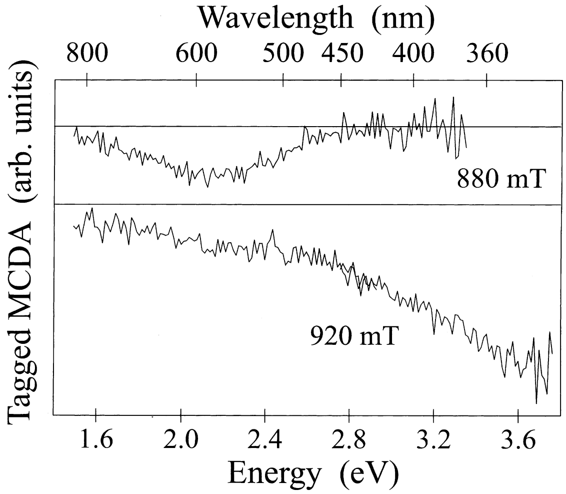

Fig. 2. 'Tagged'-MCDA spectra of 1% Ce-doped fluorozirconate glass, detected at 880 mT and 920 mT, respectively, recorded after X-irradiation at 1.5 K applying 24 GHz microwave frequency. For the sake of clarity the spectra are vertically displaced.

opposite sign. MCDA-detected electron paramagnetic resonance (EPR) on the band peaking at 285 nm yielded a single line with an angular dependence which can be understood assuming an axial g tensor with $g_{\perp} = 18/7$ and $g_{\parallel} = 6/7$, g values typical for rare-earth ions.

After X-irradiation at room temperature the MCDA spectrum showed in addition to an increased paramagnetic signal in the range 300–700 nm a new band at approximately 570 nm which corresponds to the maximum of the stimulation of the photostimulated luminescence (PSL) [1]. EPR detected in the MCDA at 570 nm (Fig. 1, upper spectrum) yielded a double-structured line peaking at $g = 1.98 \pm 0.01$ and at $g = 1.91 \pm 0.01$ whereas MCDA-detected EPR at 350 nm (Fig. 1, lower spectrum) showed only a single line at $g = 1.90 \pm 0.01$. These lines did not appear before X-irradiation. 'Tagged' MCDA measurements (Fig. 2) showed that the low field peak at $g = 1.98$ belongs to the new paramagnetic band at 570 nm whereas the high field resonances peaking at $g = 1.90$ and at $g = 1.91$, respectively, do not.

4. Discussion

The strong paramagnetic MCDA band at 285 nm can be assigned to the Ce^{3+} absorption [2]. The simulation of the measured MCDA-detected EPR line is in agreement with the theoretical g tensor for the $J = 5/2$ ground state of the $4f^1$ electron of Ce^{3+} [3]. X-irradiation creates defect centres resulting in new paramagnetic MCDA bands in which two different EPR spectra can be detected. The g values of the measured EPR resonances being smaller than g_e for the free electron indicate that electron centres have been formed [4]. 'Tagging' allows the assignment of each EPR line to its corresponding MCDA band. It was shown that the low field EPR line at $g = 1.98$ belongs to the 570 nm MCDA band and thus to a PSL-active electron centre. The high field lines having $g = 1.90$–1.91 belong to the band between 300 nm and 700 nm. Probably we deal here with two defect centres having different MCDA bands. One centre has a g value of $g = 1.98$ whereas the second one has $g = 1.90$. The double-structured line measured in the MCDA band at 550 nm is thus a superposition of two EPR lines since both show MCDA there. The identification of the defect structure of these two centres is the subject of further investigations.

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