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Letter to the Editor

Relation between side fluorescence and laser emission in an infrared-to-visible upconversion ZBLAN erbium-doped fiber

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The relation between spontaneous and induced emission, and to some extend amplified spontaneous emission in an optical fiber, due to its very elongated active media shape (pencil-like shape) is different as compared to small dimension laser active media (like ruby, neodymium glass, semiconductors, *etc*.) We have measured the relation between the laser emission and the spontaneous side emission in an erbium doped ZBLAN fiber and found that the spontaneous side emission did not decrease at the laser threshold. In this way, there is no sharp jump in intensity, measured at the fiber terminal when crossing the laser threshold. Furthermore, there is no competition between the spontaneous emission and the laser one.

Keywords: infrared-to-visible upconversion fiber laser.

1. Introduction

As it has been observed earlier [1], there is no sharp change in intensity of the green light observed at the laser threshold. This change is clearly visible but exceeds by 100% only the below threshold intensity. A clear indication of the laser threshold is the narrowing of the emission spectrum pointing that we have to do with induced emission. The relatively large length of the fiber (over 2 meters) creates favourable conditions to generate amplified spontaneous emission – ASE. The threshold for ASE to appear could be lower than that for laser emission, depending on the amplification coefficient and the active medium length, see *e.g*., [2] and [3]. In this way, there is no sharp jump in emission intensity at the laser threshold, which is normally observed in the case of small dimension laser active media.

2. Instruments and measurements

To perform the desired experiments we have used the arrangement shown in Fig. 1. For the maximum pumping power at 971 nm of 300 mW, the laser power (with output mirror of 41% reflectivity at 545 nm) reached only 6 mW. The measured efficiency

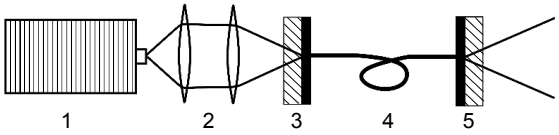

Fig. 1. Experimental arrangement: 1 – pumping diode (971 nm), emission area 1 μm×5 μm, power 300 mW max output; 2 – double lens focusing system; 3 – dichroic mirror, 95% transmission at 971 nm and almost totally reflecting at 545 nm; 4 – ZBLAN:Er^{3+} optical fiber, core diameter 1.7 μm, length – 230 cm, Er^{3+} concentration – 100 ppm; 5 – dichroic mirror, 41% transmission at 545 nm, totally reflecting at 971 nm.

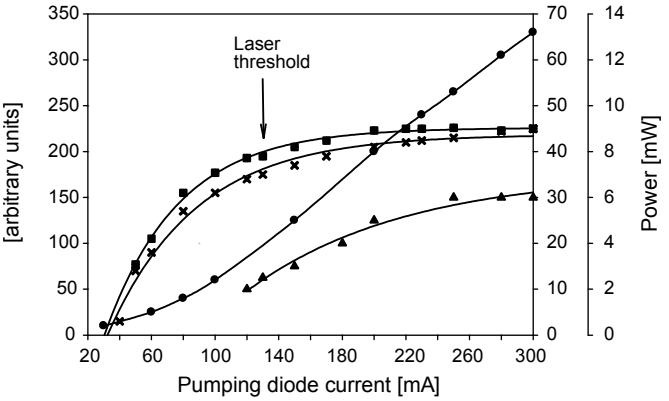

Fig. 2. Results of measurements: filled circle – 971 nm pumping power measured at the end of the fiber (right-hand scale from 10 to 70 mW); filled triangle – laser output power at 545 nm (right-hand scale, from 2 to 6 mW); cross – side fluorescence at 545 nm, with no output mirror in place (left-hand scale, from 0 to 300, arbitrary units); filled square – side fluorescence at 545 nm, with output mirror in place (left-hand scale, from 0 to 300, arbitrary units).

of the double lens coupling system was 40% (this is mainly caused by the difference in dimensions between the fiber core and the emission area of the diode). The laser threshold pumping power density was 2.3 MW/cm^2. The results obtained illustrates Fig. 2.

As seen, there is no decrease in the side spontaneous emission at the laser threshold, and furthermore, the side emission increases almost comparable to the increase in the laser power.

The whole fiber, due to the spontaneous side emission, is seen as a very bright light source in the green. It is also very interesting that there is no competition between the spontaneous emission and the induced one.

3. Conclusions

The infrared-to-visible upconversion ZBLAN:Er^{3+} fiber laser, due to its very elongated active media shape (pencil-like shape), and the possibility to generate amplified spontaneous emission (ASE), exhibits no sharp jump in intensity of the output green

beam, when crossing the threshold for laser emission. However, strong indication of the induced emission is the narrowing of the emission spectrum. We have found that there is no competition between the spontaneous emission and the laser one (see Fig. 2). It is thus reasonable to conclude that the threshold for laser emission to appear requires only a few round trip passages of the green beam along the fiber. In this way, the existing, relatively weak laser beam, does not depopulate the upper excited state, and the spontaneous emission is almost not disturbed. The infrared-to-visible fiber laser is, as far as the physics of the phenomenon is concerned, an interesting laser, but its practical applications have not been shown, as yet.

References

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