THULIUM DOPED TITANATE-GERMANATE GLASSES FOR INFRARED PHOTONICS

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Introduction

As of today, the various combinations of glasses containing rare-earth ions tested are very promising and informative for the comprehensive characterization of their spectroscopic properties [1-2]. The selection of an appropriate host glass matrix is of great importance. One of the attractive activators are Tm^{3+} ions [3]. Their main advantage is the emission of radiation at 1450 nm and 1800 nm. On the other hand, titanium (IV) oxide is a component that can improve the luminescence properties, especially for the S-band amplifier region [4].

The aim of research

Development of germanate glass containing titanium dioxide and trivalent thulium ions with interesting optical properties for applications in infrared photonics.

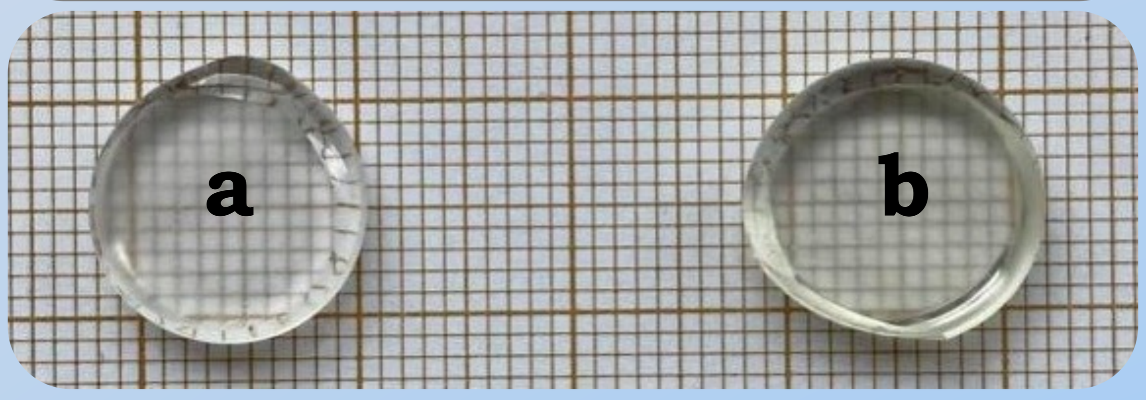

Fig. 1. Obtained glass doped with Tm^{3+}
(a) germanate matix
(b) titanate-germanate matrix

Experimental method

Inorganic glasses with the following chemical formulas **GeO_2-BaO-Ga_2O_3** and **GeO_2-BaO-Ga_2O_3-Tm_2O_3** without or with TiO_2 were synthesized. The appropriate amounts of metal oxides of high purity (99.99%, Aldrich Chemical Co.) were mixed and melted at 1250 °C/1h (Fig. 1). The structural and thermal properties of pure germanate and titanate-germanate glasses were compared. Then, the luminescence properties of the glass systems containing Tm^{3+} ions were characterized.

