

Influence of Ytterbium on the Infrared to Visible Upconversion in Praseodymium Codoped Potassium Lead Chloride Crystal

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Recently, the search for all-solid compact laser devices operating in the blue-green region and the availability of powerful near-infrared laser diodes has increased the interest in upconversion emission. Among rare earth ions, trivalent praseodymium is an attractive optical activator which offers the possibility of simultaneous blue, green, and red emission for laser action as well as IR emission for optical amplification at 1.3 μm . Pr^{3+} systems are also interesting as short-wavelength upconversion laser materials. The trivalent praseodymium ground state $^3\text{H}_4$ to $^1\text{G}_4$ transition is spin forbidden, which implies weak pump absorption in the spectral region around 1 μm , where high power sources are commercially available. The sensitization of rare-earth doped materials with Yb^{3+} ions is a well known method for increasing the optical pumping efficiency because of the efficient energy transfer from Yb^{3+} to rare-earth ions. The use of trivalent ytterbium to populate the $^1\text{G}_4$ level of Pr^{3+} ions has been proposed for applications to 1.3 μm [1] and upconversion lasers [2]. Moreover, the broad absorption band of Yb^{3+} ions allows using a wide range of excitation wavelengths with higher absorption cross sections than in single Pr^{3+} doped systems.

This work presents the spectroscopic study of the infrared to visible luminescence of Pr^{3+} ions in single doped and $\text{Pr}^{3+}/\text{Yb}^{3+}$ codoped KPb_2Cl_5 crystals. Recently, KPb_2Cl_5 crystal has been studied as a promising host for RE ions [3-7] because it is non-hygroscopic, transparent in the 0.3 to 20 μm spectral region, and readily incorporates rare-earth ions. According to Raman-scattering measurements the maximum phonon energy of optical phonons for this crystal is equal to 203 cm^{-1} [5]. Here we report the upconversion luminescence of Pr^{3+} upon continuous wave (cw) excitation in the $^1\text{G}_4$ level of Pr^{3+} ions and/or in the $^2\text{F}_{7/2} \rightarrow ^2\text{F}_{5/2}$ absorption band of ytterbium ions. Resonant excitation of the $^2\text{F}_{5/2}$ and/or $^1\text{G}_4$ levels in single doped or codoped samples leads to an intense orange fluorescence from the $^1\text{D}_2$ state with a less intense blue, green, and red emissions from the $^3\text{P}_{0,1}$ levels, whereas excitation in the high energy side of the $^2\text{F}_{7/2} \rightarrow ^2\text{F}_{5/2}$ absorption band of Yb^{3+} in the codoped crystal originates emission only from $^3\text{P}_{0,1}$ levels (Fig. 1). This latter upconversion emission can be attributed to a sequential two photon absorption in which the excited Yb^{3+} ion transfers its energy to the $^1\text{G}_4$ level of Pr^{3+} ion and then a second IR photon is absorbed which allows the electronic transition to the $^3\text{P}_0$ level. However, under resonant pumping the mechanism to populate the $^3\text{P}_{0,1}$ levels is a three photon upconversion process. It is worthy to notice that codoping with Yb^{3+} ions allows us to select the upconversion mechanism by continuous excitation wavelength tuning. The upconverted orange emission from the $^1\text{D}_2$ level shows a quadratic dependence on the pump power indicating a two photon process. This level is

populated by ETU and simultaneously by ESA involving Pr^{3+} ions in the intermediate $^3\text{F}_{3,4}$ levels.

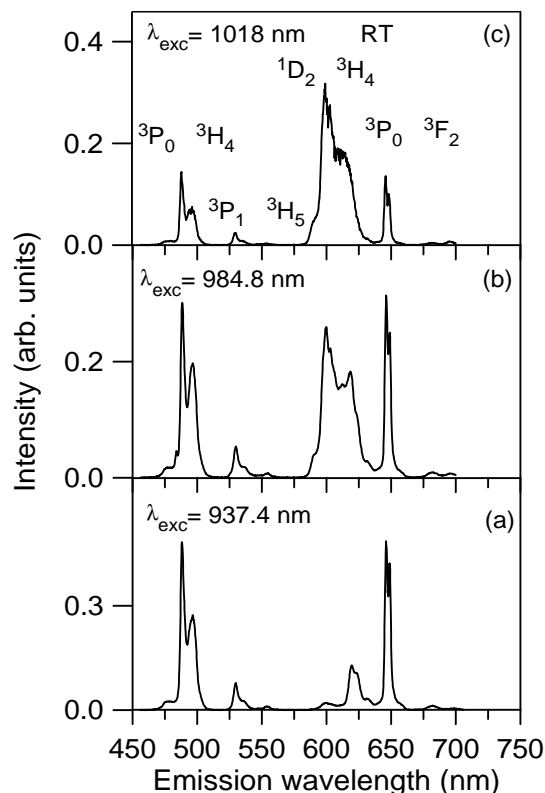


Figure 1.- Room temperature emission spectra obtained (a) under excitation at 937.4 nm, (b) at 984.8 nm, and (c) at 1018 nm in the codoped crystal.

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References

- [1] J.Y. Allain, M. Monerie, and H. Poignant, *Electron. Lett.* **27** (1991) 1012.
- [2] J.Y. Allain, M. Monerie, and H. Poignant, *Electron. Lett.* **27** (1991) 1156.
- [3] M.C. Nostrand, R.H. Page, S.A. Payne, W.F. Krupke, P. G. Schunemann, and L.I. Isaenko, *OSA TOPS* **19** (1998) 524.
- [4] M.C. Nostrand, R.H. Page, S.A. Payne, W.F. Krupke, P. G. Schunemann, and L.I. Isaenko, *OSA TOPS* **26** (1999) 441.
- [5] M.C. Nostrand, R.H. Page, S.A. Payne, L.I. Isaenko, and A.P. Yelissev, *J. Opt. Soc. Am. B* **18** (2001) 264.
- [6] R. Balda, M. Voda, M. Al-Saleh, and J. Fernández, *J. Lumin.* **97** (2002) 94.
- [7] A. Mendioroz, J. Fernández, M. Voda, M. Al-Saleh, A. J.Garcia-Adeva, and R. Balda, *Optics Letters* **27** (2002) 1525.