

Receivers of VUV and UV Radiation

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Abstract. The necessity of development of a receiver of ultraviolet radiation in the visible region of the spectrum using corundum single crystals with various impurities is substantiated. The results of experimental studies of the revealed effective converter - single crystal of corundum with impurities are presented. The excitation and radiation spectra of luminescence were also obtained. This work will help to expand the field of research of spectral and luminescence properties of corundum in the vacuum-ultraviolet (VUV) region of the spectrum. It will provide a possibility not only to register the VUV and UV radiation, but also to visualize the object.

Keywords: ultraviolet radiation receiver, converter, UV radiation, corundum single crystals.

1. Introduction

In the beginning, ruby single crystals with chromium concentration $Cr < 0.05\%$ (1) were used as a converter. However, it later turned out that an effective transformation of UV radiation into light can be achieved by corundum single crystals including chromium and other impurities (chromium is not a dominant) [1-4].

The detection of the optimum composition of impurities and their concentration at which the most complete conversion of UV and VUV radiation into light is achieved, with the required spectral characteristics of the receiver, is an urgent task. At the same time, in view of the significant concentration of impurities and their rich composition, it is not possible to theoretically trace and predict the possible numerous energy transitions. So far, the results of experimental studies are the basis for theoretical constructions. That is why the experimental studies were carried out, as a result of which it was possible to identify the case of a very effective transformation of UV and VUV radiation into a more complete light. The spectral characteristic of ruby emission is characterized by the fact that resonance absorption is observed in the wavelength range 400-550 nm, while in the intermediate 250-350 nm range absorption is very small. In the wave region shorter than 250 nm, a fundamental absorption of radiation takes place.

The spectral characteristic of luminescence also has two resonance bands in the range 690-700 nm.

2. Experimental Part

The converter is a single crystal of corundum with impurities of chromium (Cr), manganese (Mn), iron (Fe), zinc (Zn), titanium (Ti) and copper (Cu). Impurities are listed in decreasing order of their percentage. In general, their concentration is much higher than chromium in ruby [1].

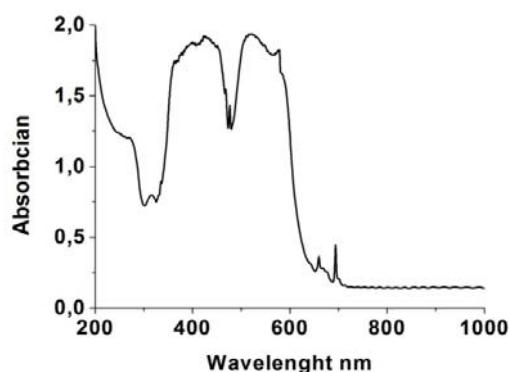


Fig.1. Absorption spectrum of the proposed converter.

Figure 1 shows the spectral characteristics of the absorption of the proposed converter. It shows that the absorption region has broadened and the absorption in this region is more intense and uniform. In order to more fully reveal the contributions of individual absorbed spectral components to the total luminescence flux, luminescence spectra were first recorded both with pumping with different frequency of monochromatic irradiation and then with continuous (white) light.

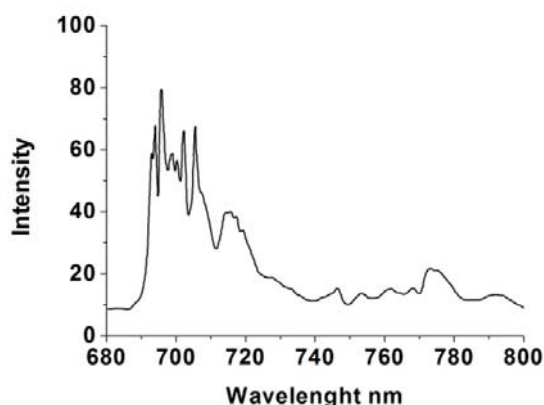


Fig.2. The emission spectrum of luminescence upon excitation with a wavelength of 468 nm.

In Fig.2, a spectral characteristic of luminescence is shown for irradiation with a wavelength of 468 nm and a band of 5 nm. The characteristic was taken by scanning with a strip of 0.5 nm. Enrichment of the spectrum is observed in comparison with ruby and an increase in the intensity of the spectral lines, i.e. increase in luminescence power.

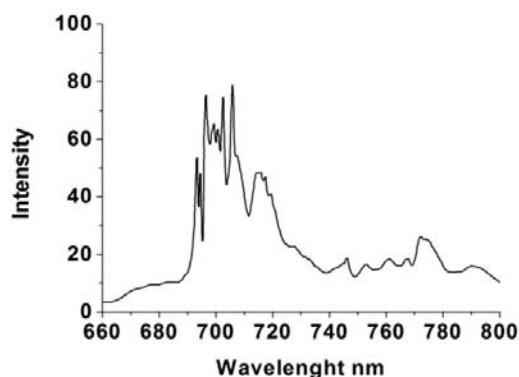


Fig.3. The emission spectrum of luminescence upon excitation with a wavelength of 370 nm.

Figure 3 shows a similar characteristic for irradiation with a wavelength of 370 nm. The wavelengths of the peaks are also noted there.