Results

Structural properties

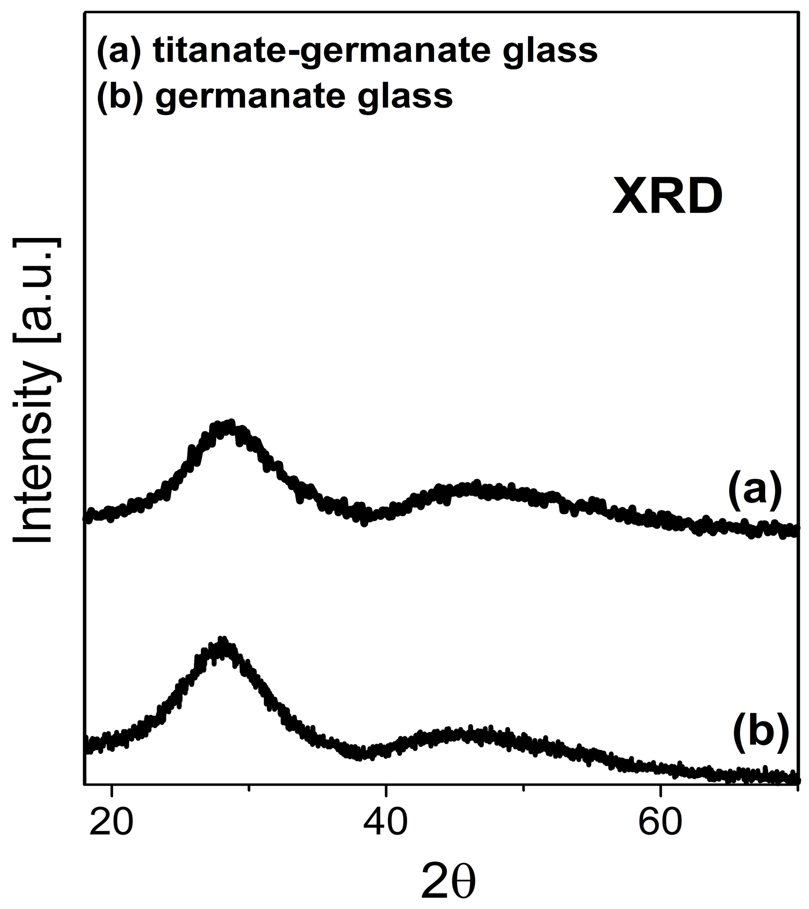

Fig. 2. X-ray diffraction patterns.

In the first step of characterization structural properties of glasses, the phase analysis was done with use of the X-ray diffraction (XRD). Independently on kind of the type of glass matrix, registered the X-ray diffraction patterns (Fig. 2) revealed only two bands characteristic of amorphous state. It confirmed that the obtained glasses are fully amorphous [5].

Thermal properties

In the second step, the DSC curves were measured to determine the thermal properties. The titanate-germanate glass sample demonstrates an additional exothermic peak observed on Fig. 3.

T_{p2} - the crystallization of the glass

The thermal stability parameter is reduced where GeO_2 is partially replaced by titanium dioxide [5].

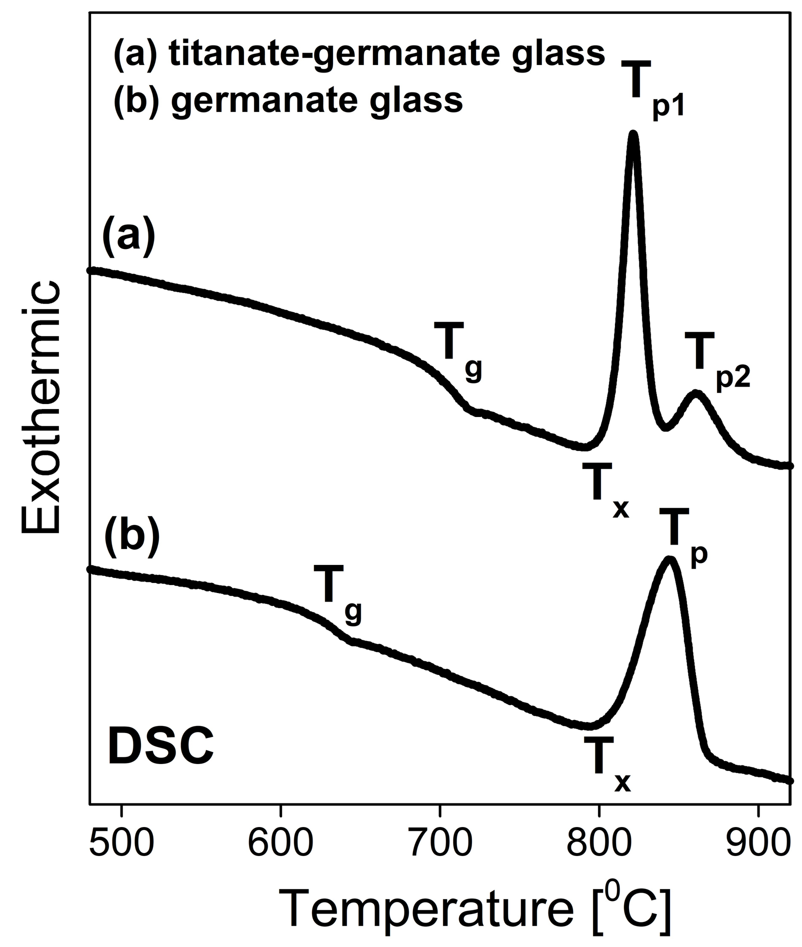

Fig. 3. DSC curves.

