Infrared to Visible Upconversion in Praseodymium Doped Potassium Lead Chloride Crystal

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Frequency upconversion of infrared light into visible light in rare-earth (RE) doped solids has attracted much interest in recent years because of its large number of potential applications. One of these is the operation of short wavelength upconversion lasers pumped with commercially available lasers. In order to investigate new upconversion materials with high luminescence efficiency, hosts with low phonon energies are required. Recently, KPb_2Cl_5 crystal has been studied as a promising host for RE ions [1-3] because it is non-hygroscopic and readily incorporates rare-earth ions. The crystal is biaxial, crystallizes in the monoclinic system (space group $P2_1/c$) [4], and it is transparent in the 0.3 to 20 μm spectral region. According to Raman-scattering measurements the maximum phonon energy of optical phonons for this crystal is equal to 203 cm^{-1} [3].

In this work we report the upconversion luminescence of Pr^{3+}-doped KPb_2Cl_5 crystal upon continuous wave (cw) excitation in the near infrared inside the $^1G_4$ level.

Figure 1 shows the room temperature steady-state emission spectra obtained under one photon excitation at 454 nm and 590 nm together with the upconverted emission spectrum obtained by exciting the $^1G_4$ state. As can be seen in Fig. 1(a), after excitation in the $^3P_2$ level (454 nm) the emission corresponds to levels $^3P_0$ and $^3P_1$. The spectrum consists of several lines corresponding to the transitions $^3P_0 \rightarrow {}^3H_{4,5,6}$, $^3P_0 \rightarrow {}^3F_{2,3,4}$ and $^3P_1 \rightarrow {}^3H_{4,5,6}$, $^3P_1 \rightarrow {}^3F_{2,3,4}$. The fluorescence emission from $^1D_2$ level was only observed under resonant pumping (Fig. 1b). Figure 1(c) shows the room temperature emission spectrum obtained by exciting the $^1G_4$ state (1018 nm). As can be observed, after infrared excitation, there is emission from levels $^3P_{0,1}$ and $^1D_2$. The dependence of the orange emission from level $^1D_2$ on the pump power is quadratic (slope 1.96) which indicates a two photon upconversion process. However, the logarithmic plot of the blue emission from level $^3P_0$ as a function of the laser power presents a slope of 2.75, which indicates than more than two infrared photons are needed to reach this emitting level.

The features of the excitation spectra of the upconverted luminescence from $^1D_2$ level together with its quadratic dependence on the pumping power suggest that a dominant excited state absorption (ESA) upconversion mechanism involving praseodymium ions in the intermediate $^3F_{3,4}$ states is responsible for the upconverted luminescence from this level. Concerning the emission from $^3P_{0,1}$ levels, the roughly cubic (2.75) dependence on the pump power of the blue emission points out to a three-photon mechanism involving the $^1D_2$ state.

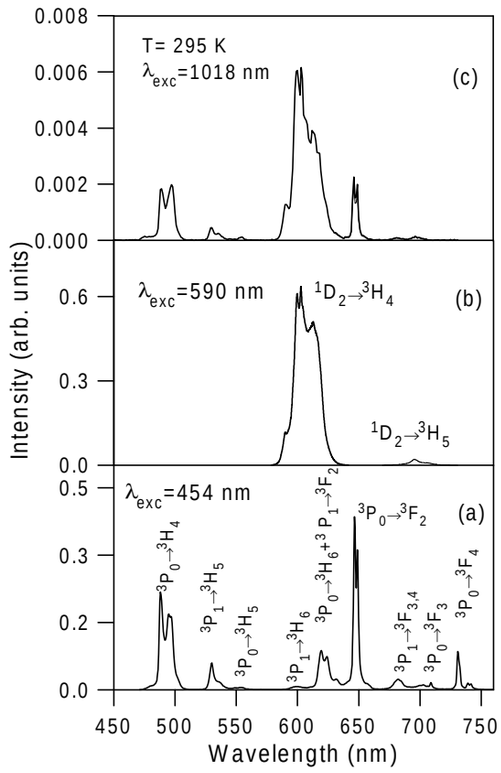

Figure 1.- Room temperature emission spectra obtained (a) under excitation at 454 nm, (b) at 590 nm, and (c) at 1018 nm.

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References

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