Edited transcript of EPIC Online Technology Meeting on Mid-IR Photonics, 13 May 2020

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Introduction

The EPIC Online Technology Meeting on mid-IR Photonics was held on 13 May 2020 to discuss the current and future applications for mid-IR technologies with special focus on connecting the manufacturing supply chain. The event was moderated by Jose Pozo, EPIC’s CTO and Ana González, EPIC’s R&D Manager, with contributions from the following:

Speaker 1: Kordian Lipski, Sales Engineer at VIGO

VIGO systems supply a wide range of products for photonics, including both epitaxial semiconductor material as well as infrared detectors and detection models.

We are a vertically integrated manufacturer with a complete production line for our infrared semiconductors and mid-IR photonic devices, starting with epitaxy like MOCVD for III-V and II-VI materials and MBE for III-V materials.

Our processing team works on every stage of material manufacturing from contacts and passivation to deposition, dry and wet etching for photolithography and preparing the structures for assembly, dicing, wire-bonding and flip-chip. We also have automated assembly hermitization packaging together with integration with electronics.

Detectors: we produce a large variety of detectors including photo conductors, photovoltaics, photo voltaic Junction, photon electromagnetic detectors and quadrants from near to far infrared. Our detectivity is approaching fundamental limit of performance and the time response of the detector is approaching gigahertz range.

MWIR infrared detector modules: this is a new line of detectors integrated with low noise preamplifier and a common miniaturized package. An example is the uncooled indium arsenide antimonide detector with a frequency response (DC) up to 3 megahertz and RoHS compliant, which makes it for marketable to consumers safely at a competitive price of 120€ each.
**Applications:** for industry, applications include spectroscopy of gas liquids and solids ensuring strong absorption lines in infrared, detection of almost any chemical compound with high sensitivity and high selectivity. Also, temperature measurements, laser metrology, minute monitoring and control of industrial and laboratory processes.

**Liner Arrays:** Another project is our medium and long wave infrared mercury-cadmium-telluride or indium-arsenide-antimonide liner arrays. Their key features are high sensitivity, high speed response from DC to few megahertz, no drift of the signal and low weight and compact packages.

**Applications:** temperature monitoring, e.g., of fast-moving objects with advantages of fast response time and resistance to environmental conditions. Another application is plastics sorting, like elimination of moving parts and filters with the devices providing high separation accuracy due to high SNR ratio and high-speed measurement.

**What we can offer:** we can supply optoelectrical products that meet your requirements,

**What we need:** collaboration projects with companies. For example, we've got the detector and if someone's got the lasers, then maybe we can make some spectroscopy.

**Questions:**

Mirvais Yousefi (LuxC): We’re working with low-power applications, could you give us a short overview of the power consumption of the different models you presented?

Kordian: Our detectors don’t have to be powered up by other sources to work at high quality. Power consumption is very low because it’s uncooled, so you don’t have to use any external equipment to cool the system. I don’t have the specs to hand, so please contact us and we’ll send them to you.

Jolyon Tidmarsh (Keit): We produce mid-IR spectrometers and I’m always on the hunt for suppliers of detector arrays, particularly two-dimensional arrays, so I was interested in your linear arrays and what the pixel counts could be.

Kordian: We can make both linear and bilinear of up to 32 elements.
Speaker 2: Rodrigo Linares Herrero, Business Development Manager at NIT

We are a Spanish company supplying innovative mid-IR detectors, high-speed infrared cameras in this range and industrial solutions and our target customers are integrators, solution developers and end-users.

We are a vertically integrated company and cover all the steps from the detector concept to the final product, including detector and ROIC design, detector processing on 200 mm silicon CMOS wafer and custom method packaging. We also design proximity electronics, manufacture OEM models and industrial cameras with inductor machine digital interfaces and provide industrial solutions for integration in the production line.

Detectors: the detectors that we manufacture are based on PBSC and we use a technique called VPD to process them, which is fully compatible with silicon CMOS wafers, and we obtain monolithic detectors with no need for hybridization. This also allows processing hundreds of detectors in a single manufacturing batch.