Luminescence characterization

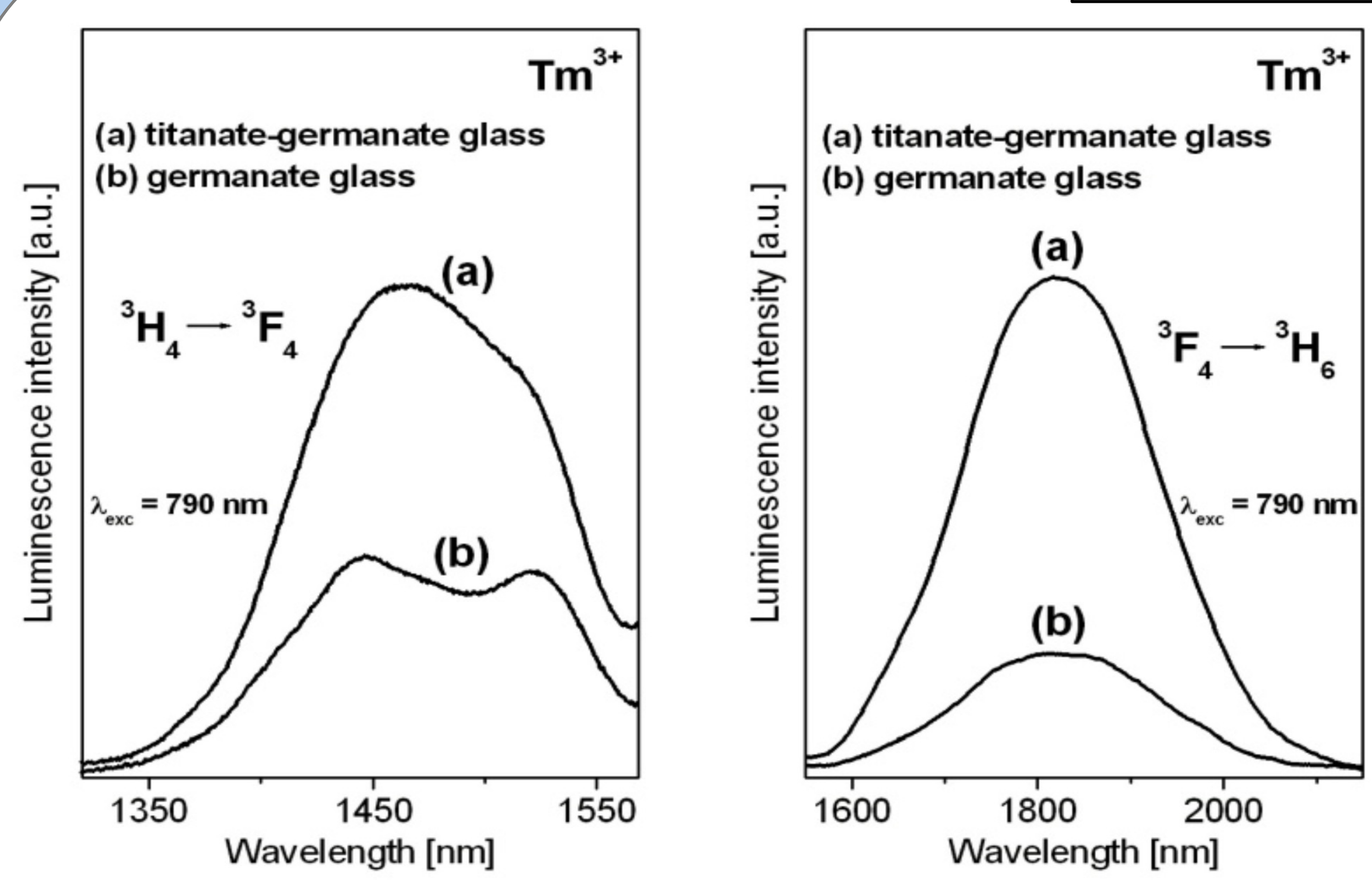

Fig. 4. Near-infrared luminescence spectra of Tm^{3+} ions.

