III-V on Silicon Photonics

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Its high refractive index and low intrinsic losses make silicon an excellent material for realizing compact nanophotonic ICs operating at wavelengths in the telecom range. Moreover, the desired circuits can be realized with the most advanced equipment available, used also for the fabrication of high-end electronic circuits. Efficient light emission and amplification directly from silicon remains a bottleneck however. Therefore, in the context of the EU-project PICMOS, we developed an alternative approach, based on the heterogeneous integration of III-V epitaxial material and silicon nanophotonic circuits. Following fabrication and planarization of the latter, small unprocessed dies of InP-based epitaxial material are bonded on top. Next, the substrate of these dies is removed down to an etch stop layer. Finally the desired active optoelectronic devices are processed in the remaining III-V layers using waferscale processes. The critical alignment between the sources and the underlying nanophotonic circuits is ensured through accurate lithography. Based on this process we demonstrated electrically injected microdisk lasers coupled to silicon wire waveguides. They were operating under continuous wave operation and had a threshold current below 0.6mA (for a 7.5um disk diameter). Using a similar integration process we also demonstrated several types of InGaAs photodetectors with high efficiency. Linked to the microdisk lasers through a silicon wire waveguide, they could form the basis of very low optical interconnects for on-chip optical interconnect but also for high bandwidth transmitters and receivers in datacenters and other short off-chip optical interconnects. We also demonstrated Fabry-Perot type lasers with larger output powers that could be used as pump lasers for clock distribution circuits or for longer off-chip interconnects.