Fabrication of Er^{3+} doped tellurite whispering gallery mode microsphere laser using 0.98 μm and 1.48 μm pump lasers

Snigdha Thekke Thalakkal[1, *], *Davor* Ristic[1], *Daniil* Zhivotkov[1], *Gualtiero* Nunzi Conti[2], *Stefano* Pelli[2], and *Mile* Ivanda[1]

[1]Institute Ruder Boskovic, Bijenička Cesta 54, 10000, Zagreb, Croatia.
[2]MiPLab, IFAC – CNR, 50019 Sesto Fiorentino, Italy.

Abstract. We reported lasing in Er^{3+} doped tellurite glass whispering gallery mode microspheres fabricated using the plasma torch method.$15Na_2O25WO_360TeO_2$ doped with 0.5 mol% Er^{3+} is used for the fabrication of microspheres. Laser light from the pump is coupled to the microsphere through a half and a full tapered fiber. An optical spectrum analyzer receives the counter propagating light from the microsphere. Pump lasers of 980 nm and 1480 nm are used to achieve the laser emission at 1570 nm.

Whispering gallery mode microsphere resonators gained considerable attention due to their applications in sensing, lasing and telecommunication [1]. High quality factor (10^6-10^9) and low mode volume of microspheres makes them suitable candidates for microlaser applications. Rare earth-based (Er^{3+}, Tm^{3+}, Ho^{3+}, Nd^{3+}) laser sources have been widely used for the fabrication of microlasers [1-3]. Rare earth ions doped with glasses such as tellurite, phosphate, fluoride and oxide glasses have been shown to be an effective material for laser production [5,6]. Tellurite glasses exhibit exceptional mechanical and thermal characteristics as well as excellent transparency from the visible to the mid-infrared spectrum [4]. The high solubility of rare earth ions in tellurite glass makes it possible to increase the doping concentrations, which enhances pump efficiency. In this letter, we reported Er^{3+} doped tellurite microsphere laser production using pump lasers 980 nm and 1480 nm. We used a home-made plasma torch set up for the fabrication of microspheres. This method is inexpensive and suitable for producing microspheres with diameters ranging from 11-88 micrometers.

$15Na_2O25WO_360TeO_2$ doped with 0.5 mol% Er^{3+} sample is used for the fabrication of microspheres. Plasma torch method consists of two electrodes which is connected to a high voltage supply, when the glass grains are passing through the electric arc they melt and acquire spherical shape due to surface tension. Figure 1 depicts the plasma torch method for the fabrication of microspheres. For the microlaser experiments, pumping is accomplished through evanescent coupling using a full tapered fiber. 980 nm or 1480 nm pump is connected to a multiplexer, which is in turn connected to the microsphere coupling system. Schematic of the experimental set-up is shown in figure 2. The counter propagating light from the microsphere is received by an OSA (optical spectrum analyzer). The microsphere coupling system was connected to

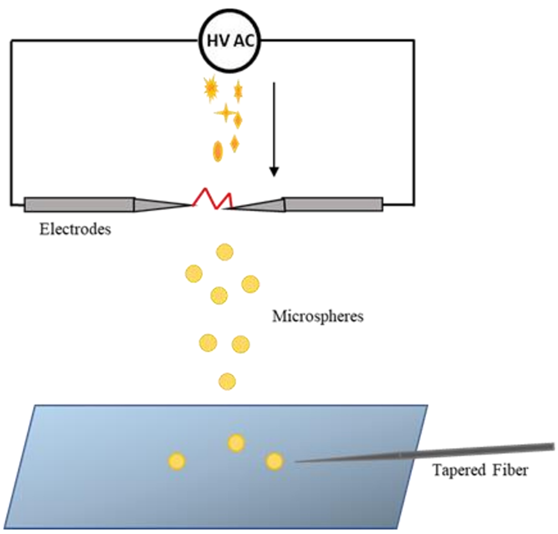

Fig. 1. Schematic of plasma torch method used for the fabrication of microspheres.