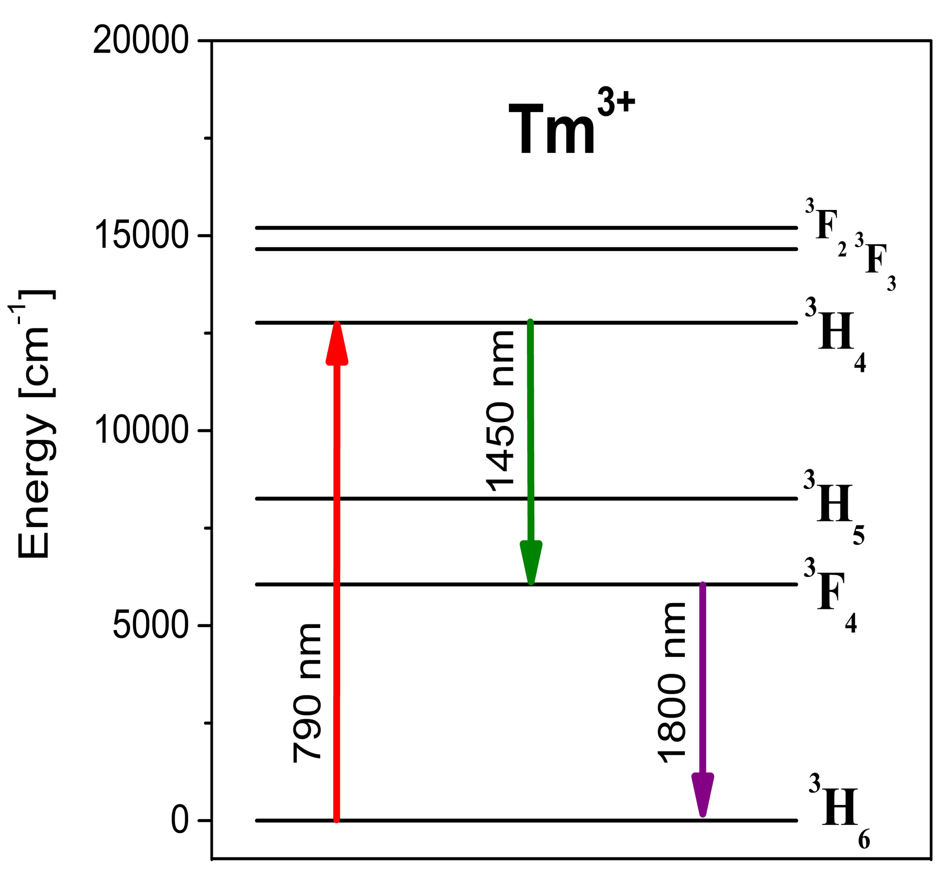

Fig. 5. Simplified energy level scheme of Tm^{3+} ions.

In the third step, the spectroscopic properties of germanate glass without/with TiO_2 singly doped with rare-earth ions were investigated.

Luminescence spectra were recorded in the near-infrared region (Fig. 4).

Two transitions of Tm^{3+} ions are observed under direct excitation by 790 nm line (Fig. 5).

In our study, the obtained glasses are characterized by a broad emission band corresponding to the transitions $^3H_4 \rightarrow {}^3F_4$ and $^3F_4 \rightarrow {}^3H_6$ of trivalent thulium.

Conclusion

All glass samples were prepared by traditional melt-quenching method, and their properties were studied. Importantly, the glass containing TiO_2 shows a fully amorphous state. The thermal stabilities parameters is reduced, whereas emission intensities of near-infrared transitions of Tm^{3+} ions are enhanced significantly in glass samples with TiO_2 compared to germanate glass. It has been proved that systems containing thulium ions exhibit emissions located at 1.45 μm and 1.8 μm that strongly depends of the content of titanium dioxide in the glass composition, and they are very promising for potential applications in infrared photonics.

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References

[1] P. Vařák, P. Nekvindová, S. Vytykáčová, A. Michalcová, P.Malinský, J. Oswald, J. Non-Cryst. Solids 557, 120580 (2021)
[2] F. Calzavara, M. Allix, M. Dussauze, V. Jubera, Marcelo Nalin, T. Cardinal, E. Fargin, J. Non-Cryst. Solids 571, 121064 (2021)
[3] B. So, J. She, Y. Ding, J. Miyake, T. Atsumi, K. Tanaka, L. Wondraczek, Opt. Mat. Exp. 9, 4348-4359 (2019)
[4] W. Tang, Y. Tian, B. Li, Y. Xu, Q. Liu, J. Zhang, S. Xu, Ceram. Int. 45, 16411-16416 (2019)
[5] W.A. Pisarski, K. Kowalska, M. Kuwik, J. Polak, E. Pietrasik, T. Goryczka, J. Pisarska, Materials 13, 4422 (2020)