High-power tunable erbium-doped fiber laser operating at 1.55 μm

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There is currently considerable interest in lasers based on the fiber waveguide geometry, and crys-
tal fiber Ne:YAG lasers are now commercially available. We recently developed a new fiber
laser technology based on doped glass which offers both a wide choice of dopant ions and the
possibility of wavelength tunability. The Er3+-
doped fiber laser is particularly interesting be-
cause its operational wavelength of 1.55 μm coin-
cides with the lowest loss region of silica optical
fibers. Furthermore, the fiber can be used as a
high-gain optical amplifier, which is compatible
with quaternary (InGaAsP) devices.

The low loss and long length of the glass-fiber
laser (200-m length has been demonstrated) make it particularly attractive for simultaneous la-
ser action and generation of nonlinear effects.

The holographic grating provides wavelength selective feedback (800 lines/mm, blazed at 1.6 μm), and
the output is taken from the zeroth-order reflection, of the grating. Tuning is effected by changing the
angle of the mirror. Figure 2 shows the resultant tuning curve. To O-switch the laser, an acous-
tooptic modulator is inserted into the cavity so that the feedback is via the first-order deflection. This configuration provides a high extinction ratio and eliminates the possibility of lasing while the modula-
tor is off. The gain of the laser is so high that Fresnel reflection from the fiber ends is sufficient
to support oscillation, and index matching of the
fiber output is required.

The performance of the laser varies with fiber length and pulse repetition rate. For the doped
fiber used in this experiment (Er3+ ion concentra-
tion, 1019/cm²; fiber N.A. = 0.21; second-mode
cutoff = 1.4 μm), the optimum length was 2.5 m.

Note that this length could be reduced by at least 2
orders of magnitude, if desired, by using a higher-
dopant concentration. At a pump power of 220
mW, corresponding to ~100 mW absorbed in the
fiber, O-switched pulses of 32 ns duration and 120-
W peak power were generated at a repetition rate
of 800 Hz. A typical pulse is shown in Fig. 3.

The intensity in the fiber core during O-switching is ~1 GW/cm². Thus the erbium-doped fiber laser
is a useful source for nonlinear optics experi-
ments. For example, Raman generation over a 40-
nm band centered at 1.65 μm has been ob-
served in a second length of high-birefringence
fiber (loss = 1.2 dB/km at 1.6 μm, length = 800
m). This length is well in excess of the optimum,
and it was possible to achieve complete depletion
of the pump pulse. If the cavity is designed to be
resonant at the Stokes frequency, simultaneous
oscillation should be possible. Further results are
presented.

Summarizing: An efficient cw and O-switched
fiber laser has been demonstrated, which is tun-
able in the wavelength region of 1.55 μm. The
laser has been optimized for high peak power and
can be used as a source for nonlinear optics.

(12 min)

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