Invited

Narrow-linewidth hybrid-integrated semiconductor lasers by exploiting feedback from Si3N4 circuits

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Hybrid integration of semiconductor optical amplifiers with frequency-selective feedback circuits, implemented using low-loss Si_3N_4 waveguides, enables robust chip-sized lasers with outstanding properties. Deploying intra-cavity ring resonators as a tunable feedback filter provides single-mode operation over a wide tuning range. Moreover, these rings resonantly enhance the cavity length, which results in ultra-narrow intrinsic linewidth. Here, we present an overview on state-of-the-art developments regarding these lasers. We report a record-low intrinsic linewidth, as low as 40 Hz, by extending the cavity length to 0.5 m on a chip using a cascade of 3 ring resonators. Tuning ring resonators in a Vernier configuration is shown to yield widest wavelength coverage, more than 120 nm around the central wavelength of 1.55 μm. The long extended cavity of these lasers suggests a corresponding small mode-hop-free tuning range, but we present a method that increases the range of continuous tuning. We compare these linewidth and tuning results for different feedback circuit configurations. Finally, we report on the first demonstration of a hybrid-integrated semiconductor laser that operates in the visible wavelength range.
These results, and the potential for further improvement, make these lasers very suitable for integration as light sources directly in photonic circuits for a broad range of applications. In particular, coherent optical communication, integrated microwave photonics, bio-photonic sensing and metrology, can benefit from the stability, tunability and narrow linewidth that these hybrid integrated lasers provide.