Infrared-to-visible energy upconversion luminescence in orthophosphate $NdPO_4$ irradiated with cw 800 nm light.

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Abstract

In this work, we present energy up-conversion of infrared into green light in mono-crystals of neodymium orthophosphate monazite-type at room-temperature under CW Ti:Sapphire laser excitation tuned in 800nm.

Introduction

The use of rare-earth elements in new materials is growing in different branches of physics[1]. In optics, rare-earth doped solid state upconverter in numerous photonic devices including color displays and upconversion lasers. Among this materials are the rare-earth orthophosphates. The interest in rare-earth orthophosphate (RPO_4) is due to their proven chemical stability and radiation-damage resistence [2]. The RPO_4 can be divided into five groups on the basis of crystal form: monazite-type; xenotime-type; hexagonal-form; orthorhombic-form; and weinsckenkite-type[3,4,5]. The lanthanide orthophosphate have been shown to accommodate large concentrations of lanthanide dopant ions without compromising the optical quality of the host crystal. Light generation by energy upconversion in high concentration (15%) of erbium-doped lutetium orthophosphate was reported early [2]. In this work, we present energy upconversion of infrared into green light in mono-crystals of neodymium orthophosphate monazite-type at room-temperature under CW Ti:Sapphire laser excitation tuned in 800*nm*.

Experimental Setup

Crystals of neodymium orthophosphates were grown by dissolving and by reacting lanthanide oxides in molten lead pyrophosphates at high temperature. The $LnPO_4$ crystal which formed on cooling were separated by dissolving the lead phosphate matrix in boiling concentrated nitric acid . Lanthanide oxides highly pure were used in all measurements.

The experimental setup is showed in figure 1. The excitation source was a CW Ti:sapphire laser operated at 800*nm* and 800mW power. The luminescence signal generated in $NdPO_4$ sample was sided collected, coupled into a 0.67 meter McPherson model 207 scanning monochromator and detected by a S-20 type photomultiplier tube at room-temperature. One polarizer plate was placed between the sample and the detector. A Tektronix digital storage oscilloscope model TDS1012 coupled to a computer by RS-232 serial interface and a Stanford Research Systems lock-in amplifier model SR-530 were used to acquire the modulated light luminescence.

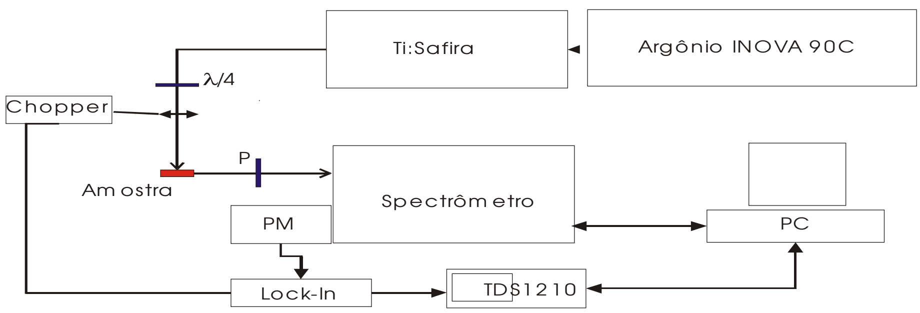

Figure 1: Experimental setup by energy upconversion in orthophosphate $NdPO_4$.

Results and Discussions

Figure 2 shows a typical room-temperature visible spectrum of $NdPO_4$ for 70mW of excitation power at 800*nm*. The luminescence with bands centered around 530*nm*, 523*nm*, 550*nm* and 554*n*, assigned to the $^2P_{1/2} - {}^4I_{1/2}$, $^4G_{9/2} - {}^4I_{9/2}$, $^4G_{7/2} - {}^4I_{9/2}$ e $^4G_{5/2} - {}^4I_{9/2}$ transitions of Nd^{3+}, respectively.

