Toward integrated photonic sensors

INSTITUT D'ÉLECTRONIQUE ET DES SYSTÈMES

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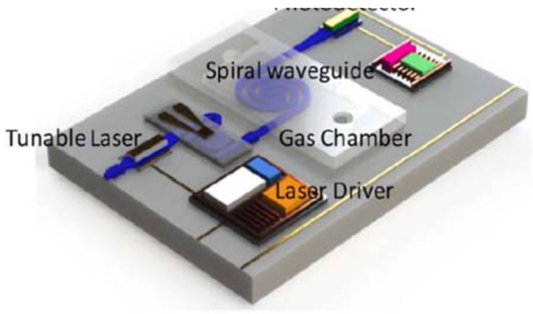
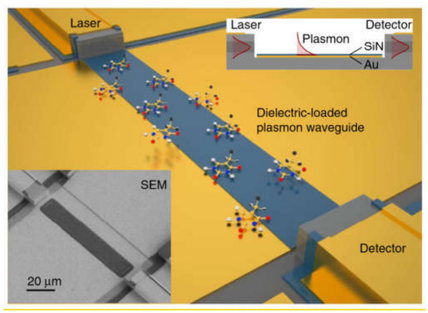
OBJECTIVE

Develop the building blocks needed for integrated mid-infrared photonic sensors

CONTEXT

1)Environment monitoring, climate change, industrial process supervision, food storage, etc., all call for the deployment of high sensitivity **integrated photonic sensors.**





2) The atmosphere has transparence windows in the **mid-infrared** wavelength range of the electromagnetic spectrum, and many molecules have their **fingerprint** in this region.

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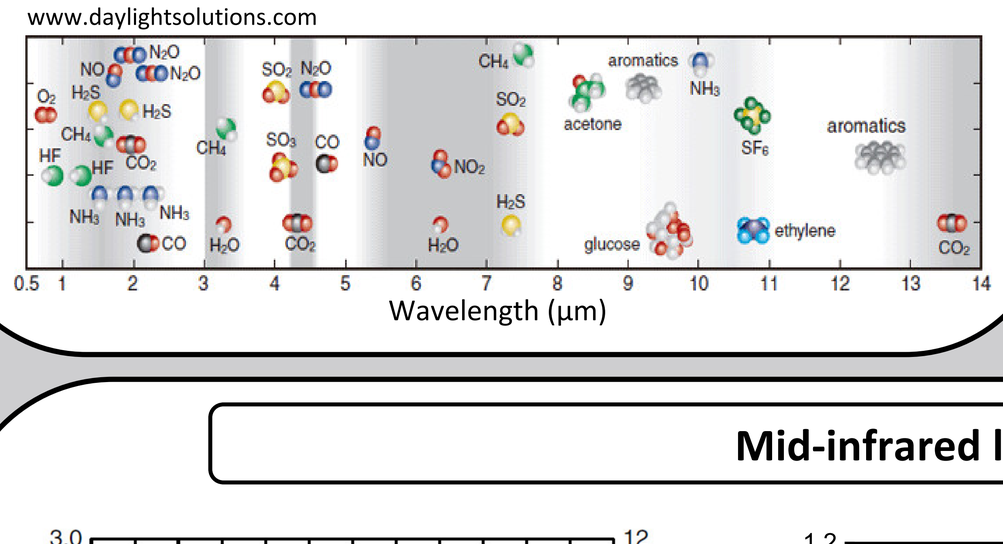


CHALLENGES

One needs to **integrate** light sources, waveguides, modulators, photodetectors, etc., on the **same chip/platform: photonic integrated circuits**.

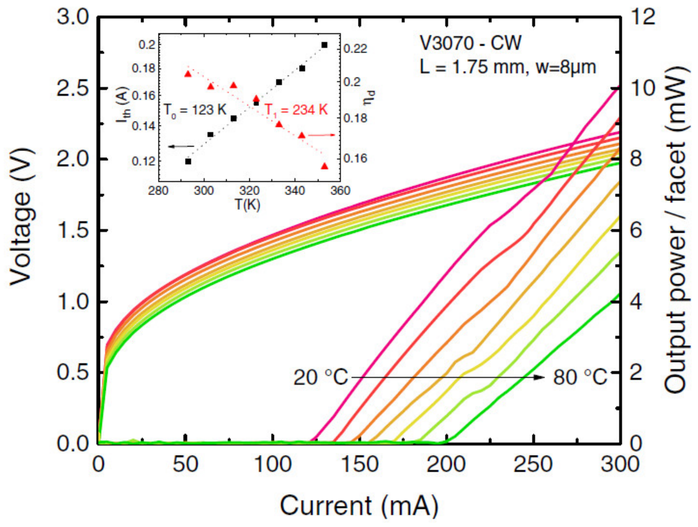
Silicon-based materials used in microelectronics (Si, SiN, SiO_2, (Si)Ge), **cannot emit light**, **but** they can be used as **waveguides**.

