High Power Pulsed Fibre Lasers

Introduction

Pulsed, high power (kiloWatt level) fiber lasers find applications in material processing, medical, defense, and study of various non-linear optical phenomena. Recent developments in rare-earth doped fibers with double-clad geometry have enabled the development of fiber lasers providing outstanding performance in output power, beam quality and overall efficiency.

Approach

Our aim is to generate a high power pulsed laser by amplifying the output from a semiconductor laser diode using a Ytterbium (Yb)-doped double clad fiber. A double-clad fiber has an additional cladding with lower refractive index around the conventional cladding, thereby allowing the inner cladding to act as a waveguide for the pump radiation. The process of amplification in a double-clad fiber is represented in Fig. 1. The core of the fiber is doped with ytterbium. The signal, which is to be amplified is coupled into the core of the fiber. The pump is absorbed in the overlap region of core and inner cladding. The pump absorption is almost uniform along the length.

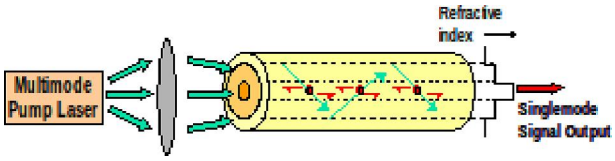

Figure 1. Process of amplification in a double- clad fiber.

The maximum output power which can be obtained from a single stage amplifier is limited by amplified spontaneous emission and nonlinear processes such as stimulated Raman scattering (SRS) and stimulated Brillouin scattering (SBS).In order to achieve the kilowatt power levels, a dual stage Master Oscillator Power Amplifier (MOPA) configuration is used which is shown in Fig. 2. The configuration consists of a stable master oscillator, which is capable of generating laser pulses of 40ns with repetition rate of 25 kHz. The first stage of the MOPA setup consists of a single mode double clad fiber. The limitations in power scaling due to the above nonlinearities may be overcome by using a large mode area (LMA) double clad fiber in the second stage.

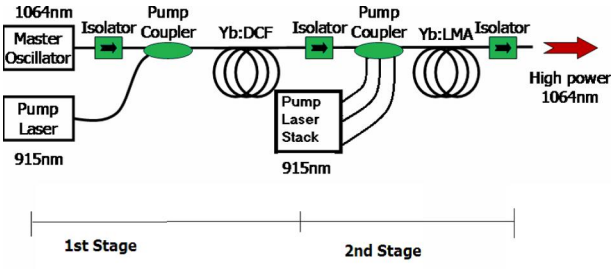

Figure 2. Block diagram of the high-power amplifier in the MOPA configuration.

In LMA fiber the core diameter and the doping concentration is increased to overcome the non-linearity in a single mode fiber. By increasing the core diameter the output of LMA fiber is no longer in single mode. The LMA fiber can be coiled in small diameter such that it introduces high loss for higher order modes as compared to first order mode. In this way single mode output can be obtained from LMA fiber.

Experimental Results

The above setup has been packaged in a rugged, portable box as shown in Fig. 3. Peak power of up to 500 W has been achieved for a 40 ns pulse at 25 kHz repetition rate at the output of 1st stage of MOPA, with a launched pump power of 4.5 W. Preliminary characterization of output powers obtained from the 2nd stage has indicated that output powers in the order of a few kWs are possible with M^2<1.5. Work is underway to scale the output power using multiple pump lasers for the second stage amplifier.

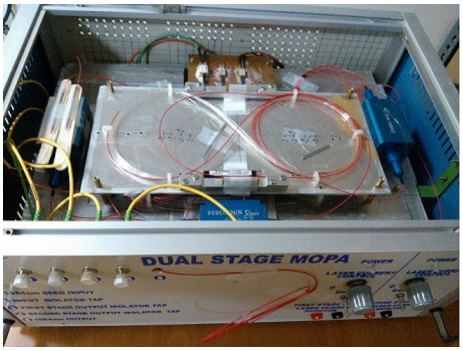

Figure 3. Experimental setup of dual stage MOPA.

Publication

Y. Panbiharwala, C. S. Kumar, D. Venkitesh, B. Srinivasan, "Investigation of self pulsing in Ytterbium doped high power fiber amplifier," to be presented at Photonics 2012, Chennai.

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