Fabrication and spectroscopy of high-quality Tm^{3+}-doped germanate glass for 2 µm laser emission

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Laser devices emitting in the 2 µm wavelength region are of interest for numerous applications going from light detection and ranging (LIDAR) to biomedicine. Most common 2 µm laser emission relies upon the exploitation of radiative transitions from Ho^{3+} or Tm^{3+} ions either in bulk or thin disk crystals, or in glass fibres as host materials. In the medium to high average power regime (>10 W), glass bulk lasers cannot be considered due to their poor thermal conductivity. Yet, such laser configuration could prove of interest for short pulse laser generation if one remains in a low to medium (up to 10 W) power operation.

As a laser material germanate glasses possess attractive properties such as low temperature melting (1200 ºC), broad transparency window from 0.4 to 4.5 µm, and the possibility to be doped with rare-earth (RE) ions at high concentration level - up to 10^{21} ions/cm^3. If compared to laser crystals, germanate glasses offer major technological advantages such as high-volume production, post-synthesis sample processing and importantly the possibility to be drawn into large cross-section fibre over several tens of metres at once. In terms of laser operation, the broadband and smooth absorption and emission spectra of germanate glass are ideally suited for the stable generation of short pulses while requiring a less demanding thermal management.

Laser operation, both with high output power (104 W) and high efficiency (68%), has been achieved in [1] for a Tm-doped double cladding germanate fibre laser pumped at 800 nm. However, for bulk germanate glass the maximum laser slope efficiency in continuous wave (CW) operation was 50% when pumped at 794 nm with a Ti:Sapphire laser [2], and 25.6% when pumped with laser diode at 790 nm [3]. Besides the cavity design, high glass quality and ions homogeneity are required to improve the laser performance. We report on the fabrication of a high-quality (highly homogeneous distribution) germanate glass material doped with Tm^{3+} ions suitable for bulk laser operation. The glass was synthesized by the conventional melting-quenching technique using high purity chemicals (>99.99%) and doped with Tm^{3+} ions at a concentration value of 2.6×10^{20} ions/cm^3.

The glass samples were cut to a length of 3 mm with a 3×3 mm^2 aperture. Optical absorption was measured to assess pumping opportunities in the $^3H_6 \rightarrow {}^3H_4$ and $^3H_6 \rightarrow {}^3F_4$ transition bands (Fig. 1a and b). The maximum absorption cross-section for the pump transition is 1.34×10^{-20} cm^2 at 792 nm. This value is 30% higher than the absorption reported in [2] and [4] and similar to the value reported in [3]. The luminescence emission was measured under 794 nm excitation and collected through a 550 µm core size optical fibre to an optical spectrum analyser (Fig. 1c), resulting in a broad emission band spanning from 1600 nm up to nearly 2100 nm.

Laser emission at 1948 nm was achieved by using Ti:Sapphire laser pumping tuned to 792 nm in an end- pumped configuration. The pump was focused onto the sample with a 30 µm spot size, and the bulk glass was placed between two flat mirrors. More detailed results will be given at the conference.

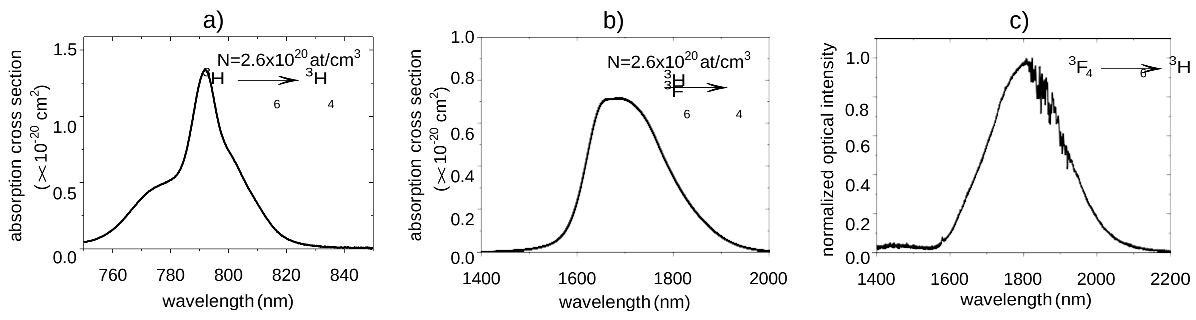

Fig. 1 Absorption cross-section for the a) $^3H_6 \rightarrow {}^3H_4$ and b) $^3H_6 \rightarrow {}^3F_4$ transitions. c) Luminescence characteristic of the $^3F_4 \rightarrow {}^3H_6$ emission.

References

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35-word abstract

A high-quality Tm-germanate glass was fabricated with homogeneous ions distribution. Spectroscopic characterization for pump and laser transitions as well as preliminary results on laser generation at 2 μm are reported.