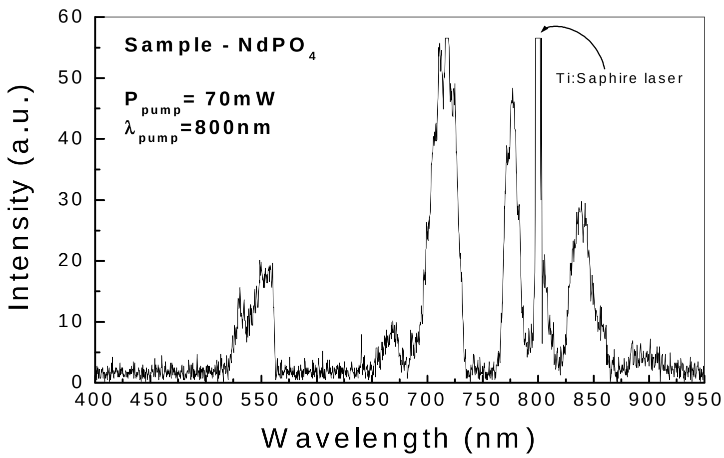

Figure 2: Typical upconversion spectrum for the $NdPO_4$ sample along π polarization axe.

A resonant excitation source photon at 800*nm* promotes population from the $^4I_{9/2}$ state to $^2H_{9/2}$ e $^4F_{5/2}$ excited-state levels. After nonradiative transition to $^4F_{3/2}$ level, a second photon resonantly excites the Nd^{3+} ions at $^4F_{3/2}$ level to the upper excited-state level, like shows figure 3. The system relax generating the bands at 530*nm*, 523*mn* 550*nm* e 554*nm*. The dependence of the upconversion emission intensities at 550*nm* upon the excitation power was investigated and the results are presented in figure 5.

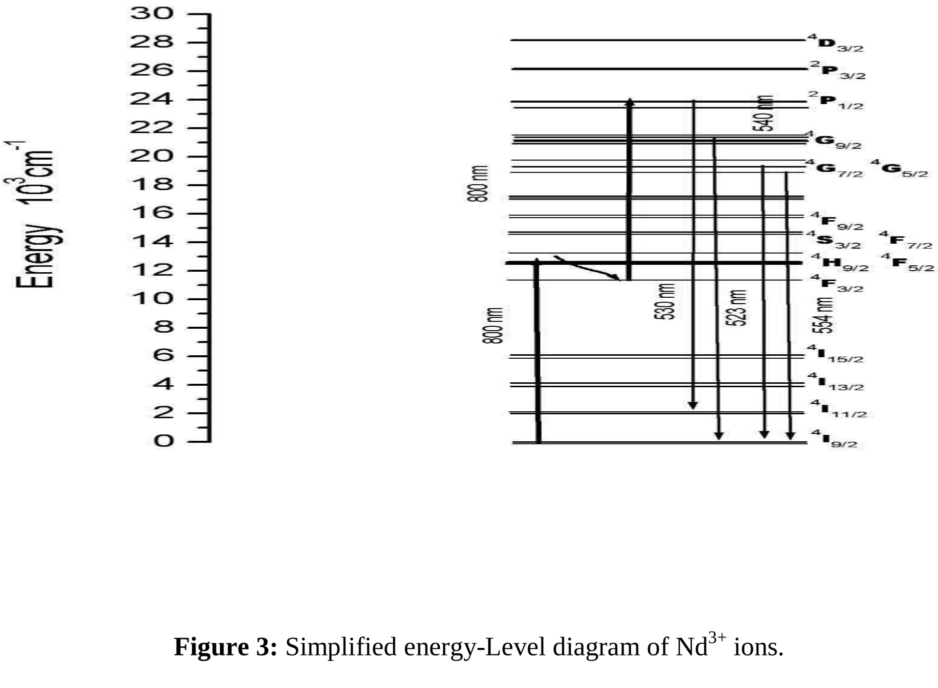

Figure 3: Simplified energy-Level diagram of Nd^{3+} ions.

