Broadband luminescence characteristics of PbS/PbSe co-doped silica fiber

•Weight percentage list of the EDF

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I. INTRODUCTION

Fiber amplifier is an important device to realize long-distance fiber communication. Due to the limitation of electronic structure of rare earth ions, the bandwidth of EDFA is narrow and the amplification band is fixed, which can not well meet the increasing demand of communication bandwidth[1].

Quantum dots (QDs) have attracted extensive attention due to their unique structural advantages and optical properties. Among many kinds of QDs, IV - VI QDs (PbS, PbSe and PbTe) have structural advantages such as large Bohr radius, small band gap, and small electron/hole effective mass [2-3]. In addition, the position of the luminescence band can be adjusted by tuning the size of the QDs due to the quantum size effect[4], which is an advantage that rare earth elements do not have. Among IV-VI QDs, PbS and PbSe QDs have many similar properties, but they also have some differences. Due to the short fluorescence lifetime and low quantum efficiency of photoluminescence (PL) in PbS QDs, its PL spectrum is weak and excitation threshold is high. However, PbSe QDs have narrower band gaps, longer fluorescence lifetime, higher quantum efficiency and lower excitation threshold[5-7]. Therefore, the luminescence intensity of the fiber doped with PbSe and PbS could be stronger than that of PbS doped fiber.

In this study, a novel PbS/PbSe co-doped fiber are fabricated by modified chemical vapor deposition (MCVD) technology and its optical properties including absorption and luminescence characteristics are investigated.

II. EXPERIMENT AND RESULTS

The PbS/PbSe co-doped fiber is prepared by MCVD technology[8]. The refractive index distribution is shown in Fig. 1, and the inset figure is the cross section of the fiber. The diameters of the core and cladding of the fiber are 7.3 and 129.3 um, respectively. The elemental composition is analyzed by X-Ray Electron Probe Micro-analyzer (EPMA), as shown in TABLE I. O, Al, Si, S, Ge, Se and Pb elements are existed in the fiber.

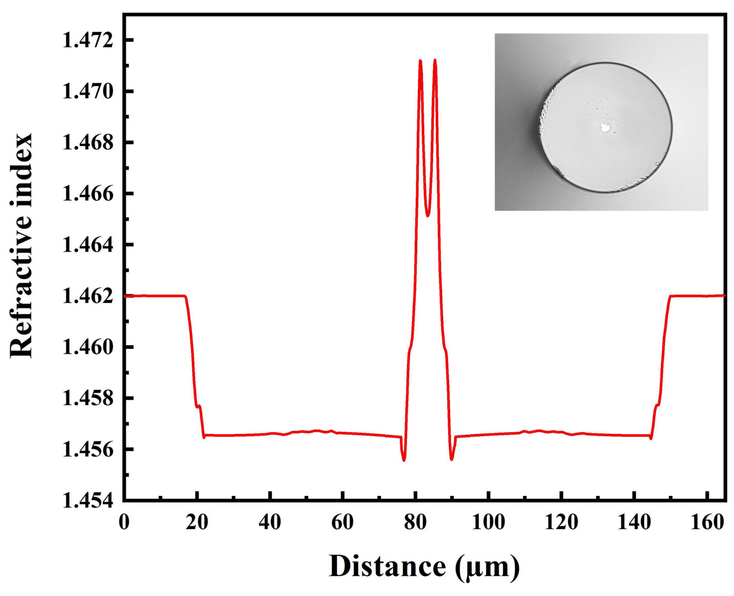

Figure 1. Refractive index distribution curve of the PbS/PbSe co-doped fiber, (inner) cross section of the fiber.

