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# Anti-Stokes UVC emission and luminescence properties silicate glasses doped with $Pr^{3+}$ ions in the wide spectral regions


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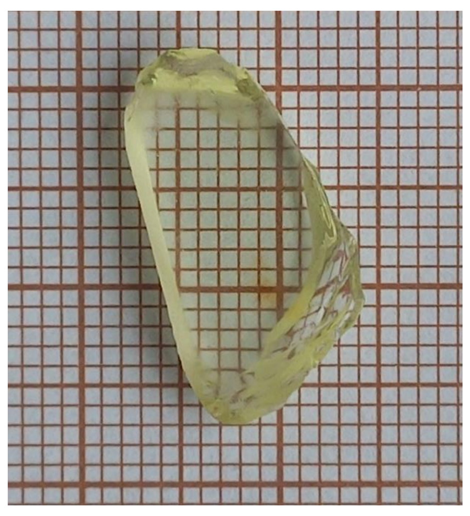
## INTRODUCTION & AIM

The importance and relevance of creating materials with the ability to absorb photons from the environment or sunlight and subsequently convert them into photons of the bactericidal range of the spectrum (220-280 nm) is due to the need to create self-sterilizing surfaces without the use of ultraviolet lamps [1]. The use of such surfaces can help to permanently reduce the content of adsorbed microbes. The intense luminescence of $Pr^{3+}$ ions in a wide range of wavelengths, including in the UV-C range (200-280 nm), allows them to be used as activator ions in the creation of materials emitting in the ultraviolet region [2]. Vis-to-UV up-conversion (UC) of $Pr^{3+}$ ions corresponds to the absorption of blue or violet light (430-490 nm region) through $^3H_4 \rightarrow {}^3P_J$ transitions with followed by the UC of the excitation energy. In addition, $Pr^{3+}$ ions as an activator can produce greenish-blue or red emission due to its excited energy levels $^3P_0$ or $^1D_2$.

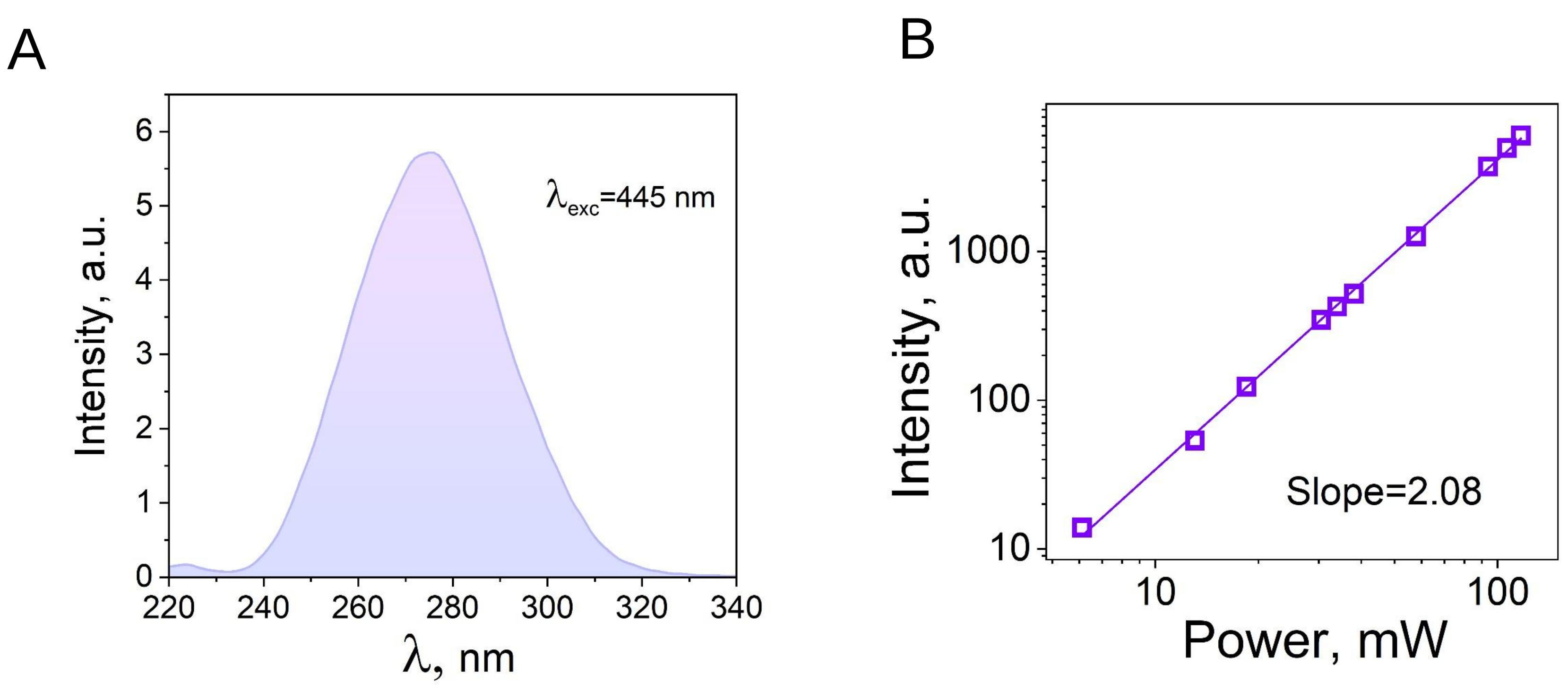
We have synthesized stable SrO-CaO-MgO-$SiO_2$ (SCMS) glasses doped with $Pr^{3+}$ ions. We investigated the absorption and luminescence spectra of the glass samples in the wide spectral range, luminescence lifetimes, the Up-converted UVC luminescence using a 444 nm diode laser and the effect of temperature on the spectral properties.

