Dy^{3+}- and Pr^{3+}-doped phosphate glass optical fibres for laser emission at visible wavelengths

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Visible lasers find applications in many fields such as medicine, materials processing, display and entertainment technology, microscopy and scientific research.

Most rare-earth (RE) ions exhibit emissions in the visible spectral range when pumped with blue light, allowing for the realization of solid-state lasers with direct emission in the visible. However, due to the lack of useful semiconductor-based pump sources with emission at required short wavelengths, so far excitation has often been obtained by using flash-lamps or gas lasers, thus remaining inefficient and bulky. In recent years, the availability of semiconductor-based pump sources such as InGaN- laser diodes with emission in the blue has risen again interest in RE-doped laser materials with emission in the visible [1,2].

Up to date most optical fibres used for laser emission in the visible wavelengths region were based on low phonon energy fluoride glasses. These glass systems not only present severe limitations in terms of chemical and thermo-mechanical properties but also their phonon energy is not suitable to exploit fully the benefits of a short wavelength pumping scheme. A potential alternative host glass material to engineer laser operating at visible wavelengths is phosphate glass, thanks to its excellent network-forming glass ability, outstanding optical properties, higher RE-ions solubility, good mechanical properties, and high phonon energy [3].

Trivalent dysprosium (Dy^{3+}) and praseodymium (Pr^{3+}) ions are promising candidates for the realization of efficient high power solid-state lasers across the visible spectrum region.

In this work we report on the synthesis of a series of novel phosphate glasses in the system P_2O_5-Al_2O_3–BaO-K_2O doped with Dy_2O_3 and Pr_2O_3. The Dy^{3+} ions doping concentrations were 0.05, 0.21, 0.83 and 2.5×10^{20} ions/cm^3, while Pr^{3+} ions doping concentrations were 0.06, 0.26, 0.86 and 2.5×10^{20} ions/cm^3. The glasses were synthesized by the standard melt-quenching technique and their physical, thermo-mechanical and optical properties were characterized (see for example Fig. 1 a and b). The effect of RE ions concentration on emission spectra and lifetimes of the excited energy levels was investigated to assess the concentration quenching effect on luminescence performance, with the aim to identify the most suitable RE-doping level for the development of a phosphate compact optical fibre lasers.

Dy^{3+} and Pr^{3+}-doped optical fibres were then drawn by preform drawing, with the preform being obtained by the rod-in tube technique, whereby we inserted a rod of core glass into a cladding tube obtained by extrusion (Fig. 1c). Preliminary assessment of the prospect for visible laser emission will be reported.

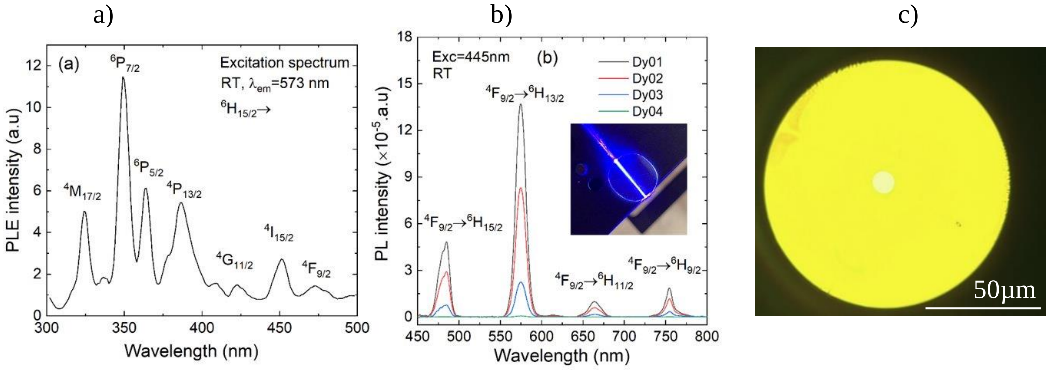

Fig. 1 a) Room temperature (RT) excitation spectrum of phosphate glass sample doped with 2.5×10^{20} Dy^{3+} ions/cm^3 (emission monitored at 573 nm). b) RT luminescence spectra under excitation 445 nm of Dy^{3+}-doped glasses. c) Optical microscopy cross-sectional image of the fabricated Pr^{3+}-doped fibre.

References

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