Performance: our detectors have detection in the whole 1-5 microns band, with a peak detection of 3.7 in the Mid-IR. They have high-speed capabilities and uncooled operation at room temperature, and because no complex cooling systems are required for operation, we can offer low-cost solutions.

Cameras: Our current state-of-the-art is the Tachyon 16k camera plus, this is a 2d array camera based on a focal array having 128 by 128 pixels and a pixel size of 50 microns. The camera is capable of achieving a maximum frame rate of 4000 frames per second in full frame and in snapshot air acquisition.

Regarding the industry solutions, we have the CLAMIR and I3MS monitoring system. These two solutions are embedded systems, that means that they can operate in operation with no need of a connection to a PC.

CLAMIR: This is a standalone system designed for laser quality assurance with retina redeposition, 3d metal printing and laser cladding including ELA processes and high-speed cladding.
The system continuously monitors multiple geometry and controls the laser power in closed loops. With this, we avoid overheating the part that the user is manufacturing and prevent unplanned stops in production due to the part having to cool down. CLAMIR is a very powerful monitoring tool and in 2018, it won an innovation ‘RADAR’ award from the EU in the Industry and Enabling Technology category.

**I3MS:** This system is designed to continuously monitor the melt pool width and generate an analogue output proportional to the melt pool width. It also has digital outputs, to tell the user when there is a warning or a failure because there is a deviation in the melt pool. This analogue can be used as an input to a control system developed by the user.

Both CLAMIR and I3MS come with a very powerful software suite for data logging of all the relevant parameters of the process and also for analysis of the data. They also include a DLL to allow an integration of the system in a third-party machine. This is very convenient for machine manufacturers that already have an HMI developed for their machine, so that they can incorporate all the functions offered by the two systems into their solution.

**Applications:** Quality assurance of laser based processes like process monitoring and control of the laser and DED 3D metal printing, laser cladding, laser welding quality assurance with real-time machine learning processing. Other applications are arc welding and WAAM process monitoring, glass manufacturing quality control in the hot end, spectroscopy and also classical spectroscopy in a very novel technique called dual-comb hyper spectral imaging.

**What we can offer:** As regards spectroscopy, we can provide a 2d focus on arrays in the Mid-IR, which can be convenient for spectrometers and also linear arrays.

**What we need:** We already have a very strong collaboration with the industry, through the H2020 projects, but we would welcome other collaborations with companies to bring mid-IR photonics into real applications in the industry.

**Questions:**

**Torsten (Huawei): You mentioned the technology is based on LED selenide, I wonder if that is RoHS compliant, because of the high content of lead in this material.**

**Rodrigo:** All the detectors that we offer are RoHS compliant. There is a proportion between the sensor and the lead material that needs to be fulfilled, and all our sensors fulfil that proportion.

**Ana Gonzalez (EPIC): I saw a LAMPAS logo in your slide, could you tell us what it’s about and your role in it?**

**Rodrigo:** LAMPAS is an H2020 project that is focused on and texturing and patterning and on surfaces with very high speed femto-lasers. In our case, our camera is used to monitor the processing in real-time.
Speaker 3: Pu Jian, VP Product Management & Partnership at Cailabs

We are a young French company developing, manufacturing and selling innovative optical components around beam shaping. Something that we're actually not very well known for, but that we can bring to the mid-IR community, is high-power sources.

**Beam shaping technology:** We own a unique technology of extremely flexible and integrable beam shaping technology called MPLC (multi-plane light conversion), and we've developed our expertise in beam shaping around this. We bring this expertise to many different applications and markets, such as telecommunications, industry or laser processes.

The technology we have for Multi-Plane Conversion is a very passive and very flexible technique for shaping and multiplexing beams, which means that we are capable of shaping in phase and amplitude any beam. We can even shape multiple beams at the same time.

We can use this technology for laser processes and for telecommunication in order to carry out multiplexing, but this can also be used for passive incoherent beam combination. This means that we can transform a certain number of single-mode, low-power input beams into one output beam with a scaling of N in terms of power.

We have a homogeneous beam profile that enables us to control precisely how each input beam is transformed into the output beam, we can achieve the optimal output quality for this beam combination. This means that for a given number of inputs, say 4 inputs, we can achieve an output beam with the lowest M2 possible.

