Porous silica glasses for rare earth ions heavily doped extra-large core fiber

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Abstract

Rare-earth doped fiber lasers have important applications in high-speed optical communication, industrial processing, medical treatment, military defense and other fields due to their low pumping threshold power, high conversion efficiency, excellent heat dissipation, wide tunable range, high coupling efficiency and compact structure. However, there are some problems to be solved in fiber lasers. The biggest barrier is from the nonlinear effects such as stimulated Brillouin scattering(SBS), stimulated Raman scattering(SRS) and self phase modulation(SPM). In recent years, in order to solve these problems, researchers all around the world have carried out a great deal of study from fiber structure and gain media, and found that the large mode area short fiber can effectively suppress nonlinear effects in fiber and reduce the influence of ambient acoustic noise.

For the gain medium, in order to overcome the disadvantage of reducing the optical fiber power caused by shortening the optical fiber length, the doping concentration of the fiber must be increased.

Herein, we developed 3D nanoporous silica rods based on glass phase-separation technology to solve these requirements. Benefiting from uniformly distributed nanoscale pores, nanoporous silica glass exhibits remarkable performance in its doping level, refractive index controlling, core diameter, and optical homogeneity. These properties make nanoporous silica glasses very suitable as a fiber-core material and greatly distinguished from other fiber materials. We prepared a series of Yb3+ heavily doped extra-large-core double cladding silica fibers based on nanoprorous silica glass. The diameter of a typical extra-large-core fiber can reach to over 80 μm with a negligible refractive index fluctuation. The fiber exhibits an excellent laser performance with a slope efficiency of 78% for 302 W laser emission at 1080 nm in a 55 cm length fiber. This study will make nanoporous silica glasses shining out new energy in fiber materials and will boost the advancement of high-power fiber lasers.

Keywords: nanoporous silica glass, active fiber, fiber laser, large mode area

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