ASE sources as pumps for 2-μm fiber amplifiers, lasers, and ultra-broad ASE sources

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Abstract. We demonstrate ASE pumping of rare-earth-doped fiber amplifiers, fiber lasers, and broadband ASE sources. Pumping with an ASE source yields the advantages of optical-optical efficiencies comparable to conventional pumps, generation of ultra-broad-band ASE sources, and reduced low frequency noise transferred from the pump to the signal.

Introduction. Fiber-based sources in the eye-safe 2-μm region are important components for many emerging applications such as LIDAR, coherent lightwave systems, and WDM transmission. Here, we report the use of amplified spontaneous emission (ASE) sources as novel kind of pump source for rare-earth-doped fiber amplifiers, fiber lasers, and broadband ASE sources. We demonstrate that pumping with an ASE source 1) delivers optical-to- optical efficiencies comparable to traditional pumping means for doped fiber amplifiers and lasers (e.g., narrow linewidth distributed-feedback fiber-Bragg-grating (DFB FBG) laser [1]), 2) enables generation of ultra-broad 2-μm ASE sources with 20-dB bandwidth up to 265 nm [2], and 3) reduces the low-frequency noise transferred from the pump to the signal [3].

Method and Experiments. First, we have evaluated the performance of a polarization-maintaining (PM) Ho-doped fiber amplifier (HDFA) pumped with a Tm-based broadband ASE source and compared with the results obtained using fiber laser pumps at 1860 and 1940 nm [4]. The spectrum of the ASE pump was centered at 1883 nm and had a Gaussian shape with a 3-dB bandwidth of 50 nm. The performance of the HDFA, whose architecture is shown in the inset of Fig. 1, was characterized with 1 mW of input power from a 2051 nm semiconductor laser seed (Eblana EP2051-DM-H17-FM) for the pump powers up to 1 W. The left panel of Fig. 1 shows the signal output power measured with three different pumps. In case of the ASE pump, the amplifier efficiency is only 12% lower than at the optimum pump wavelength of 1860 nm [4], but almost twice higher than for the pump at the 1940 nm wavelength. The input and output spectra of the amplifier are shown in the right panel of Fig. 1, revealing that the noise figure in the case of the ASE pump remains the

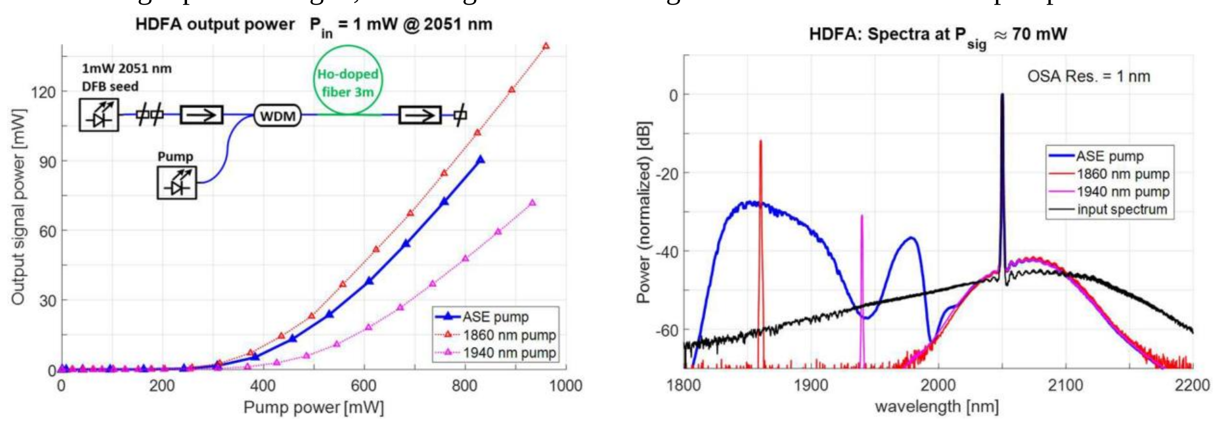

Figure 1: (left) Signal output power of the HDFA as a function of pump power for three different pumps. Inset shows the HDFA configuration. (right) Normalized input and output amplifier spectra measured with different pumps.

same as for the fiber laser pumps.

Next, to illustrate the applicability of an ASE source to pump fiber lasers, we have characterized the performance of a 2039 nm PM Tm-doped DFB FBG laser. The system under consideration is shown in the inset of Fig. 2 (left). The DFB FBG laser is pumped with an unseeded Er/Yb-doped fiber amplifier (EYDFA) which acts as a 1.5 µm ASE source. The performance of the ASE pumped laser was contrasted with results obtained using a master oscillator power amplifier (MOPA) pump at three different wavelengths (i.e., 1550, 1560, and 1565 nm) in order to change the absorption coefficient in the fiber laser. The MOPA consisted of a narrow-linewidth tunable laser (Santec TSL-710) amplified by the 1W EYDFA. The pump spectra are shown in the left panel of Fig. 2. The right panel of Fig. 2 shows the signal output power of the DFB FBG laser as a function of pump power for different pump types. We observe that pumping with a broad-band ASE is only 8% less efficient than using a monochromatic pump at 1550 nm. At the time of the conference, we will illustrate that by placing a few-nm-wide ASE filter between the two stages of the EYDFA, the ASE pumping approach enables the selection of both the ASE center wavelength and its bandwidth [5], leading to an increased optical efficiency and a reduced low-frequency noise contribution to the DFB FBG laser emission.

