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Monolithic PM Raman fiber laser at 1679 nm for Raman amplification at 1810 nm

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Stimulated Raman scattering (SRS) has been subject to much attention within the field of fiber lasers and amplifiers as it provides an extended wavelength coverage in comparison to rare-earth based devices. Motivated by the projected capacity crunch [1], different approaches are being explored to increase the capacity of communication systems [2]. One approach is by exploiting new optical wavelength bands, outside the conventional amplification windows. In the development of lasers and amplifiers in the short wave IR above the Erbium band, SRS seems to be a promising candidate. In this paper we demonstrate a monolithic RM Raman fiber laser (RFL), which acts as a pump for a Raman amplifier (RA) at 1810 nm. The lasing wavelength of a RFL, thus also for a RA, can in principle be designed arbitrarily within the entire wavelength range from the Erbium band up to the Thulium/Holmium band by the utilization of cascaded SRS [3].

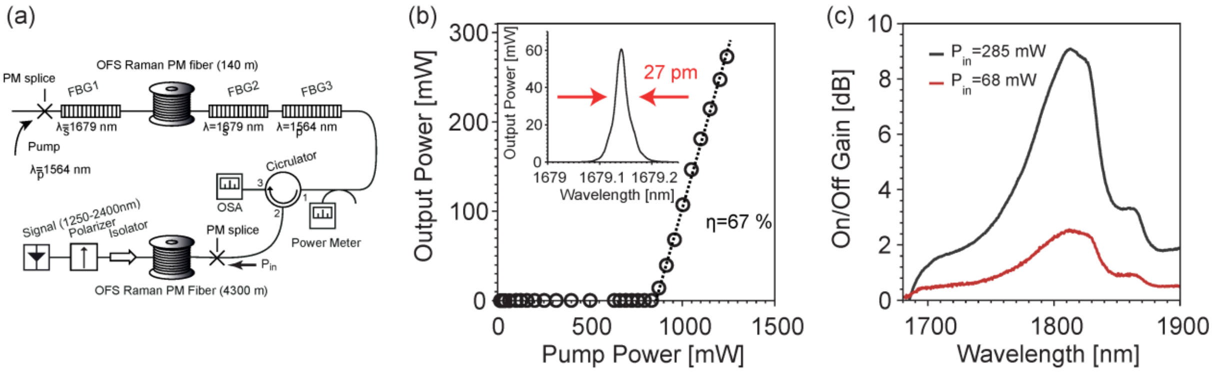

Fig. 1 (a) Experimental setup of the RFL and RA (b) Laser curve for the RFL (c) Measured on/off gain of the RA

The Experimental setup is shown in Fig. 1a, and consists of a RFL pumped at 1564 nm lasing at the first stokes shift at 1679 nm [4] along with a RA with a gain maximum at the second stokes shift at 1810 nm. The monolithic RLF cavity contains two signal fiber Bragg gratings (FBGs) 1 and 2 which define the laser cavity, along with a pump grating, FBG3, that enable two pass amplification. The gratings are written directly in the fiber, with a 50 mm phase mask, to avoid additional splice losses in the cavity. To address the issue of intensity noise transfer from the RFL to the RA, the cavity FBGs were temperature stabilized to reduce the RFL output intensity fluctuations. The RA is based on 4.3 km PM fiber where the pump is launched through a circulator in reverse with respect to the launched signal stemming from a NKT SuperK source. Both devices are based on a segment of OFS PM Raman fiber, with an estimated propagation loss of 0.42/0.46/1.3 dB/km at 1564/1679/1810 nm. The Raman gain coefficient was measured to be g_R=2.66/2.35 $W^{-1}km^{-1}$ at 1679/1810 nm.

The laser curve of the RFL is depicted in Fig. 1b, with a slope efficiency of 67 %. The high slope efficiency was obtained by optimizing the Q-factor of the cavity compared to the fiber length, through the reflectivity of the inscribed FBGs. A linewidth (LW) of 27 pm (2.9 GHz) is obtained at an output power of 275 mW. The LW was sufficiently wide to avoid stimulated Brillouin scattering in the RA. The measured Raman gain is plotted in Fig. 1c, which peaks at 1810 nm with an on/off gain of 9 dB for an input power of Pin=285 mW at 1679 nm. Based on the fiber parameters, signal transparency for up to 15 km should be attainable at current power levels, whereas discrete gain of 18 dB should be achieved for 500 mW. In comparison for a typical SMF no net gain would be possible for pump powers below 1 W, assuming similar losses and g_R=0.3 $W^{-1}km^{-1}$.

In conclusion, we have demonstrated a Monolithic PM RFL operating above the Erbium band at 1679 nm, which was shown to be a viable pump laser for a RA centred at 1810 nm. Based on our findings, we show that in spite of high transmission losses at 1810 nm, a high Raman gain coefficient provided by the OFS PM Raman fiber in conjunction with our developed RFL, has the potential to provide a high discrete gain but also distributed amplification across tens of kilometers at reasonable pump powers levels.

References

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