High brightness from an external cavity broad area diode laser using off-axis spectral beam combining

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Off-axis spectral beam combining [1] has been applied to a broad area diode laser bar with a central wavelength of 965 nm and a front facet anti reflection coating with residual reflectivity < 0,01%. A combined beam with an output power of 9 W and a slow axis beam quality parameter, M^2, of 6.4 has been achieved from 12 emitters at an operating current of 30 A. A high spatial brightness of 159 MW/cm^2-str has been achieved using this configuration.

High power broad area diode laser bars are interesting devices for different applications within biomedical optics and material processing. The main advantages of these devices are that they are of comparatively smaller size than solid state or gas lasers, i.e., the order of a few cubic millimetres; they can deliver relatively high output power levels above 100W. They have a long life time of 10,000s of hours. They also have very high wall-plug efficiency even up to 75%. But the main draw back of these devices includes poor beam quality and low spatial brightness that is a result of the high divergence along the slow axis caused by a broad emitter area. We have demonstrated an efficient method to improve the spatial brightness of the diode laser bar significantly.

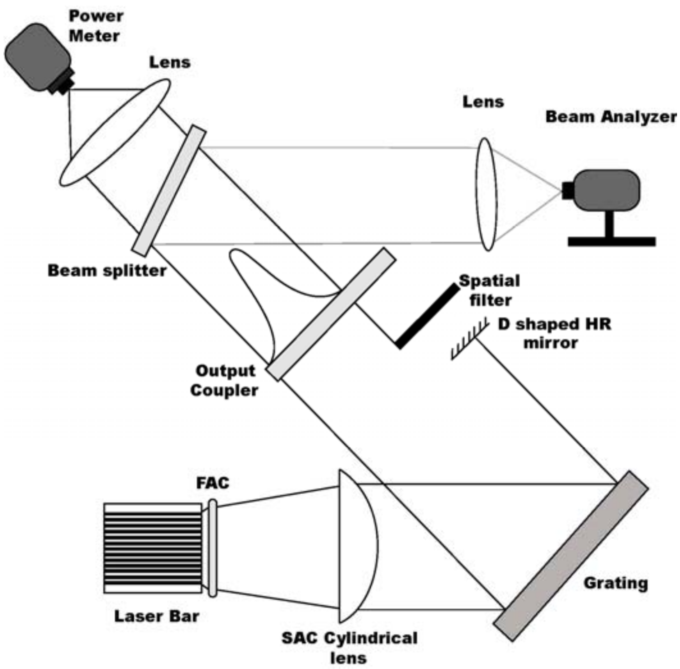
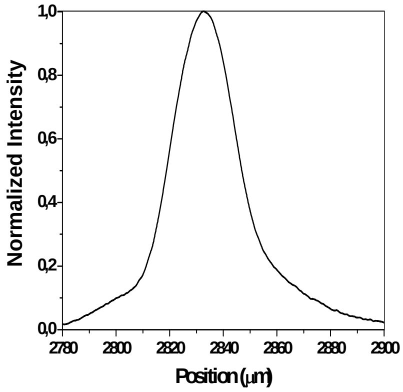


Fig. 1. The schematic of the experimental setup of off-axis spectral beam combining

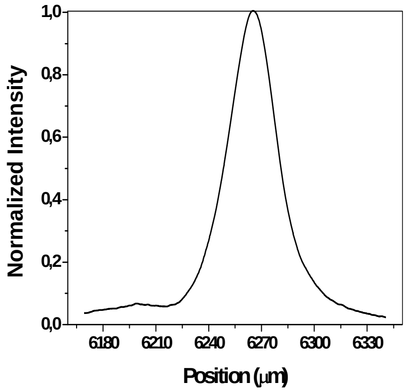
The experimental setup shown in figure 1 consists of a broad area laser bar with central wavelength 965 nm and of 150 μm emitter width and 500 μm pitch spacing. Furthermore the setup consists of a LIMO micro lens of 910 μm focal length used for fast axis collimation glued on to the heat sink of the laser, a 100 mm focal length cylindrical lens for slow axis collimation, a plane ruled reflection grating with 1200 grooves/mm, an output coupler which is 10% reflective, a D shaped sharp edged highly reflecting mirror and a spatial filter. The collimated light from different emitters is superimposed on the grating and the first order diffracted beam is fed back into the laser using the plane output coupler. It also ensures the parallel propagation of the light. In addition to that, a few spatial modes from a single lobe of the typical twin lobed output far field are again fed back into the laser using the D shaped sharp edged mirror. Thus, we selectively amplify a few spatial modes on the opposite lobe. This yields a narrow output beam with a good beam quality and high spatial brightness. At an operating current of 30 A, the 9 W output beam could be focused down to a spot of 60 μm diameter along the fast axis and 69 μm along the slow axis using an achromatic lens of 100 mm focal length. The beam profiles along the fast and slow axis at the focus of a 100 mm focal length achromatic lens are shown in figure 2 (a) and 2 (b), respectively.

The spectrum of the laser is affected by the feedback and a number of peaks equal to the number of emitters are expected in the output beam. This is evident in the measured spectrum given in figure 2 (c) where 12 equally spaced main peaks can be identified. A few additional peaks are present due to slight misalignment in the experiments.

(a)



(b)



(c)

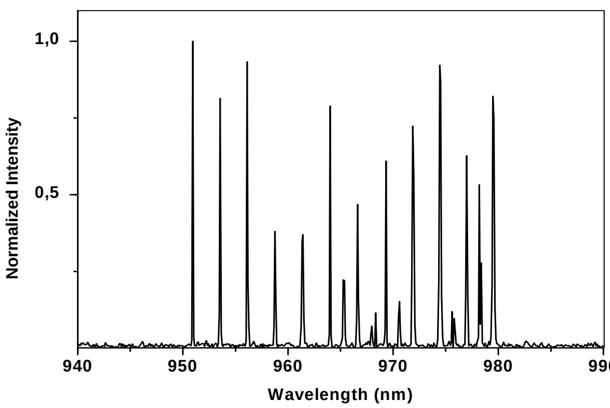


Fig. 2. (a) Fast axis beam profile at the focus of a 100 mm achromatic lens (b) Slow axis beam profile at the focus of a 100 mm achromatic lens (c) Wavelength spectrum of the output beam

We calculated the brightness of the output beam. The brightness, *B*, is defined as [2],

$$B = \frac{2P_{av}}{\lambda^2 M_x{}^2 M_y{}^2}$$

where P_{av} is the average power, λ is the wavelength, $M^2{}_x$ is the beam quality parameter along the slow axis and $M^2{}_y$ is the beam quality parameter along the fast axis. The calculated brightness was 159 MW/cm^2-str. To our knowledge, this is the highest brightness ever obtained from a broad area diode laser bar.

We have demonstrated off-axis spectral beam combining applied to a 980 nm broad area diode laser bar and have obtained an output power of 9 W at an operating current of 30A and the system delivers a high spatial brightness of 159 MW/cm^2-str. In parallel to this work, investigations on the spectral beam combining [3] of a 980 nm 12 emitter tapered laser bar is on progress and we expect to present those results in our poster.

References

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