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Monolithic Integration of Facetless Slotted Fabry-Perot Lasers and Star Coupler

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Monolithic photonic integrated circuits (PICs) based on InP have provided an effective solution to realize advance functions at a system level with compact size. Other advantages include low power consumption, simpler coupling between elements and packaging resulting in higher reliability and lower cost [1]. We demonstrate a PIC comprising of two facetless slotted Fabry-Perot (SFP) lasers, a star coupler, pseudo passive waveguides and variable optical attenuators (VOAs) (see Fig 1(a)).

The facetless SFP lasers were formed with three sections: a 650 µm long gain section enclosed by two mirror sections. [2] The mirror sections comprised of 7 etched slots with a gap of 0.88 µm and a separation of 108 µm which produce a wavelength selective diffraction grating. Shallow etched 2.5 µm wide waveguides with a bend radius of 650 µm coupled light from the laser outputs to the star coupler. The waveguides were biased to transparency to make them pseudo passive. The 1x2 star coupler was arranged by setting a series of waveguides at opposite ends of a Rowland circle, with the input waveguides directed towards the central output waveguide. Light from the inputs waveguides is allowed to propagate in the free-space region between the waveguides where it can couple to the output waveguide [3]. Long VOA sections were added to the input side of the lasers which acted as absorption regions to ensure no contribution from the facet was required for lasing. Sections were electrically isolated using shallow etched slots angled at 7 degrees to minimize optical reflections.

Due to the high number of sections requiring current, an aspect of this PIC is the ability to run metal traces over optical waveguides without contacting them. These traces connect to a series of standardised pads which allow for easier probing and positioning of pads for packaging. A scanning electron microscope (SEM) image of such a crossing is shown in Fig. 1(b). SiN_x is used as the base layer for the crossings as it can be selectively patterned without damaging the dielectric present for sidewall passivation. The SiO_2 layer is added to improve thermal and electrical isolation between the metal trace and the underlying waveguide/device as it has a preferable thermal conductivity and resistivity when compared to SiN_x [4,5]. The Titanium Gold (Ti:Au) metal traces are deposited using a 360 degree rotational E-beam metal evaporation and standard lift-off photoresist to ensure that the traces successfully traverse the waveguides without breakages.

All sections of the PIC were driven simultaneously using a multi-contact probe. Short focus lensed fibres on either side of the device allowed coupling to the facet. It was confirmed that both SFP lasers could be independently powered via the crossing and each operated with a side mode suppression ratio (SMSR) of greater than 30dB. Analysis of the SFP laser outputs using an optical spectrum analyser (OSA) confirmed that the effective cavity length corresponded to a region within the gain and mirror sections of the lasers [6]. Finally, it was demonstrated that when both lasers were powered, both their optical outputs were successfully combined via the integrated star coupler.

(a) (b)

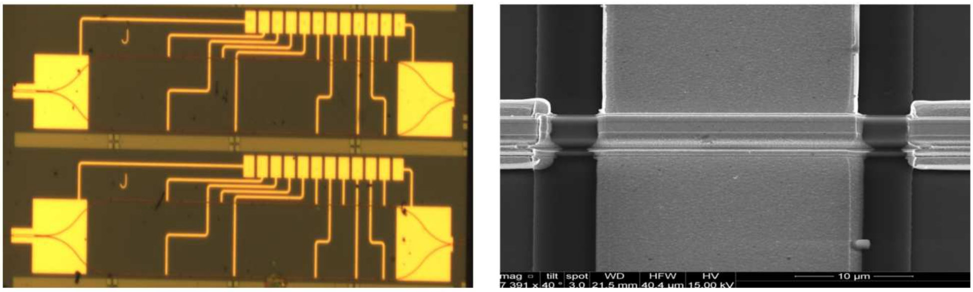

Fig. 1 (a) Image of a PIC comprising of two SFP lasers, waveguides, VOAs and a star coupler. (b) SEM image of two traces, one contacting the waveguide while the other crosses over it.

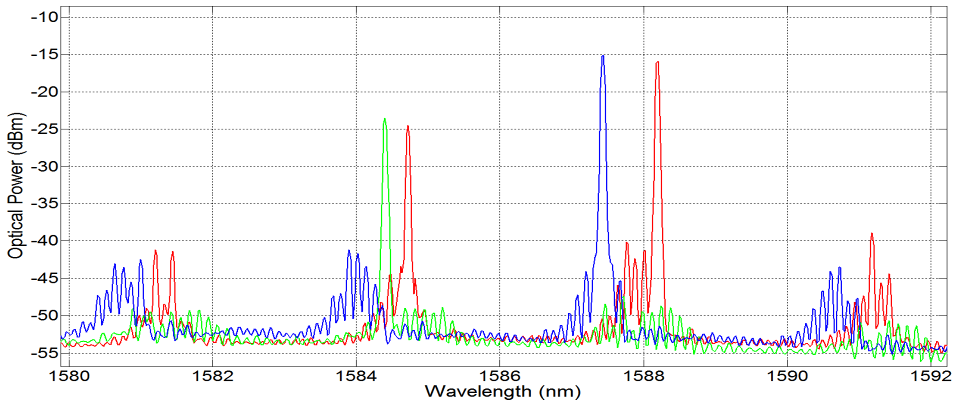

Fig. 2. Optical Spectra of top laser (blue), bottom laser (green) and both lasers simultaneously (red) as measured through the integrated star coupler.

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