Soutenance de thèse

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Optical nonlinearities in III-V-on-Si active nanostructures

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Abstract

Hybrid integrated micro- and nanolasers enable efficient light emission at chip scale with reduced power consumption and footprint. Their unique properties make them good candidates for overcoming the limitations of copper-based interconnects. Together with this, the exploitation of their optical nonlinearities has been shown to be effective in the demonstration of nonlinear activation functions in the context of optical neuromorphic computing.

The PhD work regards the design, fabrication and characterisation of InP-on-Si microdisk laser diodes, together with the modelling and characterisation of the latter in the injection locking regime for the implementation as an all-optical activation function. The design is based on numerical simulations to study the electro-optical properties of the laser. In particular, with respect to previous demonstrations, a novel electrical pumping scheme is proposed. The modelling of the device shows the possibility of achieving sub-mW operation in such a configuration, considering a disk of 3.75 µm radius. The fabrication of the devices follows, based on the adhesive bonding of the III-V and SOI sections. Experimental characterisation of the device under DC electrical pumping reports sub-mW operation for the 3.75 µm radius microdisk (390 µA of threshold current at 1.06 V of applied bias). The last part of the thesis is devoted to the study of the nonlinear operation of the microdisk in the injection-locked regime. After the theoretical description of the injected system, two different characterisations are reported at 10 kHz and 2 GHz of modulation, respectively. A saturating, sigmoid and bistable response with µW-scale switching powers is reported in the first case. A clipped GeLU, sigmoid and inverse ELU response are reported in the second case.

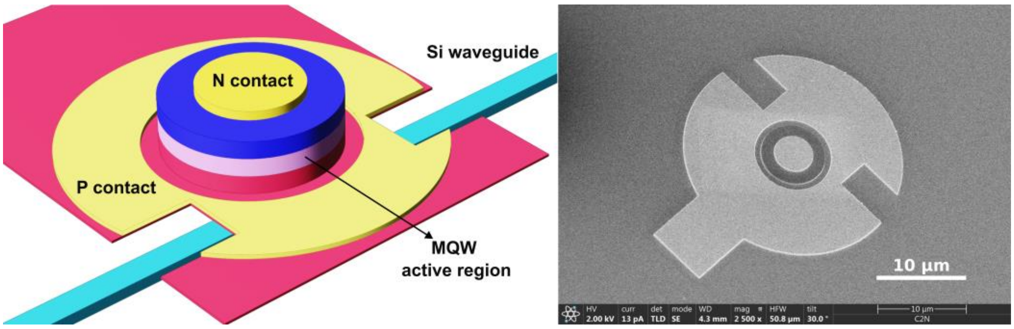

figure: (left) scheme of the III-V on SOI microdisk laser diode. (right) SEM image of the device.