COBRA long wavelength active-passive monolithic photonic integration technology platform

S. Latkowski[1*], P.J. van Veldhoven[1], D. D'Agostino[1], H. Rabbani-Haghighi[1], B. Docter[3], P. Thijs[1], H. Ambrosius[1], K. Williams[1], E.A.J.M. Bente[1] and M. Smit[1]
[1]COBRA Research Institute, Eindhoven University of Technology,
De Zaale, 5612 AJ, Eindhoven, The Netherlands
[2]EFFECT Photonics B.V., Torenallee 20, Eindhoven, The Netherlands
*S.Latkowski@tue.nl

Standardized, generic photonic integration technologies [1] enable low-cost design and prototyping of photonic integrated circuits (PIC) realizing complex functionalities for a particular application on a chip scale. The range of potential applications for such photonics integration technology platforms [1] is currently restricted by the accessible wavelengths bands. All of the currently available and mature technology platforms offer their functionalities at wavelengths at around 1.5 µm. This wavelength range corresponds to the c-band in the area of telecommunications and consequently the majority of the application specific photonic integrated circuits (ASPIC) being realized target this area [1]. In order to extend the reach to other fields of applications and broaden a potential market for such generic photonic integration technologies the range of accessible wavelengths has to be diversified [2], [3]. The mid-infrared range beyond 2µm is particularly attractive for gas sensing applications due to presence of strong absorption lines of many gas species for example: acetone, ammonia, carbon dioxide, water vapor, formaldehyde, diethylamine, ethylamine, methylamine and others. Development of a long-wavelength, monolithic, active-passive integration technology on indium phosphide (InP) substrate was undertaken at the COBRA Research Institute in order to extend the potential of the already existing technology at 1.5µm.

The COBRA active-passive generic integration scheme relies on a limited set of predefined functionalities which are provided in the form of building blocks (BB). These BBs are realized in one of two types (active or passive) of vertical layer-stack epitaxial cross-sections combined on a common substrate via butt-joint integration [1].

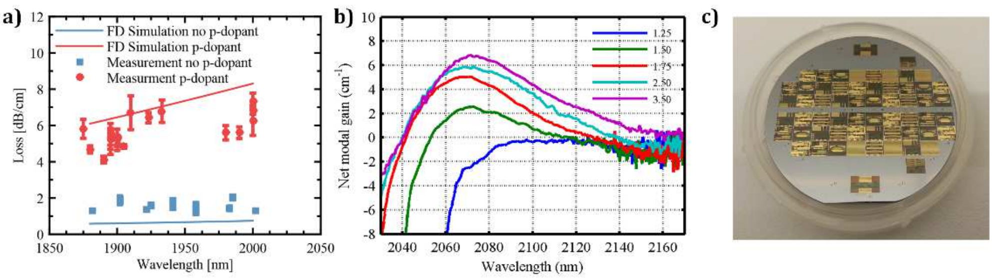

Fig. 1 (a) Propagation losses in passive waveguides at long wavelengths. (b) Net modal-gain measured from semiconductor amplifier sections based on strained quantum wells and fabricated using non-optimized ridge waveguide geometry i.e. 500 nm thick and 2µm wide c) A photograph of the fabricated multi-project wafer (MPW) containing 8 different designs.

These BBs can be combined into large complexity topologies to realize an application specific system on-chip or in other word an ASPIC. The development process of the

COBRA long-wavelength technology included modifications of the vertical cross-sections of the active and passive layer-stacks and adaptations of all BBs to realize all basic functionalities at longer wavelengths. The studies and early stage experiments have shown that at longer wavelengths an increase in the propagation loses and lower gain values shall be expected as presented in the Fig. 1(a) and Fig. 1(b) respectively. In order to reduce propagation losses due to overlap with highly doped cladding layers the thickness of the wave guiding layer was increased to 625 nm with further adjustment of the ridge wave-guide (RWG) structures in lateral direction. A new optically active core based on low temperature (560 °C) strained multi quantum wells (InGaAs) has been developed to realize the BBs which provide with on-chip means of light generation and an optical gain (semiconductor optical amplifiers) or absorption (photodiodes, saturable absorbers).

These research and development efforts have enabled fabrication of the first long-wavelength multi-project wafer (MPW) run. The wafer processing was carried using cleanroom facilities of Nanolabl@TU/e [4]. The 2" MPW wafer shown in Fig.1 (c) included 8 designs from 5 different users and projects, including two unique monolithically integrated tunable lasers with a large tuning range in the 2 mm wavelength window [5], [6].

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