Heterogeneously Integrated III-V/SOI DBR Laser with Over 7 nm Continuous Wavelength Tuning Range

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Many tele- and datacom applications require single-wavelength tunable lasers with easy wavelength control and sufficient tuning range. Such lasers can for instance be used in WDM-based optical networks or to replace fixed wavelength distributed feedback (DFB) lasers. In recent years there has been a lot of interest in tunable lasers heterogeneously integrated on the silicon-on-insulator (SOI) platform. Several heterogeneously integrated III-V/SOI tunable distributed Bragg reflector (DBR) and DFB lasers have already been demonstrated. DBR-types typically employ a single [1] or double silicon ring [2] with heaters as wavelength-selective and tunable element. In recent work we demonstrated a discretely tunable sampled grating (SG)-DFB laser with a discontinuous tuning range of more than 55 nm [3].

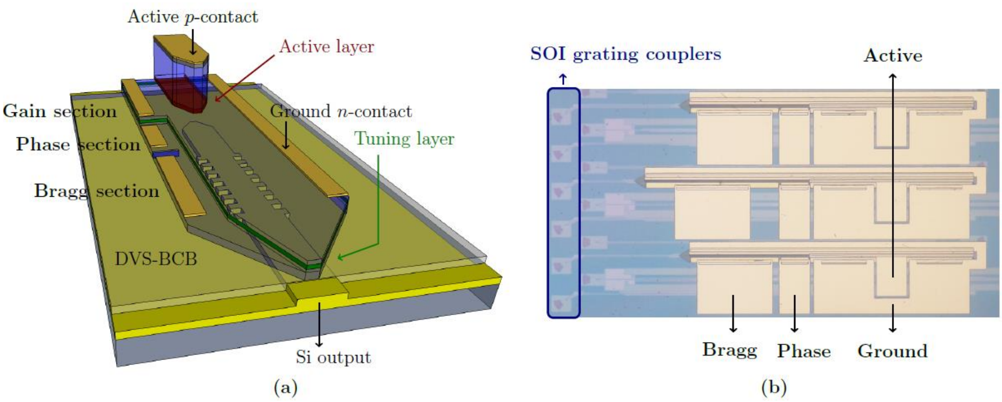

Fig. 1. III-V/SOI tunable DBR laser. (a) Schematic; (b) Microscope image.

Here we demonstrate over 7 nm continuous wavelength tuning with a novel III-V/SOI DBR laser. The laser structure consists of an SOI waveguide circuit on which a III-V tunable twin-guide (TTG) membrane is heterogeneously integrated by means of adhesive DVS-BCB bonding. The TTG membrane comprises an active layer (with 6 InGaAsP quantum wells, bandgap wavelength 1550 nm) and a tuning layer (InGaAsP, bandgap wavelength 1400 nm) in which carriers can be injected to provide gain and phase tuning respectively. The laser cavity is formed by a broadband reflecting facet and a DBR mirror. The latter is implemented as a first-order sidewall-corrugated waveguide grating [4] defined in the 400 nm silicon device layer. The weak sidewall-corrugation provides a narrowband spectral reflection characteristic to ensure single-mode lasing operation. It also provides an additional advantage over ring resonator configurations as for the latter a large free spectral range (FSR) is more difficult to obtain due to minimum bend radii requirements. Fig.1 (a) and (b) show a schematic and microscope image of the laser device respectively. Three laser sections can be discerned: a gain, phase and Bragg section. In the gain section current is injected into the active layer to provide optical gain. The tuning layer is left unbiased. In the phase and Bragg section the active layer is etched away and current is injected into the tuning layer. Upon current injection the effective index of the waveguide mode is modified through the free-carrier plasma dispersion effect and Joule heating. Simultaneous adjustment of the phase and Bragg current allows for continuous tuning of the lasing wavelength.

Device characterisation is carried out on a temperature-controlled stage at 10°C. Light is couped out from the silicon waveguide to a single-mode optical fiber (SMF) through a reflectionless SOI grating coupler [5]. Fig.2 (a) shows the LI curve of the laser. The threshold current is 60 mA and a maximum waveguide-coupled output power of about −4 dBm is obtained. The superimposed lasing spectra at different tuning currents (Bragg and phase) are shown in Fig.2 (b). The wavelength tuning range is larger than 7 nm. The redshift of the lasing wavelength indicates a dominant heating effect. By improving the heat sinking and a modification of the epitaxial layer stack (by e.g. using a thicker tuning and surrounding cladding layer) in future designs, we expect to significantly increase the optical confinement factor in the tuning layer, resulting in a stronger electronic effect and hence faster tuning (~ns). In that case an adiabatic tapered III-V/SOI coupler similar to one of the couplers reported in [6] can be used.

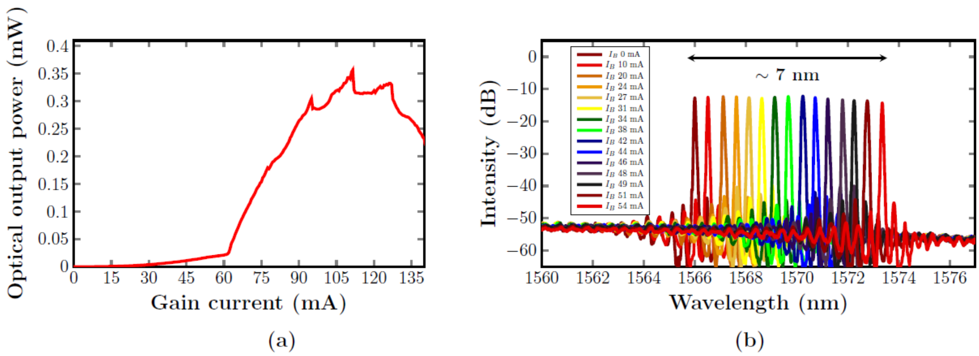

Fig. 2. Static characterization results. (a) LI curve; (b) Superimposed lasing spectra.

References

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