**Sources:** The most promising sources for portable midinfrared sources are quantum cascade lasers because there are very compact, have a good beam quality at the output, and they produce single mode beams and in a very large wavelength range. However, they have a very limited output power. Most of them, depending on the wavelengths, have an output power that is below 2W, and so what we can offer with a beam combiner and with QCL sources is to have a more powerful source based on the combination of multiple quantum cascade lasers, meaning we can achieve more than 10 watts of output power at this wavelength range, between 3 and 10 microns.
**What we need:** We are looking for new partners and new applications. We have worked on this combiner mostly for defence applications and we know that there are many other applications that could benefit from these high-power sources, so we would be really interested in looking into these new applications with new partners or maybe doing some European projects together.

We would also like to work with integrators that need these mid-infrared sources and who would be interested in using them in their solutions.

We are also looking for new suppliers for our products, particularly manufacturers of optics in mid-infrared compatible materials, mostly micro lens arrays, aspheric lenses, dichroic components and also for providers of optical coatings at these wavelengths.

**Questions:**

**Ian Riley (Vortex):** One of the things you mentioned was the need for beam splitters and dichroic coatings in that wave band and I’m sure we’d be able to assist there. We’ve got plenty of experience in that area, so we should maybe get in contact offline, in particularly if you’ve got projects where you’re struggling for a beam splitter or a dichroic, I’m sure we’d be able to help.

**George Tsibidis (IESL-FORTH):** Have you started working on laser patterning with mid-IR pulses?

**Pu Jian:** Yes, we have. I focused my presentation on just combining the sources, but our technology is actually a beam shaping technology, so we’re not necessarily doing it with a round quasi Goshen output. We can do very different shapes and this works at mid infrared wavelengths as well, as in any other wavelengths as we are doing already in other applications.

**Mark (G&H):** Does the this combiner only work with single mode and in what configuration is the output: is it a collimated beam or coming out of a waveguide or coming out of a fibre? Also, how is this different to just combining four or eight different sources through waveguides that are brought close to each other which is like your standard fibre optic beam combiner?

**Pu Jian:** It’s works with single mode sources or I would say few mode sources, so if you have a very large number of multimode sources, you couldn’t achieve lower M² than what you already had.

We can achieve the lowest M² that is available for the number of modes that you have at the inputs, so we could deal with, let’s say, three or four modes at the inputs - for each input - and then combine them to the lowest number of modes possible so then the lowest M² possible.

In terms of the outputs, there are different ways we can do that. We can actually do a collimated output, or we can inject them inside a multimode fibre, if you want to have a fibered output.

The main difference with fusion coupling different wave guides in order to achieve combining is that we are really controlling the M² or the divergence of the beam at the output, so we can improve, I would say, by a factor of two or three compared to other combining techniques, in terms of beam divergence.

**Igor Alexander (Monocrom):** I am looking for an efficient beam combiner for high-power same signal emitters. Since they are not single mode, I think you have already answered my question, so I assume it is not possible to use high power multimode emitters with this technique.

**Pu Jian:** It really depends on how multimode they are. I would say there’s a limit somewhere between many multi modes and a completely single mode where we can still work, so it depends on your sources.
Samuel Poulain (Le Verre Fluoré): What is the maximum output power that can be coupled, because we commercialize mid-IR fibre lasers to ten watts, and we will soon achieve 20-40 watts, but actually the market wants 100 watts continuous wave. It would be much easier for us if we can couple several lasers instead of making it very big one.

Pu Jian: We have not worked up to more than tens of watts in mid-IR. However, CAILABS’ technology is actually compatible with very high power because we have a reflective design, so for multimode lasers, we have already worked at multiple kilowatts, and our technology can perfectly shape lasers at sixteen kilowatts. For this kind of beam combining techniques we have already achieved several hundreds of Watts at one micron, so I’m pretty sure that we can adapt this to a 2 to 3 micron wavelength, so I don't see any issue in working with multiple times tens of watts.

Joylon Tidmarsh (Keit): Could we use your technique to combine incoherent sources?

Pu Jian: Yes, it's possible, although it's not going to be exactly the same brilliance, so it's going to be a bit louder. But again, we can achieve the theoretical minimum of brilliance you can have by combining four times four incoherent sources.