## METHOD

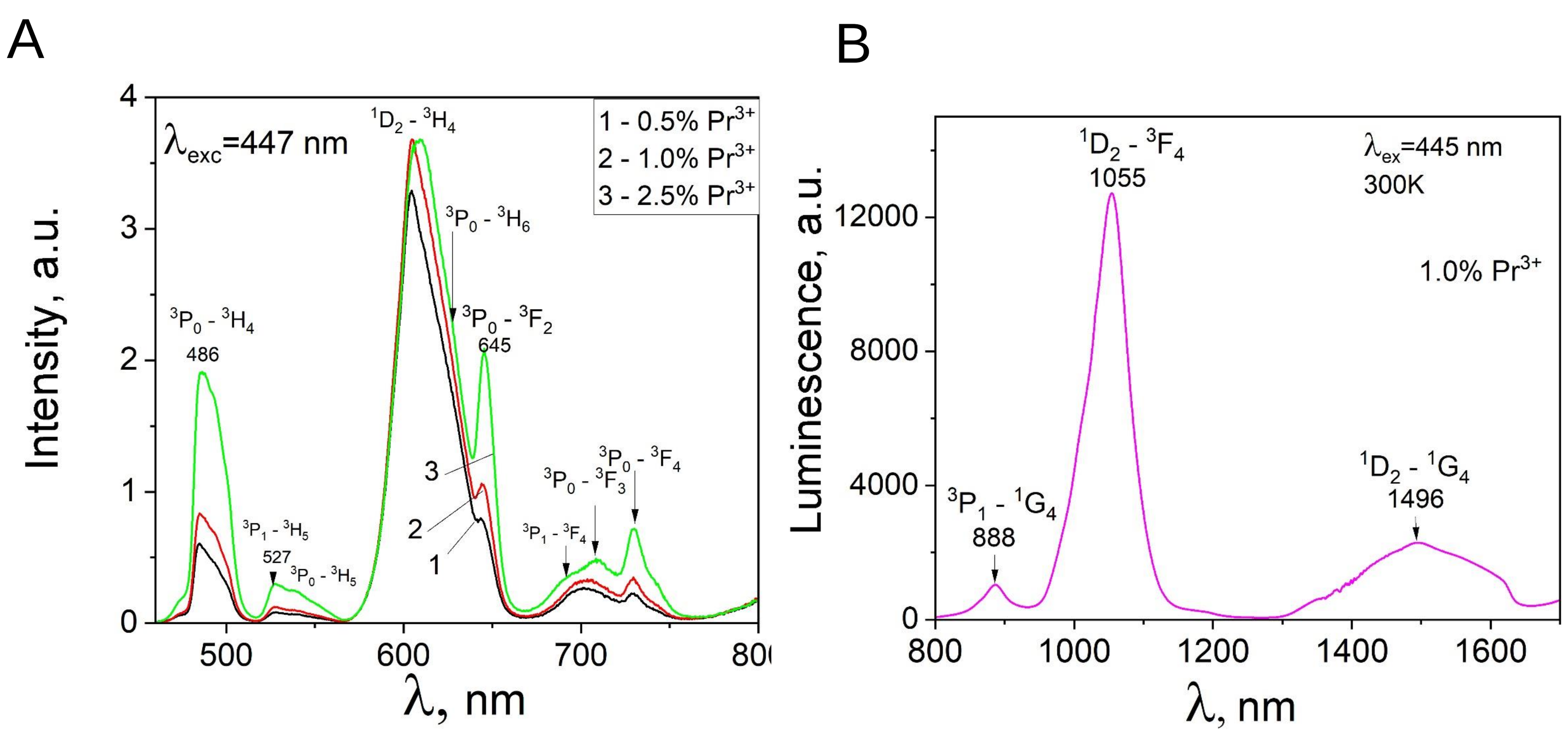


Samples of SrO-CaO-MgO-$SiO_2$ glasses with different concentration of $Pr^{3+}$ ions were synthesized by grounding of components in a mortar and heating of the powder in the crucible to 1450°C for 2 hours. The melt was poured into a brass mold.

