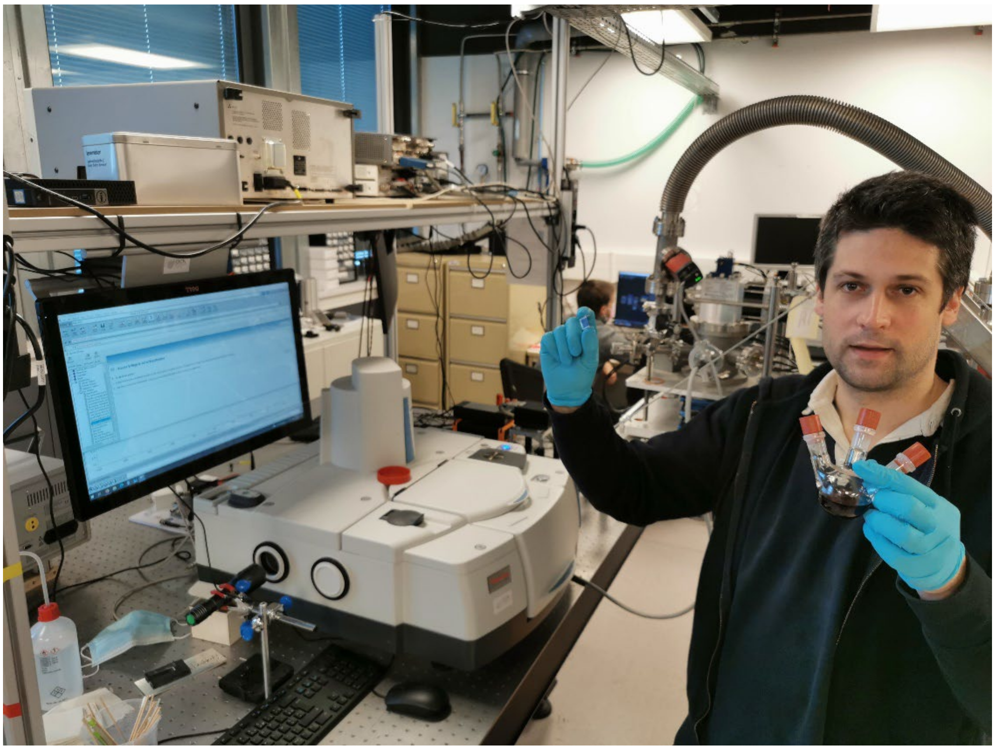
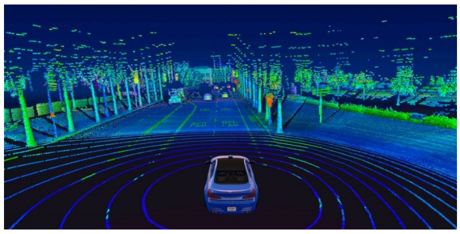
Driving down the cost of infrared detectors for useful mass market applications

Case study





Left : Dr. Emmanuel Lhuillier in his lab producing low cost infrared detectors that open new opportunities for applications like night car driving LIDAR aid (see top right), plastic waste sorting, egg quality detection. Bottom right image is an example of image acquired with a camera whose active layer is made of infrared nanocrystals

Driving a car in the night or in foggy condition can sometimes be tricky because of the lack of vision and because the driver can feel sleepy and today, infrared detectors could help drivers by mapping the 3D environment of the car and helping detect a pedestrian crossing the street ahead for example. On the environmental side, saving the planet requires humanity to sort out and recycle waste faster and more efficiently and there again, infrared detectors can help differentiate between plastics and paper waste on very fast conveyor belts for example. When it comes to food, infrared detectors can also help humanity produce more efficiently by helping sort out broken eggs or by detecting defects in fruits. However, a main obstacle to this technology is the high cost of the traditional InGaAs infrared detectors that have mainly kept infrared detectors secluded to defense or astronomy applications.

Dr. Emmanuel Lhuillier and his team at the institute for Nanosciences of Paris from CNRS and Sorbonne university in Paris solve this problem by producing lower cost infrared detectors thanks to a new nanoparticles material made of HgTe. The difference in cost is larger than one order of magnitude. For sake of illustration an InGaAs sensor costs around 1000 € while a HgTe detector only costs 70 €. This much lower cost opens new possibilities for mass market applications.

Such a lower cost is mainly driven by simpler production schemes because producing HgTe detectors doesn't require the same very expensive Molecular Beam Epitaxy tools based on ultra-high-vacuum required to manufacture traditional semiconductor thin film and the production is also faster (one day). In the case of

HgTe, a solution of nanoparticle is produced in traditional chemistry glassware like the one held by Emmanuel on the picture in his left hand (in his right hand, he is holding a HgTe detector that can be used for infrared sensing).

Emmanuel's team uses a laser system from mirSense at 4.4µm that can generate pulse widths down to 30 nanoseconds to characterize the response time of their detectors. Their detectors work mostly in the short-wave infrared but have some responsiveness in the mid-infrared and hence the need to characterize this borderline responsiveness at 4.4 microns wavelength. Furthermore, the QCL system is also used to excite some intraband transitions of the nanocrystals (see further on the list of publications).

It appears that mirSense was chosen as the supplier of Quantum cascade lasers because the driving electronics of mirSense is able to generate pulses down to tens of nanoseconds of pulse width which is quite interesting for the characterization of the response time of the infrared detectors.

Several papers were published with the QCL laser system from mirSense and here is a short list:

- *Guided-Mode Resonator Coupled with Nanocrystal Intraband Absorption*
  Adrien Khalili et al., ACS Photonics (2022)
  https://doi.org/10.1021/acsphotonics.1c01847
- *A colloidal quantum dot infrared photodetector and its use for intraband detection*
  Clément Livache et al., Nature Communications 10, 2125 (2019)
  https://doi.org/10.1038/s41467-019-10170-8
- *Band Edge Dynamics and Multiexciton Generation in Narrow Band Gap HgTe Nanocrystals*
  Clément Livache et al, Applied Materials & Interfaces10, 11880 (2018)
  https://doi.org/10.1021/acsami.8b00153

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