* Corresponding author: sthekket@irb.hr

https://doi.org/10.1051/epjconf/202328705031

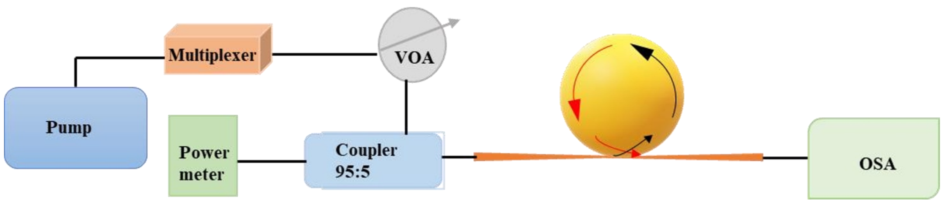

Fig. 2. Schematic of experimental set up for the microlaser experiment using a full tapered fiber

the 95% splitter's outputs. A power meter connected to the 5% output of the coupler is used to measure the source power. Green light up-conversion can be observed when microsphere is coupled to the tapered fiber. We achieved single mode and multimode lasing in 1.5 µm-1.6 µm range using 1.48 µm and 0.98 µm pump lasers. Single mode lasing reported with 980 nm pump and multimode lasing observed with 1480 nm pump lasers are shown in the figure 3 and figure 4 respectively.

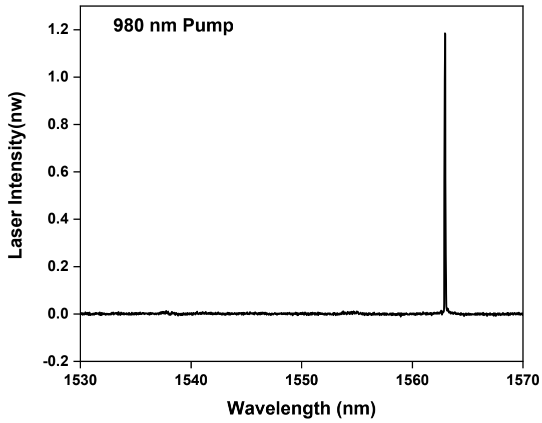

Fig. 3. Single mode lasing observed with 980 nm pump.

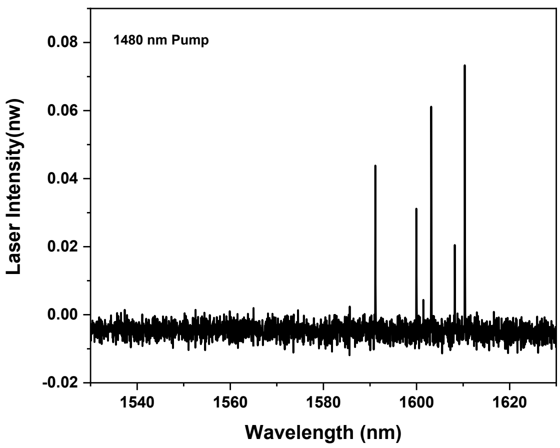

Fig. 4. Multimode observed with 1480 nm pump.

In addition, we measured the quality factor (Q) of the microsphere. The measured value is 0.4×10^{6}. The Lorenz fitting of the mode for Q factor measurement is shown in figure 5.

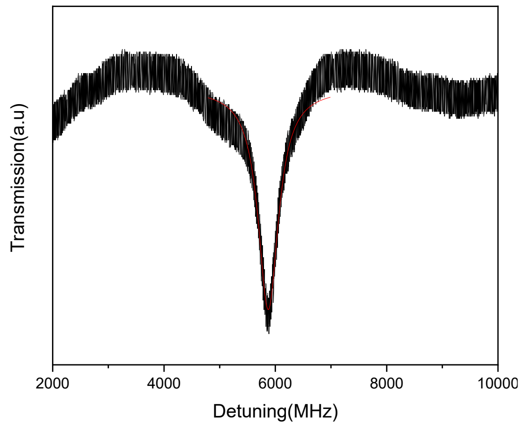

Fig. 5. Lorenz fitting of the mode for the Q factor measurement.

Croatian Science Foundation IP-2019-04-3045; Croatian Government and the European Union through the European Regional and Development Fund – the Competitiveness and Cohesion Operational Programme (KK.01.1.1.01.0001).

References

[1] X. Peng, F. Song, S. Jiang, M. Gonokami, N. Peyghambarian., Applied physics letters **82.10** ,1497-1499 (2003)

[2] J. Yu, X. Wang, W. Li, M. Zhang, J. Zhang, K Tian, Y. Du, S. Chormaic, P. Wang. Journal of Lightwave Technology **38.7**,1880-18869 (2020).

[3] T. Kishi, T. Kumagai, T. Yano, S. Shibata., AIP Advances **2.4** ,042169 (2012).

[4] E.A. Anashkina, Fibers **8.5** ,30 (2020).

[5] P. Feron, Annales de la Fondation Louis de Broglie **29**, 1-2 (2004).

[6] C.H. Dong, Y. Yang, Y.L Shen, C.L. Zou, F.W. Sun, H. Ming, G.C. Guo, Z.F. Han, Optics communications **283.24**, 5117-5120 (2010).