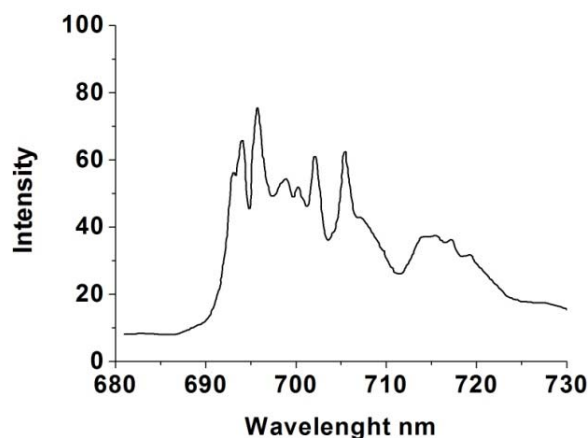


Fig.4. The emission spectrum of luminescence upon excitation with a wavelength of 357 nm.

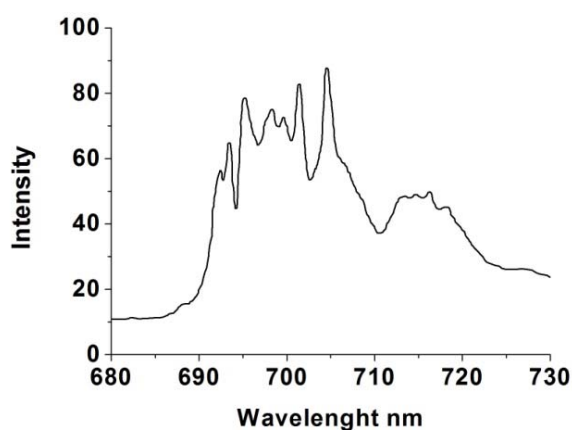


Fig.5. The emission spectrum of luminescence upon excitation with a wavelength of 300 nm.

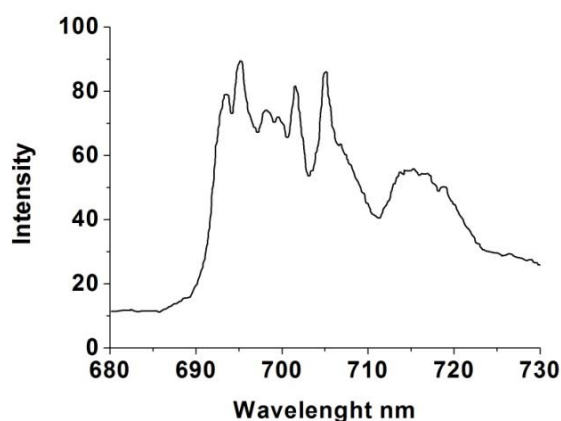


Fig.6. The emission spectrum of luminescence upon excitation with a wavelength of 250nm.

Then the luminescence characteristics are shown for irradiation with wavelengths of 357 nm (Fig. 4), 300 nm (Fig.5), 250 nm (Fig. 6). They can be used to trace the changes in the intensities of individual peaks and the overall luminescence pattern, depending on the wavelength of irradiation. In general, progress is being made in the region of short-wave "vacuum" radiation,

which is one of the main research objectives. Unfortunately, monitoring progress is limited by the capabilities of the equipment used. Nevertheless, it can be seen that the absorbed short-wave radiation makes a significant contribution to the total luminescence flux.

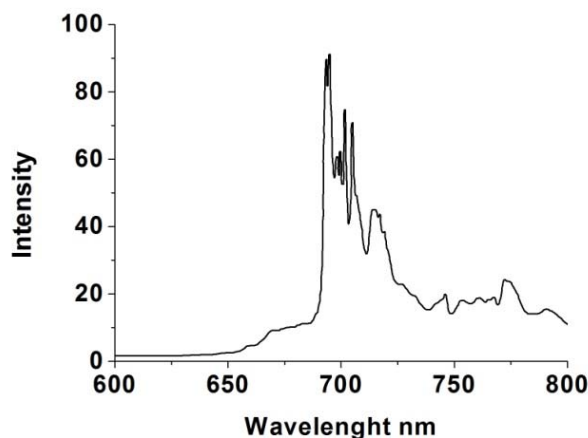


Fig. 7. The emission spectrum of luminescence upon excitation with "white" light.

Figure 7 shows the general characteristic of luminescence in "white" irradiation. The inclusion of the investigated single crystal of corundum in the receiver of UV and VUV radiation as a converter, when irradiated with a "solar" spectrum, resulted in an increase in the output current, and consequently in the sensitivity of the receiver, by 30% in comparison with ruby.

The absorption spectrum was obtained by spectrophotometer SP8-150 UV / VIS PYE UNICAM.

The luminescence spectra were investigated using a "Perkin-Elmer Model Mpf-44B" fluorescence spectrophotometer. The concentration and composition of the impurities were determined on an X-ray spectrometer "AMRTEC".

3. Conclusion

Thus, the proposed corundum single crystal with these impurities is an effective converter for the UV and VUV radiation receiver. As a result, the work will enable to widen and systemize the study of spectral and time characteristic of corundum with various mixtures and by having the improved system of luminescence registration, to design a competitive receiver for VUV and UV ranges of a spectrum.

Reference

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