Mode-Hop-Free Tuning of a Chip-Based Hybrid Integrated InP-Si3N4 Laser

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Mode-hop-free Tuning of a Chip-based Hybrid Integrated InP-Si_3N_4 Laser

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Chip-sized diode lasers with ultra-narrow spectral linewidth are of high interest for many applications, e.g. for phase encoding in optical communications and precision metrology [1,2]. Recently, a record-narrow intrinsic linewidth of 290 Hz was achieved with hybrid integration of an InP semiconductor optical amplifier (SOA) and a low-loss dielectric waveguide feedback circuit with a Vernier spectrally selective feedback filter that significantly extends the on-chip cavity length [3]. However, increasing the cavity length also reduces the cavity mode spacing, which causes undesired instabilities in the form of mode hops and power fluctuations when tuning the laser wavelength.

Here we overcome these instabilities and demonstrate a new approach towards mode-hop-free tuning of such lasers, well beyond the standard limit that is formed by the cavity mode spacing. The hybrid laser used in the experiments is shown schematically in Fig. 1a, comprising an InP SOA and a Si_3N_4 waveguide circuit with a tunable phase section (heater based), and two tunable microring resonators (MRRs) of slightly different radii.

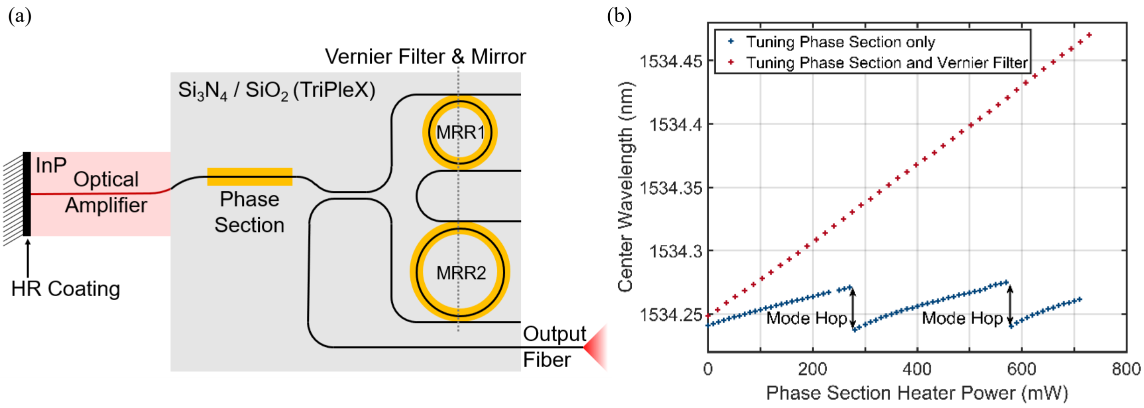

Fig. 1 a) Scheme of the hybrid laser, comprising a InP based chip (red) and a Si_3N_4 based chip (grey) with resistive heaters (yellow) b) Wavelength tuning of the laser vs heater power. When tuning the phase section only, mode hops occur. Synchronous co-heating of the MRRs increases the range of mode-hop-free tuning more than five-fold.

The lower trace in Fig. 1b shows wavelength tuning of the laser by tuning the phase section only. This standard tuning method results in mode-hop-free tuning only over a single free spectral range of the laser cavity, which is 0.04 nm (5 GHz). This tuning limit is given by longitudinal mode hops (see vertical arrows) to neighboring resonator frequencies. To overcome this tuning limit, we synchronously control the phase section and both MRRs with a proper ratio. It can be seen in Fig. 1b, as the upper trace, that the mode-hop-free tuning range is increased by more than a factor of five, to 0.22 nm (28 GHz). It is important to note that it is not only due to synchronizing the three involved tuning elements, because also the slope of wavelength tuning versus heater power is clearly increased. The latter can be explained in that the light performs multiple passes through the phase-shifting heaters in the MRRs, such that the MRR heating also changes the effective length of the laser cavity.

Our result indicates that both an ultra-narrow linewidth and a broad mode-hop-free tuning range can be achieved with hybrid integrated lasers. An analytical analysis of the novel tuning method and a further extension of the mode-hop-free tuning range is currently under investigation.

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