Speaker 4: Thomas Moritz, Business Line Manager at AMS Technologies

We are the only provider of custom products and solutions of interdisciplinary competencies across photonics, thermal management and power technologies. Our mission is to facilitate innovative companies to convert these technologies and into an asset for success.

Every detector needs cameras to focus the light onto the chips. Sometimes it’s very easy, you have just the lens applied up close to the chip and then mount it together with the detector chip into some kind of fixture or holder. However, for more complicated, more complex applications, a lens assembly may be necessary. The wavelengths range where that optics works is mainly defined by the materials used as substrate together with the need for coating.

Materials: Among the most common materials used for such optics are germanium and chalcogenide glass. Chalcogenide has several advantages over germanium: it has a lower weight and a better DN to DT, which means the index of refraction changes by temperature in the lower scale and it’s more easily processable than with other technologies.
Lens manufacture: The conventional way of manufacturing lenses is by just turning a blank, using some special abrasives to give the final shape of the blank. Alternatively, diamond turning can be used to cut the shape out of the blank, which is then polished using special abrasives to achieve the final shape of the lens, which can make more complicated shapes in a shorter time.

Position glass moulding: The second technology is position glass moulding. This process is dedicated to really high volumes because it requires high precision tooling. It’s a high-temperature compression moulding process, performed in a very controlled environment and following a precisely controlled technology.

Advantages of moulded lenses: Using moulded lenses has many advantages: you have a reduced size, weight and cost because of high-volume manufacturing. You have enhanced thermal properties and possible athermalisation in a high temperature range by combining different materials for different lenses. There is also the opportunity to use high quality chalcogenide glass and they are very highly customizable.

Disadvantages: The disadvantages include small size, approximately up to 25-30 millimetres, because it’s a pressing process. To make bigger diameters, you need really high power and unfortunately, not all glass types are mouldable.

What we can offer: I think what we can bring to the table is our market knowledge, our long-lasting relationship with our partners. We have experienced specialists in photonics and thermal solutions and in power electronics, so we can bring all this knowledge together to work on challenging projects with our customers, based always on their needs and creating either a solution based on a customized standard product of our partners or specially designed lenses. Putting that together with electronics into a box, forming a solution for our customer, that’s what our main focus is.

Questions:

Joylon Tidmarsh (Keit): On your first slide you showed you could supply BD6 lenses with DLC. I’m thinking it’s like a protection against chemicals, does it have pinholes?

Thomas: BT6 is a composite, so it’s mixed out of a lot of different chemicals and then melted together, so your lens is as good as your melting is. For the diamond-like coating (DLC) there is data on the number of pinholes that I’ll send you.
We are fibre-optic bridge manufacturers, so we put fibres on top of detectors or light sources. We are focused on three types: polycrystalline fibres for mid-infrared with transmission up to 17 micron, chalcogenide fibre and hollow waveguides.

Chalcogenide fibres: The advantages of chalcogenide fibres based on arsenicum sulphide, they are simply the best for the range up to six microns, with some problems with H-Se bonds. For the longer wavelengths, up to nine microns, you can use arsenicum Selene glass. While these fibres have many advantages, e.g., strength, they also have some drawbacks: they are slightly brittle and toxic, so there are precautions for medical use.

Polycrystalline fibres: These are very unusual as they are not glass. The structure is ten to hundreds of nanometres and the fibre is extremely flexible, so it's almost impossible to break. An advantage of polycrystalline fibres is that they are transparent in very broad range, up to 17 microns, is its spectra of transmission of PIR fibre. As a result, we can couple infrared fibres with MCT detectors, and we are planning to do some projects with members of this event right now.

Hollow waveguides: Hollow waveguides are regular players in this kind of comparison: they are great because there is no material, it's just air, and you only have internal mirrors. With mirrors based on the position of silver at silica capillary and silver iodide, you can play with the thickness of these layers. They are special mirrors, so you can make a very high transmission at 10 microns but there will be problems over 5 microns. However, if you change thickness, which we can do, we can shift it and make a very good hollow wave guide for carbon monoxide lasers in this range.

