

Pump absorption in Rod fibers

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This application note addresses observations of low pump absorption in the DC-200/70-PM-Yb-ROD fiber.

Due to stimulated re-emission of 976nm light at the zero-phonon line, the pump absorption in an Ytterbium doped rod fiber strongly depends on the population inversion level. Without seed signal, the inversion level is high and will distort the pump absorption measurement at 976nm. This is a feature of the pump absorption measurement itself and not an indication of low pump absorption.

Introducing a seed signal will decrease the population inversion and increase the measured pump absorption. The inversion level will also affect the gain profile due to re-absorption of the signal light. Therefore, the pump power, the signal wavelength, the signal level and the fiber length will all influence the pump absorption in the fiber.

Pump absorption measurement

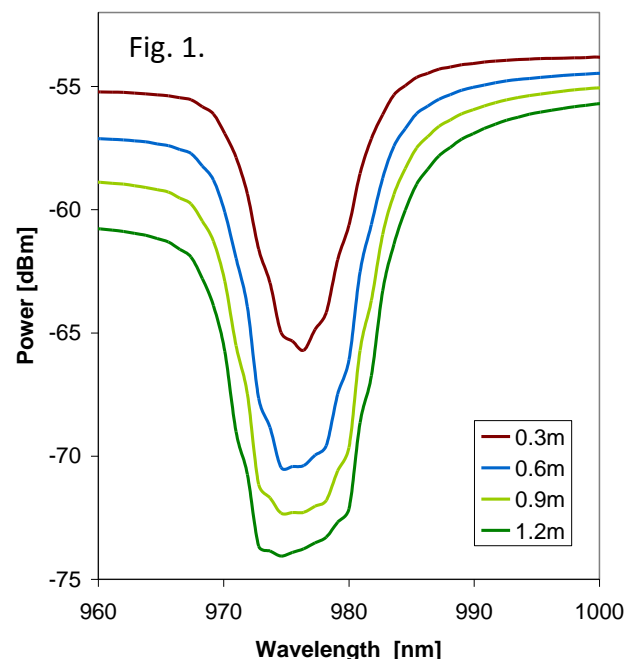
White light is coupled through 1.2m of rod fiber and the full spectrum is measured at the output. Subsequently, we cut 0.3m off the rod from the output-end without disturbing the in-coupling and measure the spectrum again. The 0.3m cutback and the spectral measurement are repeated until the end of the fiber is reached. The spectrum around 976nm is shown in Fig. 1 for a 1.2 to 0.3m measurement series.

Analysis

The power as a function of length is plotted for 915nm, 940nm and 976nm as shown in Fig. 3. Linear fits yields the pump absorption. For 915nm the pump absorption is 11.5dB/m. The theoretical value for the pump absorption at 976nm is 3.2 times the value at 915nm (valid for the material composition used in the DC-200/70-PM-Yb-ROD product), which is above 30dB/m. However the measured value is far below 30dB/m and is seen to decrease with length.

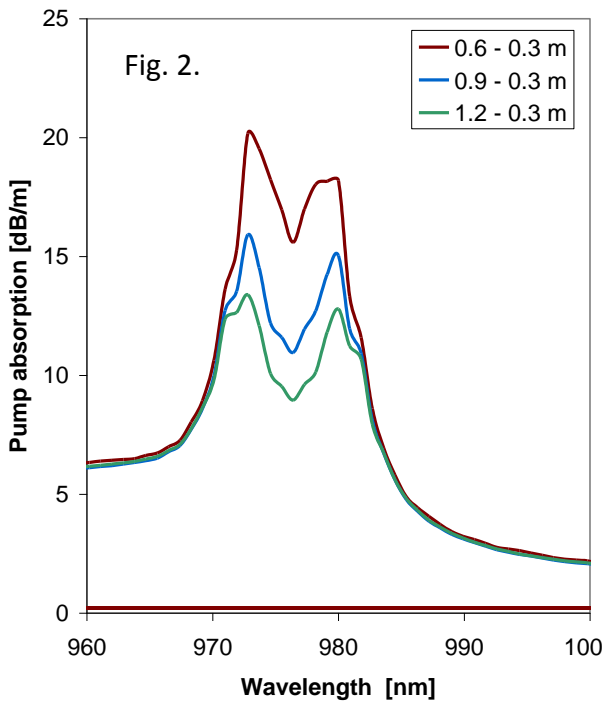
Note that this is a feature of the pump absorption measurement itself and not an indication of poor pump absorption at 976nm.

In Fig. 2, the spectra from Fig. 1 are subtracted and one can identify a large dip at 976nm which is due to re-emission of pump light at the zero-phonon wavelength 976nm. This re-emission of pump light is the reason for the decrease in measured pump absorption. It has to be emphasized that *this is an affect of the measurement and not the fiber*. The dip in the pump absorption *only* occurs when the population inversion is very high. The amount of re-emission scales with the fiber length and will lead to a decrease in the measured pump absorption per meter when the fiber length is increased.



Without seed signal, the population inversion is very high and will distort the pump absorption measurement since much of the absorbed pump light will be stimulated to reemit at 976nm. Introducing a seed signal will decrease the population inversion and stimulate transmission at the laser wavelength rather than the zero-phonon wavelength 976nm. Subsequently, the

measured pump absorption will increase to the expected levels.



signal wavelength, the signal level and the fiber length has an influence on the gain and the pump absorption in the fiber. The exact parameters should be determined experimentally by using a longer rod as a starting point.

Further Reading

- O. Schmidt, T. V. Andersen, J. Limpert, and A. Tünnermann "187 W, 3.7 mJ from spectrally combined pulsed 2 ns fiber amplifiers" OPTICS LETTERS, Vol. 34, No. 3, February 1, 2009.
- F. Röser, C. Jauregui1, J. Limpert1, A. Tünnermann " 94 W 980 nm high brightness Yb-doped fiber Laser" OPTICS EXPRESS 17310, Vol. 16, No. 22, 27 October 2008
- N. Deguil-Robin, J. Limpert, S. Petit, I. Manek-Hönniger, and F. Salin, " Double-Pass versus Single-Pass Fiber Amplification: A Numerical and Experimental Comparison," in Advanced Solid-State Photonics, Technical Digest (Optical Society of America, 2005), paper WB26.

In addition, the population inversion level will affect the gain profile due to re-absorption of the signal light. Therefore, both the pump power, the