TABLE I. Mass percentage of doping elements in the core of the fiber

Elements	Mass%
O	59.35
Al	0.08
Si	39.94
S	0.04
Ge	0.21
Se	0.19
Pb	0.19
Total	100.00

III. RESULTS AND DISCUSSION

The absorption loss spectrum of the PbS/PbSe co-doped fiber is measured by cut-back method, as shown in Fig. 2. There are absorption bands centered on 773 and 1161 nm with corresponding absorption coefficients of 0.65 and 0.87 dB/m, respectively. Besides, the absorption peaks at 937 and 1239 nm are the absorption peaks of water vapor and hydrogen, respectively[9-10].

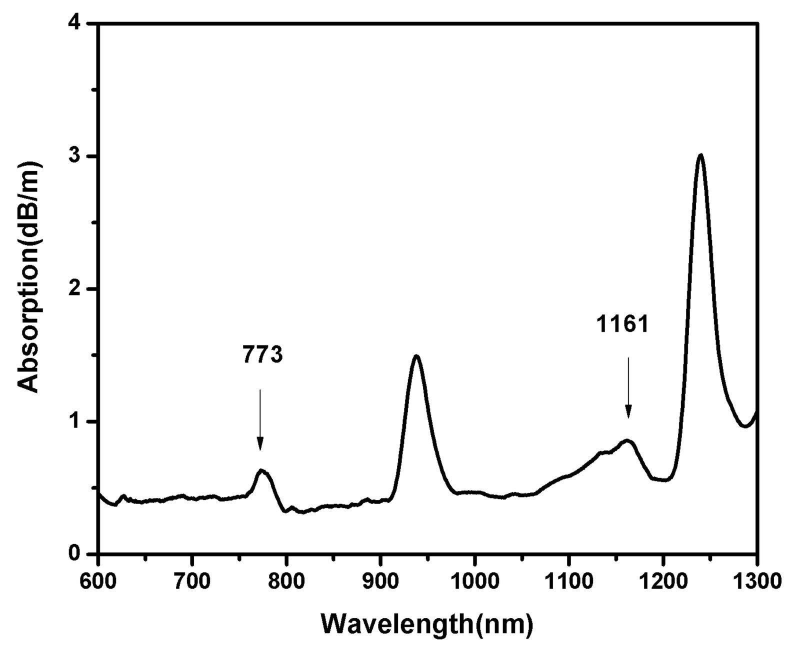

Figure 2. The absorption loss spectrum of the PbS/PbSe co-doped optical fiber.

The luminescence spectra of the co-doped fiber excited by 980 and 808 nm laser are shown in Fig. 3. The luminescence spectrum excited by 980 nm laser is about 60 dBm, which is 20 dBm more than that by 808 nm laser. The luminescence spectra under 980 nm pump powers are shown in Fig. 4. The luminescence spectrum covers a broadband of 1000-1350 nm. The broadband luminescence distribution is due to the wide-size distribution of PbS and PbSe QDs in the fiber. Furthermore, with the increasing of the pump power, the luminescence intensity is continuously enhanced. With the increase of pump power, the luminescence intensity finally reaches its saturation state. When the pump power is high enough, almost all carries are excited into high energy level, resulting in the saturation of stimulated absorption[10].

