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Efficiency improvement of up–conversion luminescence of Yb^{3+}/Tm^{3+} co-doped tellurite glass microsphere

Yantang Huang[1,2]*, Shijian Zhuang[2],Longxiang Peng[2] , Jinshu Wu[2] ,Tingdi Liao[1] ,Canhua Xu[2], Yafang Duan[1†]

[1]*Research Center for Photonic Technology, Quanzhou Normal University, Quanzhou 362000, China*

[2]*College of Physics and Information Engineering,FuzhouUniversity,Fuzhou 350116, China*

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Abstract Three potential techniques, i.e. the optical taper fiber–microsphere device(OFMD), employment of the low phonon energy tellurite glass and the optimal concentration of rare-earth ions are investigated and identified for improving the efficiency of up-conversion (UC) luminescence for rare-earth ion doped materials excited by laser. The tellurite glass with composition of $77TeO_2 – 12Na_2O – 5ZnO – 5La_2O_3$ was synthesized with different Yb^{3+}/Tm^{3+}co-doped concentration. The OFMD with high efficiency coupling and high energy density whispering gallery mode (WGM) was constructed. By the excitation of 976nm laser, the WGM resonance enhancement UC blue (475nm) and red (648nm) light were obtained. The WGM resonance enhancement UC luminescence mechanism, the rare-earth ions energy transfer mechanism and the optimal Tm^{3+} concentration were investigated .

1. Introduction

During the past several decades, the enhanced up-conversion efficiency of rare earth （RE）doped material for various applications has been widely studied[1,2], especially in the fields of optical applications such as three-dimensional display[3],laser cooling[4], laser and optical amplifiers[5],optical temperature sensor[6]. Currently, the major commercial white light-emitting diode (LED) is the phosphor-converted LED made of the InGaN blue-emitting chip and the Ce^{3+}:$Y_3Al_5O_{12}$ (Ce:YAG) yellow phosphor dispersed in organic epoxy resin.The manufacturer has also studied ultraviolet(UV) LED to achieve the effect of white light, and its luminous efficiency is higher than that of blue light[7]. The LED lighting based on a frequency down-conversion luminous mechanism process, the device is usually deteriorated due to the UV damage epoxy resin shell . What is noticeable is that the redundant UV(blue) light is harmful to the human eye, it caused the pupil myopia increased year by year. The UC luminescence excited by 980nm laser is easy to obtain the white light in which the emission proportion of the three primary colors i.e. red, green and blue is controllable[8]. It will overcome the disadvantages of commercial white LED, because of infrared light with low harmful for eyes. But so far, the UC luminescent efficiency was relatively low[9,10], how to improve the UC luminescent efficiency is very important.

The important factors are the choice of host matrix and the RE ions doped, the RE ions absorbing more excited photons. The tellurite glass was usually proposed for its high