L.3: Development of engineered 1 W narrow linewidth fiber amplifier at 1550 nm

All-fiber amplifier system has been developed in which 10 mW power of a narrow linewidth seed laser diode at 1550 nm is scaled to 1 W level in master oscillator power amplifier (MOPA) configuration. In MOPA configuration, a low signal strength seed source with narrow linewidth is amplified in multi-stage to generate desired output power. All-fiber based amplifier systems are preferred due to their several advantages over conventional solid-state counterparts such as better heat removal due to large surface to volume ratio, high beam quality (Gaussian beam), misalignment-free operation and compact design. Amplification process requires optimization of many parameters like gain fiber length, pump power, signal strength, thermal effects, amplified spontaneous emission (ASE) and stimulated Brillouin scattering level, etc. Numerical simulations were performed in designing amplifier stages. The designed setup consists of a narrow linewidth seed source, a pre-amplifier and an amplifier stage. Schematic of the setup is shown in Figure L.3.1.

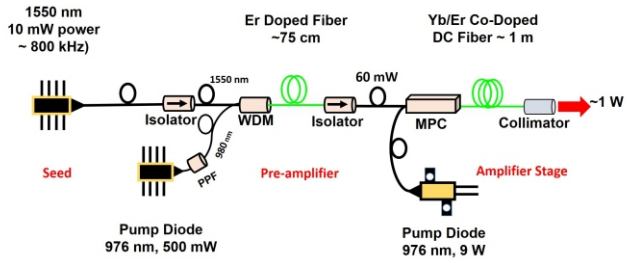

Fig. L.3.1: Schematic of fiber amplifier setup.

Seed source is a commercial fiber-coupled single frequency laser diode (Eblana Photonics, Model: EP 1550-0-NLW-B-800FM) with specified linewidth of ~800 kHz at 1550 nm with output power of ~10 mW. Pre-amplifier stage consists of ~75 cm long Er-doped non-polarization maintaining single mode fiber (SMF) with core diameter of ~9 µm. The active fiber in the pre-amplifier is pumped in core by a fiber Bragg grating (FBG) stabilized pump diode at 976 nm using a wavelength division multiplexer (WDM) through its 980 nm port. A pump protection filter (PPF) is spliced between pump diode and 980 nm port of WDM to protect the pump diode from any backward propagating ASE towards it. Seed source is spliced to 1550 nm port of WDM through a fiber coupled isolator to avoid any unwanted feedback towards the seed source, which can disturb its linewidth and can also cause damage. A fiber isolator was used after the pre-amplifier to protect it from backward propagating light if any. In the pre-amplifier stage, power was scaled to a level of 60 mW. Output of the pre-amplifier stage is input to amplifier stage. The amplifier stage consists of an active multiple pump combiner (MPC) having two pump ports and a signal port at one side and an active fiber of ~1 m length at the other side. Active fiber is Er/Yb co-doped double clad (DC, 10/120 µm) fiber, which is pumped in inner clad by a multi-mode fiber coupled laser diode (JDSU, 9 W) at 976 nm wavelength through pump port of MPC.

The signal port of MPC is spliced to pre-amplifier output. The output of amplifier stage is spliced to the fiber coupled collimator with beam size of ~3 mm. Output power of the amplifier is measured after collimator using power meter (Ophir, L50(150)A-BB-35 detector with VEGA display). The amplifier setup was assembled in a portable enclosure to make it ready for field applications. Photographs exhibiting internal and external views of the developed engineered version of the amplifier setup are shown in Figure L.3.2(a) and Figure L.3.2(b), respectively.

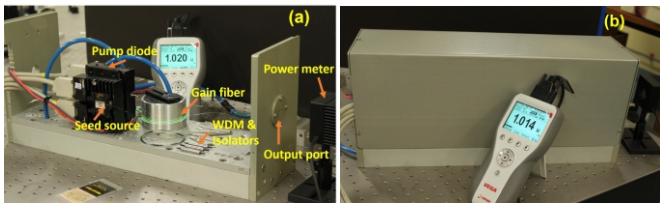

Fig. L.3.2: (a) Internal, and (b)external view of the amplifier system.

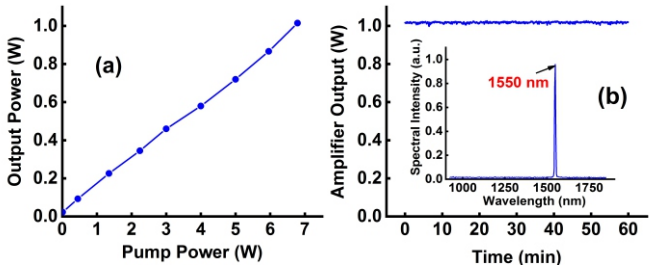

Fig. L.3.3: (a) Amplifier output power with pump power, and (b) stability of amplifier output at ~1 W level and the inset shows its optical spectrum.

Variation of the amplified output power with the pump power is shown in Figure L.3.3(a). The amplifier output increases almost linearly with increase in the pump power. Maximum 1 W output power at 1550 nm was achieved at 7 W pump power giving rise to ~15% pump to signal conversion efficiency. There was no appreciable increase in the linewidth with respect to the seed source. The amplifier performance is highly repeatable. Figure L.3.3(b) shows the typical run of amplifier for one-hour duration. The amplifier output is stable with fluctuations within ±0.1%. Optical spectrum is shown in the inset of Figure L.3.3(b), which clearly shows that amplifier output is peaked at 1550 nm without any contribution from pump and ASE. The system when used with suitable instrumentation has application in measurement of velocity of projectiles. Further, the operating wavelength is in eye safe regime and such amplifiers also find applications in metrology, high resolution spectroscopy and interferometry based measurements.

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