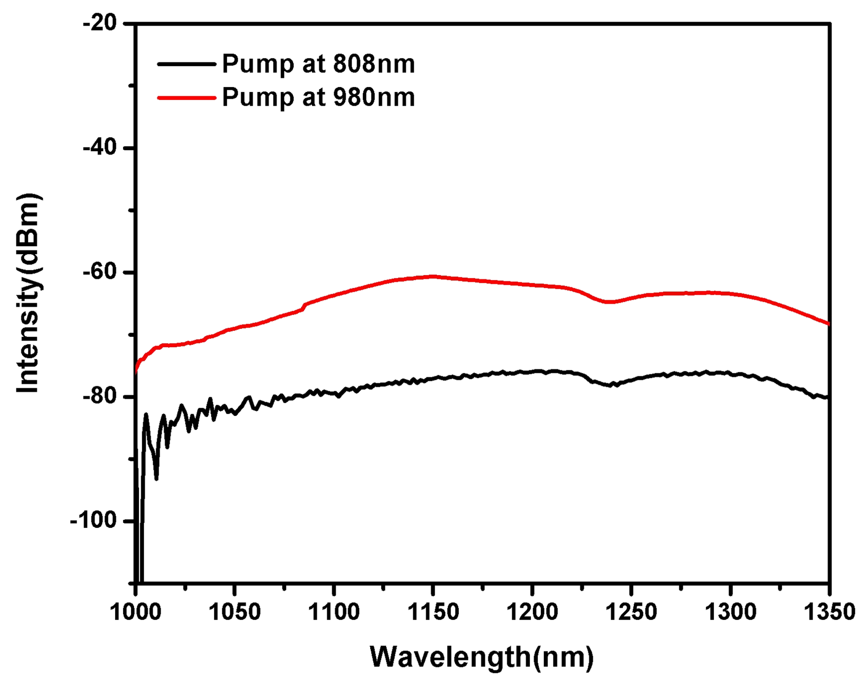

Figure 3. Luminescence spectra of PbS/PbSe co-doped fiber excited by different pump light source.

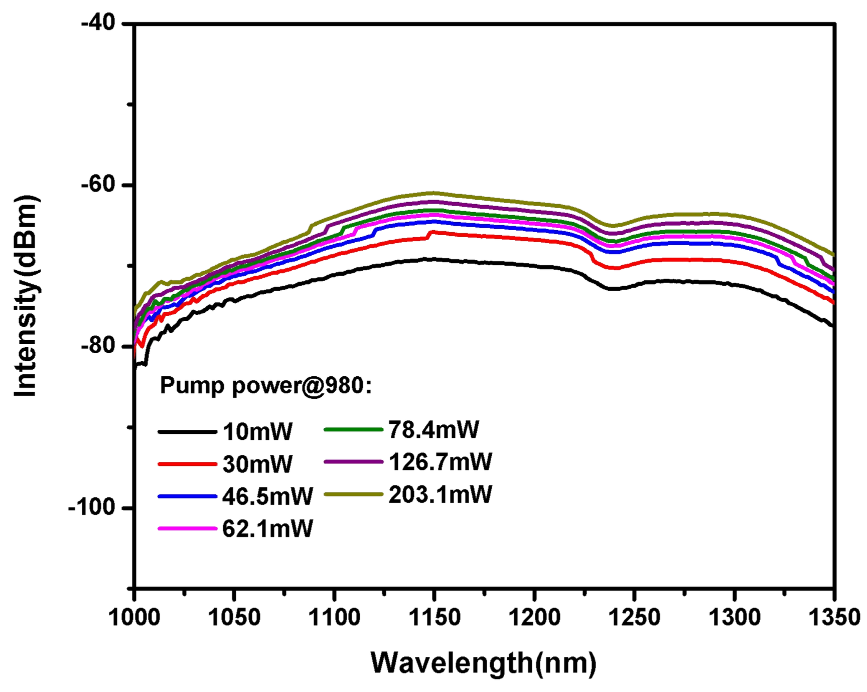

Figure 4. Luminescence spectra of PbS/PbSe co-doped fiber under different pump powers.

IV. CONCLUSION

The absorption and luminescence properties of PbS/PbSe co-doped fiber are studied in this paper. The absorption spectrum shows two absorption peaks at the wavelength of 773 and 1161 nm. The bandwidth of luminescence spectrum excited by 980 nm laser covers the broadband of 1000-1350 nm, which is due to the wide-size distribution of PbS and PbSe QDs in the co-doped fiber. The luminescence intensity increases with the increase of pump power. Although, the bandwidth of the PbS/PbSe co-doped fiber is wide, its luminescence is weak. Therefore, we need to improve the fabrication technology to fabricate high purity doped fiber to obtain stronger luminescence.

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