Advantages of hollow waveguides: The advantage is that you never have a laser induced threshold at the entrance, because there’s no material or frenal reflection. At the same time, a hollow waveguide is good for narrow divergence with very narrow beams, for laser beams like CO2 lasers going to cascade lasers. For example, you can have a carbon dioxide and carbon monoxide laser and cables, made from hollow wave guides. The only point with hollow wave guides is that the bending radius reduces transmission, because hollow wave guides are quite sensitive to bending, so you can lose up to 20% or more.

Also, with poly crystalline fibres or hollow waveguides, we can couple quantum cascade lasers with pure fibre pigtailling. We are doing this together with Nanoplus, and hopefully, in a few months we will have several options for working prototypes. These bundles can also go towards infrared detectors, so that's why in general we want to really accelerate our collaboration with VIIGO, to have fibre optic pigtailed detectors.

Spectroscopy: Infrared fibres are excellent pure fibres for fingerprint region for spectroscopy, between 4 and 16 microns, so this is transmission of pure fibres with different ATR tips: diamond, zinc selenide, silicon. When we need it for shorter wavelengths, we use
chalcogenide fibres and cubic zirconia to produce a very good transmission. We supply a number of very different fibre optic probes to FTIR manufacturers, like ABB, Mettler Toledo and Surma, and we also help our customers to use our couplers for making efficient couplings between FTIR spectrometer and fibres, which can used to monitor processes.

**What we need:** One of the biggest fields which is not developed as we want is infrared endoscopes, which can really go inside the human body to control not only operations, but also detection of tumours in the stomach wall or rectum wall, because tumours are usually half a degree warmer, and sensitivity of this method is about 0.1 °C. This, and the fact that the fibre is flexible means it can go in any kind of hole and is why medical fields are probably going to be the biggest in the future. What we are desperately looking for are partners who will help us to make a complete endoscope.

Angus Bell (Emerson) : Regarding your fibre coupled system, does it see the external air or is it completely sealed?

Viacheslav: This housing can be an inert gas and then of course it’s just a solid fibre which can go up to 15 metres, and you can control the gas composition in several pipes, in different parts of a combustion reactor or whatever else. That's why there are no other gases between the area of measurements.

**Speaker 6: Angus Bell, Lead Technologist at Emerson**

I'm from Cascade Technologies, which is a quantum cascade laser gas analysis based company, founded in Scotland in 2003 as a spin-out from Strathclyde University. In 2014 Cascade was acquired by Emerson, and has since continued to do continuous gas analysis, aerosol leak detection and also some work in medical and pharmaceutical extraction systems.

**Laser chirp technique:** The technique that we use is a Laser Chirp technique. This is based on the fact that when you put a voltage pulse through a QCL, as well as getting a pulse of light out, the temperature of that QCL ramps up as well, and you effectively get an almost linear chirp of the frequency or the wavelength of your laser during the pulse.

We typically pulse our lasers with a 500 nanosecond pulse and we repeat that every 100 microseconds. During the 500 nanoseconds, we sweep the frequency of our laser by a couple of wavenumbers, and so if there are some molecular absorptions around, then each pulse contains that molecular absorption, so we get a full spectrum with each pulse.
That transmission spectrum of a gas is then converted into an absorbance, and, using fitting routines, we fit a multi-line spectrum to that absorbance and, knowing the path length of the absorption, we can then get a concentration.

This technique is very sensitive so we can get sub ppm sensitivity and, because of the fact that we’re taking a spectrum every pulse, we can do it very fast. Therefore, getting sub ppm sensitivity faster than a Hertz repetition rate is relatively straightforward.

**Products:** Emerson produce a number of different quantum cascade laser based process gas analysers. Most of them are based around QCL, so we’re looking at optic absorption in the mid infrared. Most of the small molecules of common gases contain very strong absorptions in the mid-IR and the marriage of those two things is what makes this work very well.

**CT 5000 systems:** The CT 5000 systems were first introduced in 2016 and have up to six different QCLs in them and can measure up to eight different gases at the same time. We sell a few different models of these. The CT 5800, for example, is designed for hazardous areas like natural gas applications or hydrogen purity and is explosive-proof from the inside so that if device explodes, then the natural gas outside isn’t affected.

