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InP-based Photonic Integration Platform: Status and Prospects

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Photonic integration has a key role in the further expansion of the information technologies and it is expected to result in the disruption of many industry sectors [1]. Such a transition promises to lower the energy consumption of optoelectronic systems as well as to enable a broad range of new applications. Multi Project Wafer (MPW) runs for photonics have been implemented during the last decade, which target the use of a generic integration technology with high functionality at low cost [2].

At the Fraunhofer HHI, a generic photonic platform has been developed within the framework of the European projects EuroPIC and PARADIGM. It is commercially available either through MPW runs brokered by JePPIX [3] or by dedicated private runs. The platform started with receiver-only capabilities and evolved rapidly over the years into a Tx-Rx platform. Figure 1 shows a schematic of the evolution of our platform including the potential developments for the near future (Generation IV).

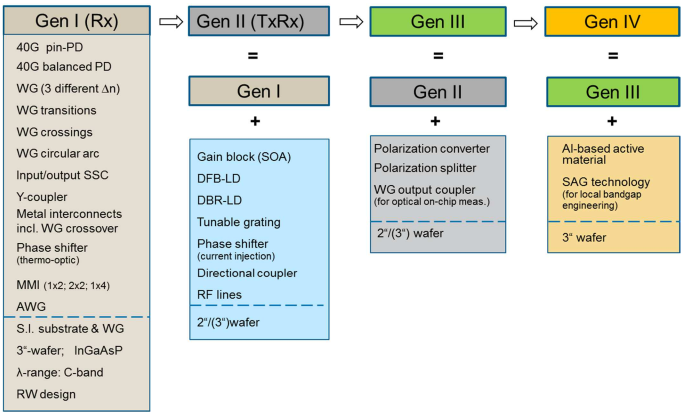

Fig. 35. Schematic showing the evolution of the HHI photonic platform.

The platform is based on a Fe-doped semi-insulating substrate which provides high electrical isolation between active devices as well as reduced parasitics for high speed operation. Furthermore, the epitaxial growth of light emitting diodes (using InGaAsP active quantum wells) and photodiodes (using InGaAs bulk) is done separately, meaning that sources and detectors are optimized independently. Moreover, p-type doping is performed only in areas where low contact resistance is required (i.e. in the active devices) by local diffusion. This allows the co-existence of both active devices with low series resistance and low-loss passive waveguide components free from intra-band absorption loss. Regarding on-chip optical routing, the platform offers three types of waveguides (Fe-doped Q1.06) with low, medium and strong confinement. As a unique feature, it also offers a spot-size converter (SSC) to provide optical coupling to single mode optical fibers.

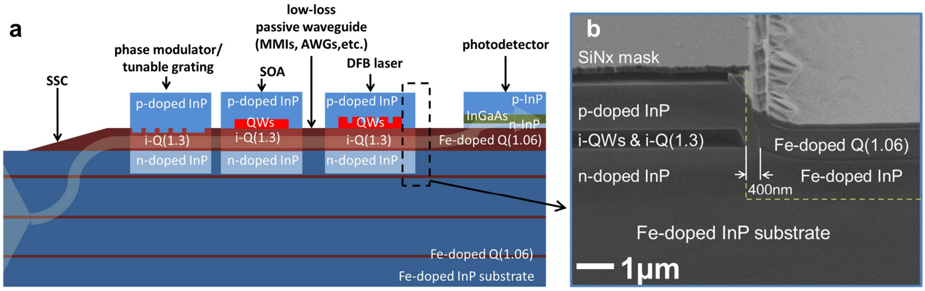

Fig. 36. (a) Cross section schematic along the light propagation direction. (b) Scanning Electron Microscope photo along the active-passive interface corresponding to area indicated with dashed line in Fig 2a.

The platform performance is sufficient for many applications requiring transmitter and receiver capabilities. It includes photodiodes with >40 GHz bandwidth and responsivity >0.8 A/W, as well as dark current ~1 nA at -3 V, distributed feedback lasers with >20 GHz bandwidth at 100 mA, waveguide propagation loss <1 dB/cm, spot-size converter with ~1.5 dB insertion loss for chip-to-fiber optical coupling, polarization converter with >15 dB extinction ratio over C-band [4], etc. In order to achieve this performance, an extensive process development has been carried out, including the optimized butt-joint regrowth across 3-4 µm high mesas to achieve 0.8 – 1.2 dB loss per active-passive interface (see Fig. 2b).

A number of devices and technologies are under development for their integration to the platform. For example, the performance of polarization converters is being optimized to eventually be able to replace off-chip (bulky) discrete optical elements. Moreover, the inclusion of Al-based active material for high temperature operation is also under investigation. Selective area growth to engineer the electroluminescence/absorption spectrum of each individual component is another potential extension.

Our current photonic integration platform relies on mature technology to offer an extensive library of building blocks, which is already being exploited in diverse applications. Future platform generations will incorporate new features to further increase the performance and extend its functionality.

References

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