Progress in membrane gain media for high-power broadband lasers

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Laser frequency combs are needed for a huge variety of real-time sensing and spectroscopy applications [1]. Wavelength versatile broadband laser gain media are essential for mode-locked oscillators and combs at different wavelengths regions. To this end, the use of well known semiconductor disk lasers (also known as vertical-external-cavity surface-emitting lasers [2]), has already resulted in excellent work on dual frequency-combs [3]. This concept can be further extended using a more novel approach, the semiconductor membrane external-cavity surface-emitting laser (MECSEL) [4] , which opens new possibilities for wavelength tailoring and laser engineering.

In a MECSEL, a semiconductor hetero structure membrane solely is sandwiched between two transparent heat spreaders and used in transmission mode as a laser gain element in the same way as ion doped solid-state gain media are exploited. This avoids the need of a monolithically integrated distributed Bragg reflector (DBR) typically used in semiconductor disk lasers. The absence of a DBR allows for a broader gain due to the fact that the resonance condition for the DBR becomes obsolete [5]. The given freedom of design in carefully engineered semiconductor gain structures allows to place more and different quantum wells in the same active region to create a wide and uniform gain bandwidth. A further consequence of the missing DBR and an additional benefit is double-side pumping. The active region without a monolithically integrated DBR can be accessed with pump lasers from both sides which further widens the potential for power scaling and covering an even wider gain. MECSELs have been recently realized and already show a relatively broad gain bandwidth [5, 6].

We propose a novel approach, applying the MECSEL technology, to create broadband gain elements for mode-locked frequency comb applications, which cover a broad (tens of THz) gain bandwidth at any wavelength accessible with semiconductor materials, in a similar fashion as titanium-sapphire lasers have done it at the 680 - 1050 nm wavelength range [7]. In particular we show our latest results in the near-infrared range (780 nm [6], 825 nm [8], $\sim 1\ \mu m$) and show a perspective on very broadband semiconductor gain elements based on the MECSEL concept.

References

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