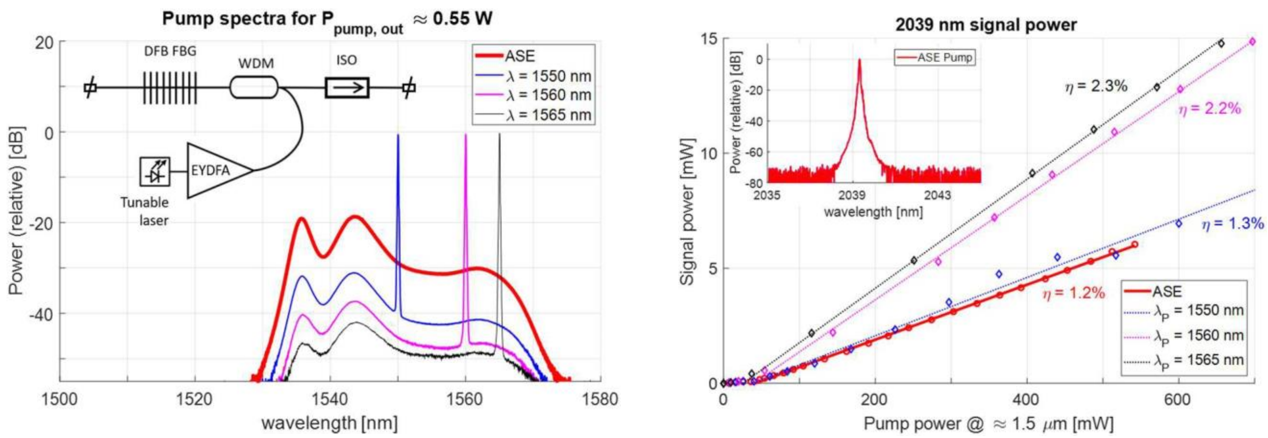

Figure 2: (left) Spectra of 1.5 µm ASE and MOPA pumps. The inset shows the schematic of the 2039 nm DFB FBG laser architecture. (right) Power emitted by the laser as a function of pump power, for four different pumps. Inset shows the spectrum of the laser when pumped with an ASE source.

Finally, we show that using a broadband ASE to pump a rare-earth-doped ASE source covering a longer wavelength range leads to generation of an ultra-wide ASE source. In particular, we used a Tm-based ASE source to pump a length of an HDF, as shown in diagram (A) in Fig. 3. The output spectra at different integrated output power levels are shown in Fig. 3. We observe that for output powers above 10 mW, the 20-dB bandwidth of this ASE source is 265 nm, spanning from 1825 nm to 2090 nm. To the best of our knowledge, this is the broadest 2-µm ASE source delivering more than 50 mW of integrated output power (see [2] and references therein). Further simplification of the ASE architecture and equalization of the spectral shape are possible by modifying the system topology (as shown schematically in (B) in Fig. 3), optimizing the fiber lengths, and controlling the ASE pump polarization. These results will be presented at the time of the conference.

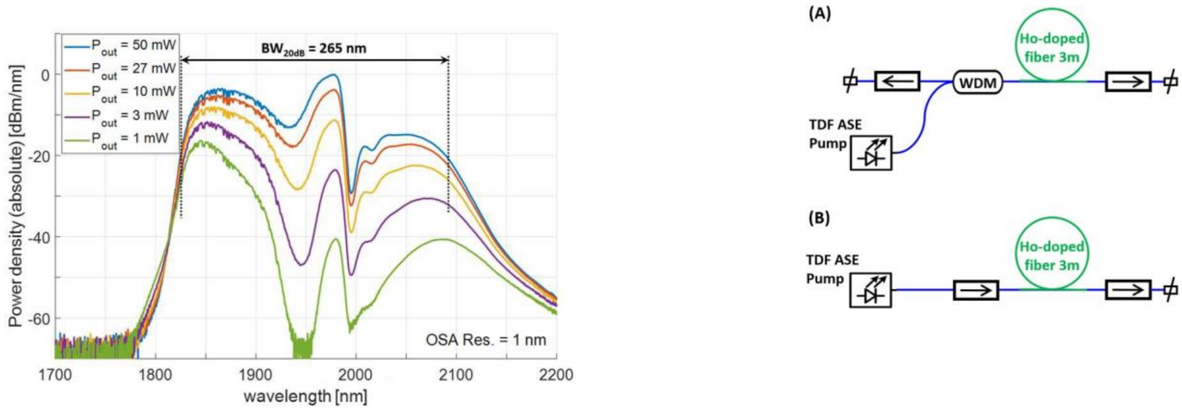

Figure 3: (left) Ultra-broad ASE spectra measured with the architecture (A) (shown in the right panel) at different ASE pump power levels. Configuration (B) shows a simplified broadband ASE topology.

Conclusion. Overall, our results show clear advantages of using ASE sources as an alternative and simple means for fiber amplifier or laser pumping with performance comparable to that obtained with traditional pump configurations.

References.

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