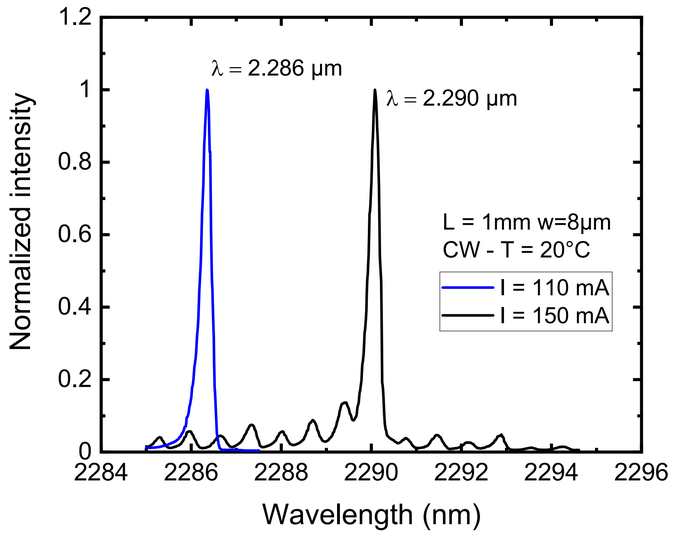
Light emitters are made with so-called **III-V semiconductors**, *i.e.* GaN, GaAs, InP, GaSb, etc.

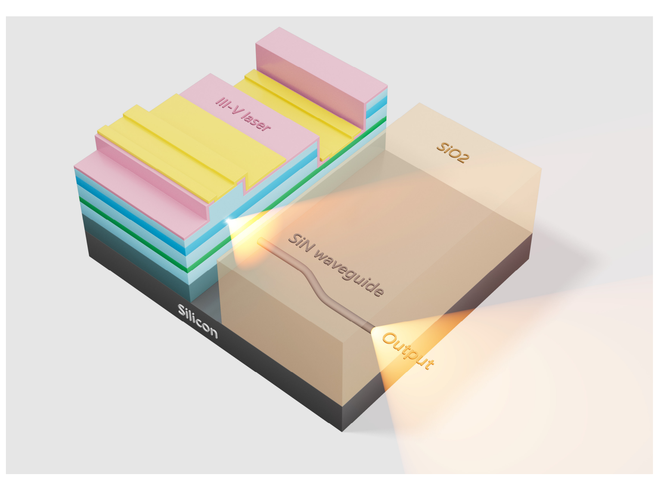
Dissimilarities between these materials families generate crystal defects when growing III-Vs on Silicon, which degrade devices performances. This **problem** is only **partly solved**.

If Si photonics is the most wanted, **other photonic platforms** are possible: III-V (GaSb) or chalcogenide (GeSeTe) materials can also be used.

Mid-infrared lasers grown on Silicon







Light – current – voltage characteristics and emission spectra of GaSb DLs grown on Silicon.

First laser on a photonic integrated circuit

Mid-infrared interband- and quantum- cascade lasers have also been grown on Silicon.

See, Tournié *et al.*, Light: Science & Applications 11 (2022) 165, doi:10.1038/s41377-022-00850-4 and references therein.

See, Remis *et al.*, Light: Science & Applications 12 (2023) 150, doi:10.1038/s41377-023-01185-4.

THE WORK

Much work remains to be done before a real sensor is demonstrated.

Depending on his/her skills and aspirations, the candidate will be involved in:

- Modeling of the photonic devices (lasers, waveguides, photodetectors).
- The epitaxy of laser and photodetector heterostructures.
- The processing of the epitaxial wafers.
- The processing of the photonic platform.
- The electro-optical studies of the discrete and integrated devices.
- …….

THE ENVIRONMENT AND FACILITIES

The work will be carried out in the nanoMIR group of IES, a joint research unit between U. Montpellier and CNRS. NanoMIR is a world leader in mid-infrared optoelectronic devices, and it has achieved a number of breakthroughs in the integration of mid-IR lasers on silicon.

IES is equipped with molecular-beam epitaxy systems dedicated to the growth of semiconductor heterostructures, and with material and device characterization setups. The devices are fabricated in the 400-m^2 clean room of the university located in the same premises as nanoMIR.

The candidate will be fully immersed in a team of ~ 3 permanent staffs and 3 PhD candidates.

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