**4400 series:** These were brought out in 2019 with a slightly simpler design that tend to run at room temperature with up to four lasers for measuring up to 4 or 5 gases.

**What we need:** Cascade has been involved in this area for the best part of 20 years and has had a lot of collaborative developments with very different companies around the world. This is something that would really like to continue doing. i.e. to work with established partners and seek out new partners.

For us, this means looking for mid- and near-IR solutions to help our customers with better or different sources, different detectors, different components. Although we've been based on
chirped QCL’s for a number of years, we’re not wedded to that technology and we’d be happy to explore other ways of doing things to get better performance for our customers.

Questions:

Melanie (Axetris): We receive a lot of requests from the market for a cheap solution for H₂S measurement, but so far, there seems almost no chance to achieve these measurements. Can you tell me something about your experiences with H₂S detection?

Angus: That’s maybe a discussion for another forum and we’d be happy to talk about that in a more one-to-one situation.

Speaker 7: Pascual Muñoz, Professor at Polytechnic University of Valencia

I’m a professor at the Universidad Politécnica de Valencia and also one of the founders and current board members of VLC photonics and most recently, manager of a micro fabrication pilotline in Valencia.

I am part of the Spanish photonic integration ecosystem that we have grown over the last 15 years comprising several research organizations, our own clean room for testing PICs and some start-ups and companies, some of which are spinoffs from the research institutions working on photonic integrated circuits.

As regards photonic integration, we’ve been working for a while, mostly on silicon nitride and we are now developing a platform to cover all the spectra, so visible, near-IR and mid-IR, by using only silicon nitride.

With respect to photonics and photonic integration, there are three technologies currently available: 1) a visible technology, 2) near infrared technology, developed by our company VLC photonics, and 3) a technology based on a membrane of silicon nitride to cover visible near infrared and mid-infrared.

For the last few years, we’ve done regular MPW runs in the near-infrared, where you can have a piece of the area for your design and you can therefore share the cost of manufacturing with others.

For the mid infrared, we are now in the second proof of concept round, which is nearly finished. We have membrane technologies within the same wafer and the same processing and chips that are aimed to perform, at the moment, in three wavelength ranges within the same wafer: 1-2, 2-3, and 3-4 microns. We’ve had to pause our activities due to Corona, and there are still a few processes to refine such as the under edge of the waveguide and the testing.

This is the current state of the technology and the Process Design Kit, the technology and available building blocks and our roadmap for the next year. We are aiming to expand the micron wavelength range to 5-6 and 6-7 and different building blocks in the next 18 months. Then, for 2022 we want to hybridise with different components.
What we can offer: This is our schedule for the multiply wafer runs we're going to be having our zero run late this year, so in the short-term what we are offering is access to this proof-of-concept multiplayer wafer run, so you can test the technology. In the mid and long term, we want to have a platform that has active and passive functionality in the mid-infrared, as well as in the near IR and visible.

What we need: We are looking for cooperation on the technology side, with active device suppliers for our hybrid integration processes, and on the application side, of course, early adopters that can

Questions:

Iwan Davies (IQE): IQE offers epitaxial services, mainly young gallium arsenide and indium phosphide-based substrates, but also antimonides as well. As for antimonides, that is still the domain of US fabs at the moment, but we are certainly looking to bring some of that technology over to Europe very soon. Maybe we'll be able to help you with something on those substrate materials, we offer a custom-designed epitaxial service and can manufacture whatever epitaxial design you wish.

Pascual: Okay, thank you, yes certainly we will be in touch.

Geoffrey Duggan (Lumerical): We're a software company that offers modelling in photonic components using really accurate solutions to Maxwell's equation, but in what you have been talking about today, we offer another product called interconnect, where we're able to take the building blocks that you described, parameterize them in terms of their performance and build them into compact model libraries which can then be used in interconnect for circuit simulation.

Pascual: Thank you, yes, we know Lumerical very well, and we understand that it is very helpful to these kinds of developments.
Mirvais: This is a fantastic development, and one question I have is regarding integration of source and detectors in a hybrid scenario, the temperature across the whole system would be a big challenge. I think this would require an early stage approach. Have you already taken this into account in the design and the architecture?

