Generation of high power 1535nm light from a short cavity cladding pumped Er:Yb phosphate fiber laser

T. Qiu, L. Li, V. Temyanko, J. Wu, A. Schülzgen, N. Peyghambarian
Optics Sciences Center, University of Arizona, Tucson AZ 85721
tqiu@optics.arizona.edu

T. Luo, S. Jiang
NP Photonics, Inc., 9030 S. Rita Rd., Tucson, AZ 85747

A. Mafi, D. Kouznetsov, J. V. Moloney
Arizona Center for Mathematical Sciences, University of Arizona, Tucson, AZ. 85721

Abstract: More than 3.5 W power at 1535 nm is efficiently generated from a cladding pumped Er:Yb codoped 14 cm-long phosphate fiber laser. The short cavity length shows potential capability for watt level single frequency output.

©2004 Optical Society of America
OCIS codes: (140.3500) Lasers, erbium; (140.3510) Lasers, fiber; (060.2410) Fibers, erbium.

The generation of high power radiation around 1550 nm from a compact fiber laser source has been of great interest due to its applications in optical fiber communications and instruments demanding eye safe light beams. When single frequency operation is required, it is often necessary to use a short piece of single mode fiber to facilitate single longitudinal mode selection. However, this significantly limits the output power from the fiber lasers to mW level [1-3]. In an attempt to generate high output power from a short piece of fiber, we report here a cladding pumped Er:Yb codoped phosphate fiber laser, which generates several watts output power from a 14 cm long fiber. Internal slope efficiency above 40% is obtained.

Phosphate glass fibers are used in our laser because they allow for high concentration doping of rare earth ions and, therefore, provide the high gain [4] needed for a short cavity fiber laser. Codoping Er with Yb significantly improves pump absorption at 976 nm and reduces Er clustering at high concentrations. We used a phosphate fiber with 125 μm cladding and 18 μm core diameters. The core is uniformly doped with 1 w% of Er and 8 w% of Yb ions. These doping levels are high enough to provide sufficient pump absorption and signal gain within 14 cm length. The core is positioned off-center to improve the absorption of pump light that is coupled into the cladding. Cleaved facets with 4 % Fresnel reflection at both fiber ends provide the feedback for the laser cavity. To provide efficient cooling most of the laser is immersed in water (see figure 1).

The pump diode laser delivers up to 35 W of light through a multimode fiber with 100 μm core diameter. The pump wavelength is stabilized at 976nm. The pump fiber is butt coupled to a piece of undoped silica fiber which is mechanically spliced to the active phosphate fiber. An air gap is kept in this splice to maintain the laser facet reflection. The pump loss through butt coupling and the mechanical splice is about 25%.

Figure 2 shows the 1535 nm laser output power measured from the free end of the active fiber outside the cooling tube as a function of external pump power measured before the butt coupling. The lasing threshold is 0.73 W and a maximum of 3.5 W output was obtained at 26 W pump power. Since the fiber laser has equal reflection at both facets, we expect an approximately equal output from both ends. Hence, a total power of about 7 W is estimated which results in a slope efficiency of 27 %. Since only about 65 % of the pump is absorbed by the fiber due to coupling losses, scattering, and pump leakage through the output end, the internal efficiency related to absorbed pump power is above 40 %. A further increase of the pump power leads to thermal instabilities of the laser output end because it is not water cooled. However, it is believed that the laser output is scalable to more than 10 W using a completely cooled fiber laser. The 10
dB spectral linewidth of the free running laser is about 1 nm and $M^2$ of the output beam is measured to be 2.5. Fiber lasers with narrower linewidth and single transverse mode are under development in our group.

In conclusion, we demonstrated multiwatt laser emission at 1535 nm from a short piece of heavily doped phosphate fiber. The power generated per unit length represents a record for Er doped fiber lasers. We like to acknowledge support from MRI program sponsored through Air Force Office of Scientific Research.

References