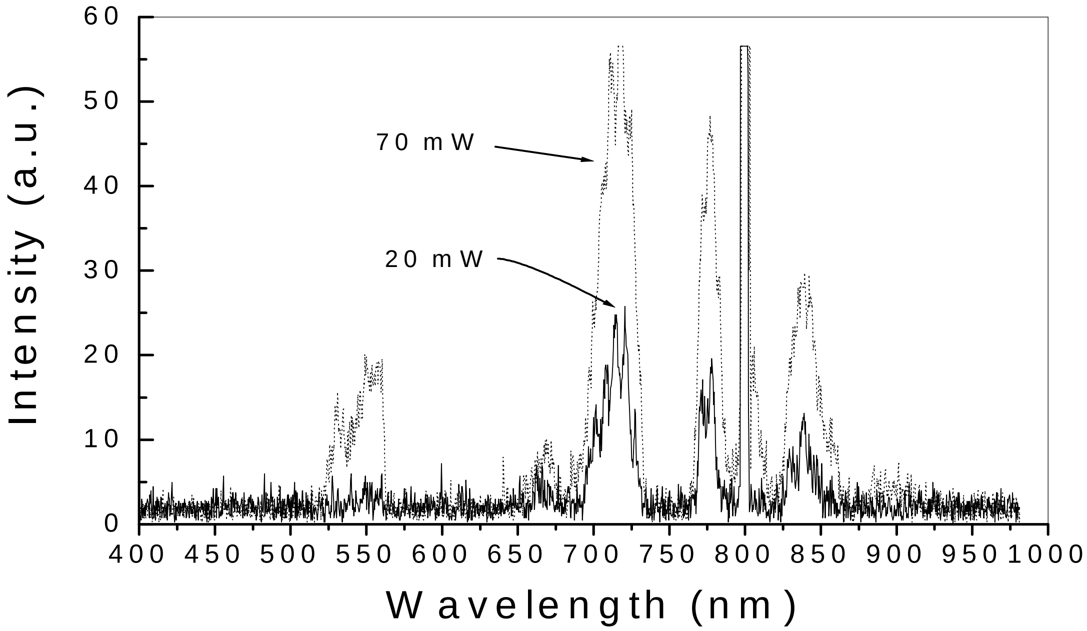

Figure 4: Emission at room temperature of $NdPO_4$.

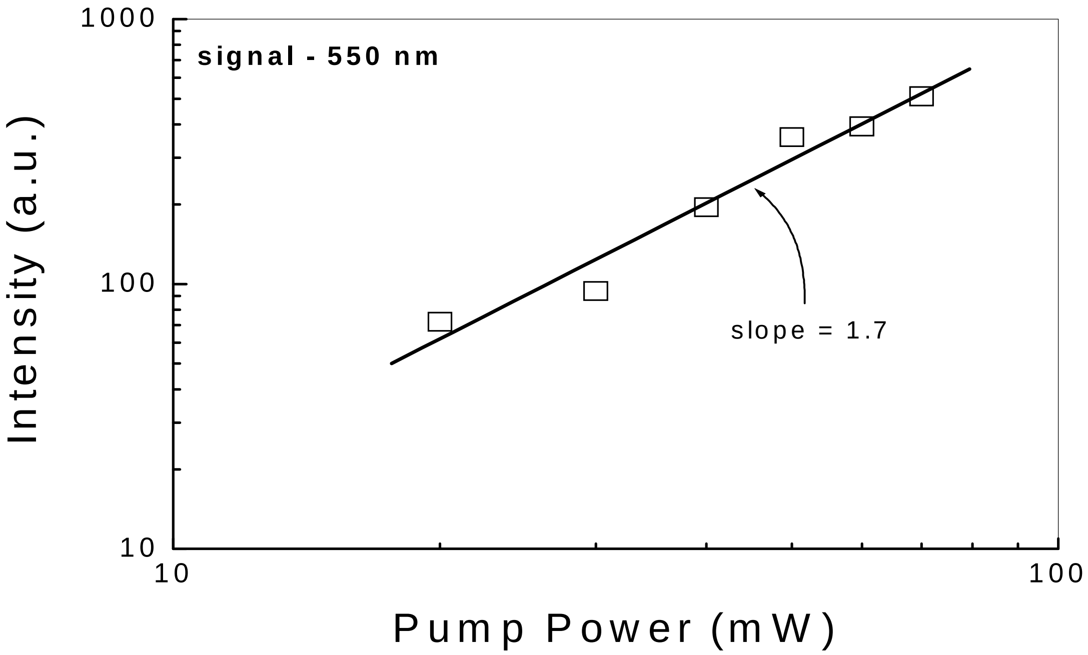

Figure 5: Dependence of the upconversion emission intensities at 550*nm* upon the excitation power.

Conclusions

Visible light in mono-crystals of neodimium orthophosphate monazite-type via infrared-to-visible energy upconversion irradiated with cw 800*nm* laser was generated. The signal between 523*nm* and 554*nm* can be identified as to correspond to the $^2P_{1/2} - {}^4I_{1/2}$, $^4G_{9/2} - {}^4I_{9/2}$, $^4G_{7/2} - {}^4I_{9/2}$ e $^4G_{5/2} - {}^4I_{9/2}$ transitions of Nd^{3+} ions. The dependence of the upconversion emission intensities at 550*nm* upon the excitation power indicate that the dominant mechanism was the excited-state absorption.

Acknowledgements

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