Highly doped multicomponent phosphate glass fibers for compact pulsed optical amplifiers

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max. 500 words abstract:

In recent years, there has been a growing interest towards compact high peak-power pulsed laser sources for applications such as Light Detection and Ranging (LIDAR), range findings, remote sensing, communications and material processing.

A common laser architecture used to realize these sources is the Master Oscillator Power Amplifier (MOPA), in which a seed laser, the master oscillator, produces a highly coherent beam and a fiber amplifier boosts the output power, while preserving its main spectral properties.

The use of this architecture has driven the research for high-gain and compact fiber amplifiers, in order to mitigate nonlinear optical effects that grow with fiber length. Multicomponent phosphate glasses are recognized to be an ideal host material for engineering the amplification stage of a pulsed MOPA thanks to their ability to maximize energy extraction and minimize the nonlinearities. Thanks to their high solubility of rare-earth (RE) ions and weak ion–ion interactions, phosphates can be doped with large amounts of RE ions (up to 10^{21} ions/cm^3) without clustering, thus allowing the fabrication of short active devices with high gain per unit length (> 5 dB/cm).

Moreover, phosphate glasses possess a large glass forming range, good thermo-mechanical properties, high emission cross-sections, high optical damage threshold and no evidence of

photodarkening even at high population inversion. The Stimulated Brillouin Scattering (SBS) gain coefficient in the phosphate fibers has been shown to be 50% lower than that of silica fibers.

With the aim of realizing compact optical fiber amplifiers operating at 1 and 1.5 μm, a series of highly Yb^{3+}- and Yb^{3+}/Er^{3+}-doped custom phosphate glass compositions were designed and fabricated to be used as active materials for the core of the amplifiers. The fabricated active phosphate glasses were thoroughly characterized in their physical, thermo-mechanical, optical, and spectroscopic properties. Suitable cladding compositions were explored and final core/cladding glass pairs were selected to realize single-mode and multi-mode optical fibers.

Core and cladding glasses were synthesized by melting and subsequently quenching a powder batch of high purity chemicals (99+%) inside an alumina crucible at a temperature of around 1400 °C for 1 h under a controlled atmosphere (dry air, water content < 3 ppm). The core glass was then cast into a cylindrical mold to form a rod, while the undoped cladding glass was shaped into a tube by rotational casting method or extrusion technique. The latter has been extensively employed over the last decades for the manufacturing of tellurite and germanate glass preforms, while only recently the first example of active phosphate fiber preform fabricated through extrusion process has been reported by our research team.

Phosphate fibers were then manufactured by preform drawing using a custom induction heated optical fiber drawing tower, with the preform being obtained by the rod-in-tube technique.

Preliminary results of pulsed optical amplification at 1 and 1.5 μm are presented for a single-stage MOPA.

max. 300 words abstract:

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A common laser architecture used to realize these sources is the Master Oscillator Power Amplifier (MOPA), in which a master oscillator produces a highly coherent beam and a fiber amplifier boosts the output power, while preserving its main spectral properties.

Phosphate glasses are recognized to be an ideal host material for engineering the amplification stage of a pulsed MOPA since they enable extremely high doping levels of rare-earth ions to be incorporated in the glass matrix without clustering, thus allowing the fabrication of compact active devices with high gain per unit length.

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