New Developments in Tellurite Glass Fibers

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Abstract: Recent developments on the manufacture of tellurite glass fibers are presented. Technical issues related to glass synthesis, preform manufacturing and fiber drawing as well as prospective of commercial exploitation are discussed.
OCIS codes: 060.2390 Fiber optics, Infrared; 160.4530 Nonlinear optical materials; 170.2750 Glass and other amorphous materials.

1. Tellurite glass fiber fabrication

Its outstanding physical properties make of silica the glass material of choice for optical fiber applications. However, in many cases the use of alternative oxide glass compositions, in particular for the development of more compact or/and more efficient devices, could be advantageous. Some phosphate glass and multicomponent silicate glass compositions have been used for the development of commercial fiber laser operating at 1.5 and 2 um respectively. However, other promising oxide glass compositions such as germanate or tellurite glasses still remained to be truly exploited in the form of commercial devices.

Tellurite glass allows for concentration in rare-earth ions doping up to 10^{21} ions/cm^3, it also possesses a high nonlinear refractive index (50.10^{-16} cm^2/W), a low phonon energy making mid-IR transmission possible up to 5 μm and a Verdet constant of 30 rad·(T·m)$^{-1}$ making this glass suitable for magneto-optic applications as well.
Like for most oxide glasses, although a controlled environment is required for the synthesis of tellurite glasses, the process is not technically challenging if compared to non-oxide soft glass preparation. The typical process is carried out by melting chemical precursors in noble metal crucible and quenching the liquid melt in suitable metal mold. The intrinsic optical losses of tellurite glass manufactured using this approach is lower than 0.1 dB/km which demonstrates the potential of this material for optical applications.

"Standard" techniques used for manufacturing step index tellurite glass optical fibre preform involve the assembly of discrete core rods and tube elements when using a direct rod-in-tube technique. In spite of the care taken during fiber manufacturing, the typical loss value in single-mode fiber reaches few dB/m. This value can be improved down to 0.1 dB/m using built-in-casting or suction casting techniques. Although the above loss values are still tolerable for short length device, the reproducibility of the manufacturing techniques in terms of preform geometry and fiber quality remains a limitation for exploiting tellurite glass fiber at industrial level.

2. Towards generation of high power mid-IR Supercontinum (SC) spectrum in tellurite glass fibers

To date most research efforts have focused on rare-earth ions doped tellurite glass, leading to laboratory demonstration of fiber laser devices operating at 1.5 μm and 2 μm. For exploiting the nonlinear properties of tellurite glass, research groups have reported the generation of supercontinuum spectrum in holey optical fibers microstructured in order to tailor the zero dispersion wavelength (ZDW) of the fiber near the pumping wavelengths of 1 μm and 1.5 μm.

Actually, tellurite glass possess a ZDW in the 2 μm region so that pumping at this wavelength releases the need of ZDW tailoring. Mid-IR SC spectrum can then be generated in standard step index fiber without any particular geometrical constrains expect for the fiber to operate in the single-mode regime.

Through this approach, Kulkarni et al. [1] generated a 2.6 W supercontinuum spectrum spanning from 2 μm to 4

μm, using a 8.5 m long step index fibres made of low nonlinearity ZBLAN glass. The step index fiber design results in decreased complexity and improved control and repeatability in the fiber manufacturing process as compared to holey fibers (HFs). With a nonlinear refractive index nearly 20 times that of ZBLAN glass, a higher damage threshold and a higher thermo-mechanical and chemical compatibility with silica glass fibre devices, tellurite glass fibres offer thus the possibility to develop similar multiwatt supercontinuum sources in the mid-IR but in a compact device format

For this purpose we have developed a tellurite glass composition meeting the following requirements:

- Low O-H radicals content for mid-IR transmittance as shown in Figure 1. Subsequent extrinsic losses due to O-H band absorption are of the order of 50 dB/m.
- High polarisability with a refractive index (n) at 1.533 μm n = 2.067.
- High glass transition temperature, T_g = 390 °C and extended glass stability with an onset crystallisation temperature of T_x = 550 °C.

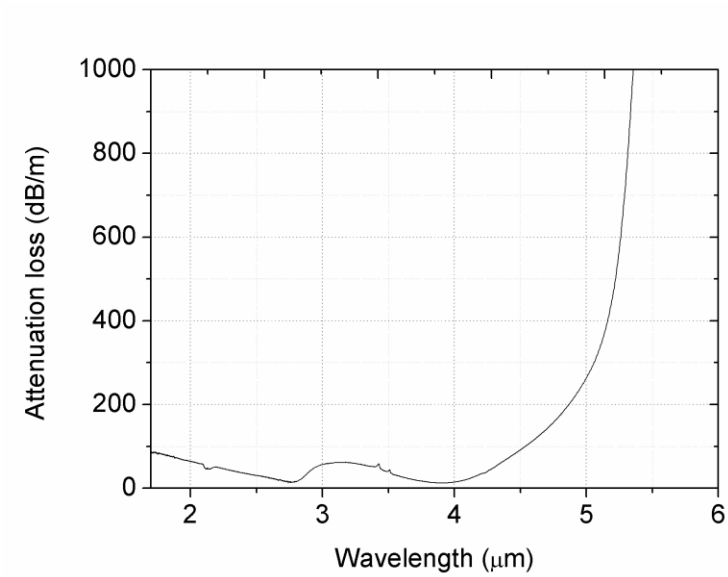

Figure 1: FTIR transmission spectrum of tellurite glass developed for high average power SC generation in mid-IR

Taking benefit of the recent progresses achieved to generate 2 μm pulsed sources [2], the development of an optical fibre made from this tellurite glass composition should allow for producing high power and compact supercontinuum sources operating in the mid-IR.

3. References:

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