## RESULTS & DISCUSSION

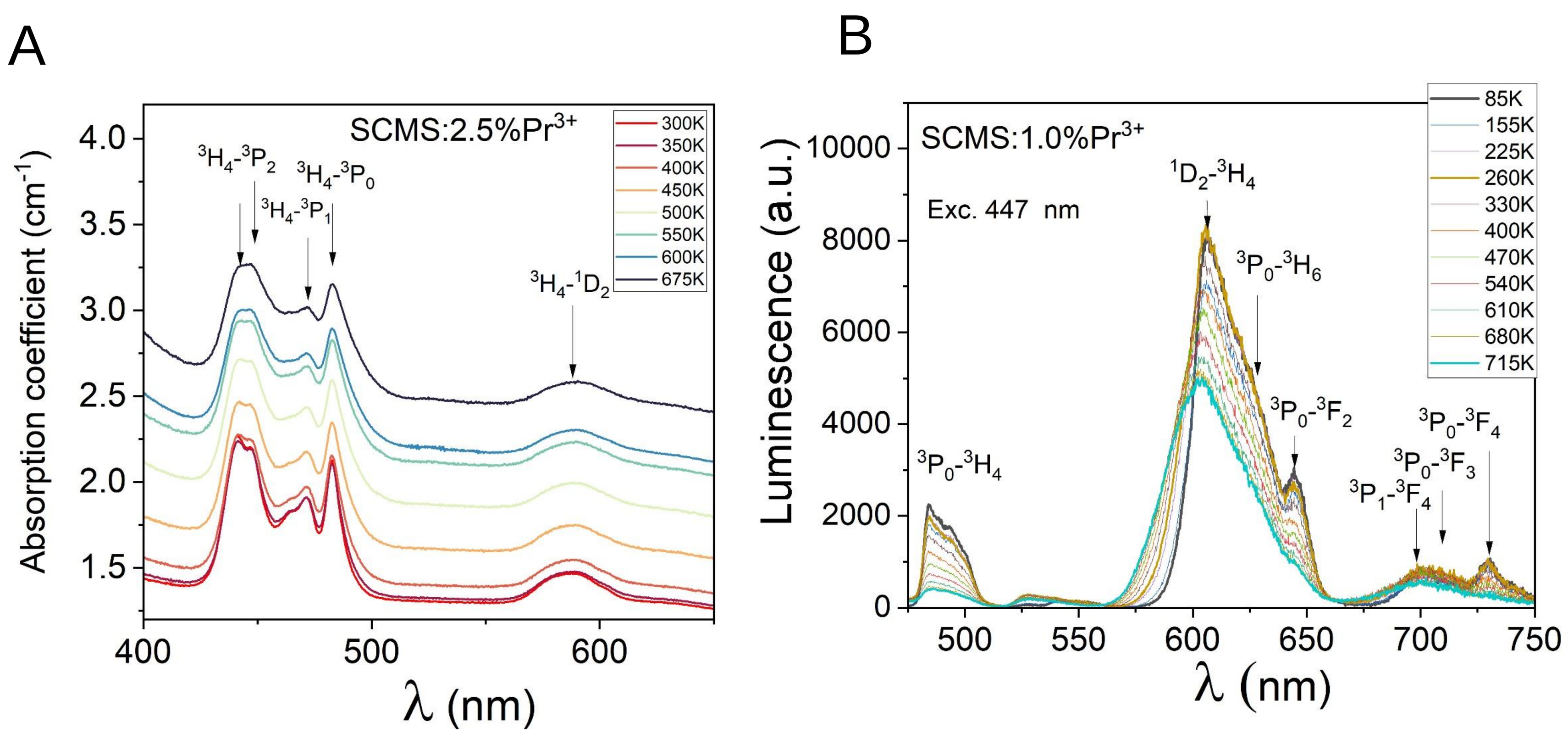



The UP-converted UV luminescence (a) and integrated emission intensities vs 444 nm CW excitation power (b) of the SCMS: 1% $Pr^{3+}$ glass.




The luminescence spectra of the SCMS: $Pr^{3+}$ glasses with different concentration $Pr^{3+}$ ions in the visible (a) and the near-IR regions (b).

## RESULTS & DISCUSSION




Effect of the temperature on SCMS:2.5% $Pr^{3+}$ absorption bands (a) and luminescence spectra of the SCMS: 1% $Pr^{3+}$ (b) glasses.

**Lifetimes of $^3P_0$ and $^1D_2$ levels of $Pr^{3+}$ in the SCMS glasses.**

| SCMS:$Pr^{3+}$ | τ | |
|---|---|---|
| | $^3P_0$ [μs] | $^1D_2$ [μs] |
| 0.5% $Pr^{3+}$ | 2.20 | 187 |
| 1.0% $Pr^{3+}$ | 2.12 | 145 |
| 2.5% $Pr^3$ | 2.06 | 74 |

The up-convection luminescent radiation (230-330 nm band) was obtained in the UV spectral region with the maximum at 275 nm for the SCMS: $Pr^{3+}$ glasses upon excitations by lower-frequency radiation. The up-converted emission in the silicate glass with $Pr^{3+}$ ions is due to the two-photon excitation process.

The effect of the increasing temperature on the $^3H_4 \rightarrow {}^3P_2$ absorption band is insignificant. Thus, the excitation of up-converted emission of $Pr^{3+}$ ions can be efficient even at high powers of the laser diode.

The luminescence of $Pr^{3+}$ ions in the glasses corresponds to the spectral maxima in blue, reddish-orange, and near-infrared spectral regions. It was found that significant non-radiative energy transfer occurs between $Pr^{3+}$ ions, especially in glasses containing higher concentrations of $Pr^{3+}$ ions.

Investigation of $Pr^{3+}$ ions luminescence as a temperature function results that temperature elevation gives rise to the moderate lowering of $Pr^{3+}$ ions luminescence in the visible region and the emission band extension, especially at longer wavelengths.

## CONCLUSION

Synthesized glasses can be used as materials for photonic, including the creation of light-emitting diodes and the development of UV self-sterilizing surfaces.

## REFERENCES


[1] E. Eadie, et at., *Sci Rep.*, *2022*, 12, 4373.
[2] E.L. Cates, et at., *J. Lumin.*, **2015**, 160, 202-209.



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