Pascual: When we design the technology, we need to foresee where the actives will be coming into place and the different areas of the chip, even if that is going to be happening in two years’ time. Then we need to put in place processes and process steps where later on we can incorporate the usual tricks such as thermal isolation trenches and thermal chance to cope with technology.

Mirvais: This would be a typical scenario where hybrid integration may play a role, because the temperature profiles and the temperature deltas are so huge and the wave guides are so large that coupling actually works. Would you promote different hybrid approaches here, with actively controlled regions within a package rather than a chip?

Pascual: Within packages, it’s always welcome, but we want to do something that comes to chip level at this time. In the future, we may do something within packets - it’s always an option.

Wilfried Noell (SUSS): Can you provide spot size converters for mid-IR, because when you have a mid-IR laser like a QCL, they’re extremely elliptical so it would be nice to have something like a spot size converter, is that feasible?

Pascual: Okay, this is something that, if you’re interested, we can have a private, offline conversation about.

Speaker 8: Sergio Nicoletti, Business Development and Project Management at CEA-LETI

A few years ago, we presented a concept paper in which we were trying to highlight what can be done on a piece of silicon for chemical gas sensing using optical detection. We have since been working on three main building blocks: the array of quantum cascade laser transferred on silicon, the integrated circuit to replace optics and the development of the sensing cell fully integrated in silicon.

We have several platforms going on at CEA-LETI and we can cover continuously from visible up to 10 microns, either with silicon nitride, silicon on SOI, silicon germanium, germanium and every kind of device that can work in the given wavelength range.

Our choice for medium fired PICs was to develop a platform which is fully compatible with the IC and MEMS facility, and when we are talking about compatibility we are not talking only about materials, but also about the fact that we should have a fabrication flow which is consistent.

At the end of PIC fabrication, our wafers are flat. We do a planarization step and we use cap layers. This is because our aim is to integrate other components on it, if you have any topology on your wafer you won’t be able to fabricate any other components on the device or on the wafer itself. That was a choice and it turns out that, so far, we probably have the broadest platform, at least in Europe.
Another point for having cap layers is the fact that there might be interaction with the environment. Typically, if you don’t cap your wave guide, you also have interaction with the gas, which is outside the PIC itself, and you can have noise added to your measurement. Of course, in the case of germanium, you also have the issue of stability, because germanium can react with the environment and in particular, with water.

Challenges: Challenges include anti-reflecting coating and the assembly of the devices, because to inject directly on a waveguide, you need the precision of the order of a micron or even less, so work has to be done on how we will assemble these devices.

MIRPHAB. The idea of MIRPHAB, of which I’m the coordinator, is to provide a unique entry point for the prototyping of chemical sensors based on tuneable diode lasers spectroscopy adsorption. Within the MIRPHAB pilot line, we have been developing all the building blocks required for the implementation of a sensor, and in particular, we have been working a lot on the miniaturization and on the packaging of these sensors.

Today the pilot line is up and running, the project will last at least up to the end of 2020 and the basic idea is that anyone can come to see us and have access to a number of devices or architecture for sensors that we have developed within the project, and that may be customized on the system, on the basis of the user requirements, so the customization is what we consider to be the added value.

What we can offer: We are a research and technology organization and we have access to huge fabrication facilities, so we can offer prototyping devices through access to our pilot lines for the fabrication of PICs.

Furthermore, since we are working together with people from microsystem and IC technology, we can also provide required know-how to integrate systems up to the highest level, also bringing electronic components and micro electromechanical components onto a chip or onto a subsystem.

MIRPHAB: As I previously mentioned, MIRPHAB is a pilot line providing a service for the prototyping of chemical sensors using the mid-infrared wavelength band. It’s open access and we can act as an entry point for supplying all the components and subsystems required for meaningful chemical sensing. You can have more information about this project on our website and EPIC have made an extremely nice video presenting the capability of our pilot line:
What we need (MIRPHAB):

Our target is to miniaturize the sensors as much as we can, and we need to hear from companies providing fibres to discuss some common developments.

The other thing we need is the capability to provide packaging on request, and when we reach volume fabrication, we will need companies to help us address any bottlenecks that may arise. We will need packaging that is variable, small and cheap, which is not the case for many of the packaging used today for mid-infrared technologies.