Tunable Hybrid-Integrated Diode Laser at 637 nm

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Photonic quantum technologies, such as quantum-key distribution and photonic quantum processing, are currently undergoing a transition from research labs to industrial applications [1]. Upscaling of such systems calls for on-chip laser sources. In particular, many applications require lasers in the visible range, e.g., for addressing particular atomic and ionic transitions, quantum dots or nitrogen vacancy (NV) centers. Specifically, narrow linewidths and wide tunabilty are required for addressing quantum emitters. Scaling and industrial applications also demand mode stability and robustness, such as for portability.

While some chip-integrated lasers have been demonstrated in the visible, they do not provide the required mode-stability [2] or are even based on separate chips [3, 4] which are temporarily edge-coupled using alignment stages. In contrast, our laser consists of a gallium arsenide semiconductor optical amplifier (SOA), permanently bonded to a Si_3N_4 feedback chip, called hybrid integration. The integrated laser is placed on a Peltier element and photonically and electronically packaged in a standard diode laser housing. This enables intrinsic long-term mode stability of the laser, as well as portability.

The laser is an extended cavity diode laser (ECDL) based on an on-chip 2-ring Vernier filter, which provides frequency selective feedback and an extension of the cavity length, leading to a narrow intrinsic linewidth. Using resistive on-chip heaters, the emission wavelength of the laser can be tuned.

The laser has a wavelength of 637 nm, the shortest wavelength reported so far for a hybrid integrated ECDL based on Si_3N_4 feedback circuits. It has an intrinsic linewidth below 10 kHz and provides a fiber-coupled output power of 2.5 mW (on-chip 4.5 mW). The laser allows wide tuning over the entire SOA gain bandwidth of 8 nm. Furthermore, it provides high passive stability and a wide mode-hop free tuning range (MHFTR) of 43 GHz, which is a record-high for chip-integrated diode lasers in the visible. These properties make the laser well suited for active frequency stabilization. Frequency stabilization is crucial for reducing technical noise and long-term drifts in a laser and has not yet been demonstrated for a hybrid-integrate laser in the visible. Initial measurements show that frequency stabilization is possible with our laser.

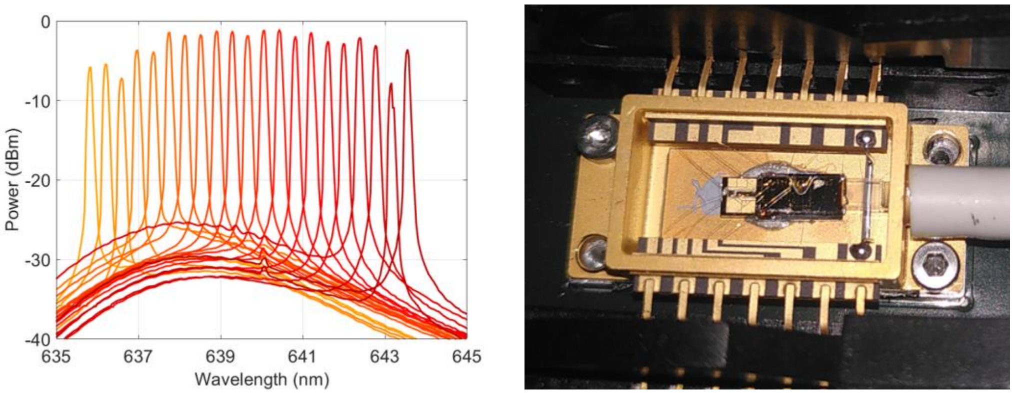

Fig. 1 (a) Coarse tuning over the entire gain bandwidth of the SOA: 21 spectra, recorded with different heater settings. (b) The full laser module, hybrid-integrated and packaged in a standard butterfly package with an attached output fiber-array and wire bonding for convenient access to the on-chip heaters.

References

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