The 5 highlights of June 2017

"There is no technical limitation to what we can achieve"

New implantable chip to hook up bionic arm to brain

Bringing a new level of security and privacy to cloud services

Flexible RFID Tags for a Smarter, Interconnected World

Chip technology and photonics enable smaller, faster and cheaper medical devices

FEATURED ARTICLE

A breakthrough camera solution for harsh weather conditions

Preface July 2017

The 5 highlights of June 2017
Life is busy! So you might not always have the time to keep up with imec’s latest news and achievements. On this page you can find a quick overview of what imec has been doing in the past month.

**Imec showcased new technological breakthroughs at the VLSI Symposia**

Imec presented its latest technological innovations at the 2017 VLSI Symposia, a leading conference on semiconductor technology and circuits:

- A new technique was unveiled that reduces the source/drain contact area of PMOS transistors to a record-breaking new value, a significant breakthrough that will greatly improve the devices’ performance. [Read more about it](#).
- Sub-10nm germanium gate-all-around (GAA) devices were showcased for the first time. New device architectures were also introduced, bringing significant improvements for both strained germanium p-channel FinFET and GAA FET devices. [Get the details](#).
- Ground-breaking results proved ferro-electric memory to be a highly promising technology at various points in the memory hierarchy, and as a new technology for storage class memory. [Learn more](#).

**Summer vibes at imec**

What better way is there to celebrate the good weather than by enjoying some good food, drinks and music surrounded by your colleagues and friends? The imec Summer Festival – which took place on June 23rd in Leuven – was the perfect recipe for imec employees to welcome the summer season: live performances, food trucks and great vibes, lasting from the mid-afternoon until the wee hours.

**Imec equals quality**

Imec strives to meet the quality demands and needs of its industry partners, customers and employees. For the eighth consecutive time, the company was awarded the ISO 9001 certificate, highlighting its business processes, talent management and corporate culture of accountability.

**Novel chip technology to offer faster, cheaper, reliable diagnostic testing**

miDiagnostics, a spin-off from imec and Johns Hopkins University, is developing technology to allow diagnostic testing by detecting cells, proteins, nucleic acids, and/or small molecules from just a few drops of blood. Their latest breakthroughs, leveraging on imec’s holographic lens-free imaging technology, were recently published in the 2017 IEEE International Symposium on Biomedical Imaging (ISBI) Proceedings. Get the details [link to https://www.imec-int.com/en/articles/midiagnostics-closing-in-on-breakthrough-test-for-complete-blood-count]
Imec spin-off co-founder among Belgium’s ‘MIT Innovators Under 35’

Jelle De Smet, co-founder and CTO of imec spin-off EYEco eyeCO, was selected by the MIT Technology Review as one of the Belgian Innovators Under 35. Created in 2015, this list aims at recognizing the most remarkable technological entrepreneurs and researchers in the country.

Established in 2016, EYEco eyeCO is developing age-defying eyewear. Their goal is to commercialize glasses that can electronically correct people’s vision across the entire surface of the glasses lens, offering a higher level of visual comfort, without losing sight of the glasses’ aesthetic requirements.

Semiconductor technology & processing

"There is no technical limitation to what we can achieve"

Dr. Kinam Kim – President and General Manager of Samsung Electronics’ Semiconductor Business – shares with us his perspectives on the past, present and future technologies to which he has been – and will be – contributing.

At ITF2017 Belgium, Dr. Kinam Kim – President and General Manager of Samsung Electronics’ Semiconductor Business – received imec’s ‘Lifetime of Innovation Award’. By means of this award, imec recognizes Dr. Kim’s leadership and strategic vision, as well as the impact he has had on the global semiconductor industry. After all, the innovations that Dr. Kim has been pursuing over the past three decades are extensively being leveraged in a great number of applications – from computers and smartphones to the technology that is being used to accommodate the world’s largest data centers.

In this article, Dr. Kim shares with us his perspectives on the past, present and future technologies to which he has been – and will be – contributing. And he specifically calls out to the world with a very hopeful closing statement: “It is my personal belief that there is no technical limitation to what we can achieve. Maybe, someday, we might hit a wall – but I am sure we’ll always find ways to circumvent and overcome any issues. After all, researchers must always believe in the future!”
The past: unlocking the potential of 3D memory technology

Over the past three decades, Dr. Kim and his teams at Samsung have been instrumental in the development of several disruptions in the semiconductor space. When asked which have been the main innovations he has contributed to, Dr. Kim calls out two major achievements: the introduction of three-dimensional (3D) ‘recessed cell array’ transistors (which have become a standard in the memory industry), and the development of 3D NAND flash memory. Both are at the core of a wide range of devices and applications that we use on a daily basis – from computers and smartphones to digital cameras, video games, scientific instrumentation, industrial robotics and medical electronics.

“If we look back at the last ten to twenty years, Samsung Electronics’ Semiconductor Business has innovated in – and in some sense revolutionized – the domain of memory technology,” Dr. Kim kicks off. “Let’s take DRAM (dynamic random-access memory) as an example. Everyone in the industry was using planar transistors to build memory; with transistors being built up as a series of very thin layers of silicon semiconductor material – resembling a multi-layer sandwich.”

“But as new devices started to require ever more – and more densely built – memory, we moved to the 100nm optical regime and soon came to the conclusion that planar transistors were no longer able to meet the industry’s ever-increasing memory requirements. After all, at a regime of 100nm or less, planar transistors become very leaky – which limits their performance and potentially even causes complete circuit failure.”

“To overcome this issue, Samsung invented a three-dimensional structure – building upward and adding more layers to increase transistors’ density and performance. In research, we called this a ‘recessed cell array’ transistor. That has really been a massive change for the chip industry. Ever since we introduced this three-dimensional approach, it has become a standard: every company in the business has adopted it. Today, it has become a mainstream technology that is at the basis of countless devices that surround us,” he adds.

A second major achievement that Dr. Kim calls out, is the development of 3D NAND flash memory – which is typically used in removable USB storage devices (known as USB flash drives) as well as most memory card formats and solid-state drives available today.
“Indeed, 3D NAND flash memory has been another development to which we have largely contributed – with Samsung inventing the so-called ‘charge-trapping flash memory’ following ten years of continuous research. Thanks to the charge-trapping flash approach, we can continue to support the very aggressive scaling of NAND flash technology by storing information in charge traps in the nitride layer and applying it to vertical 3D structures. And again, following its introduction, everybody adopted Samsung’s approach,” Dr. Kim says.

Until today, the approach suggested by Samsung allows memory manufacturers to reduce manufacturing costs in five ways:

• Fewer process steps are required to form a charge storage node
• Smaller process geometries can be used (therefore reducing chip size and cost)
• Multiple bits can be stored on a single flash memory cell
• Improved reliability
• Higher yield since the charge trap is less susceptible to point defects in the tunnel oxide layer

The present: changing the lives of billions of people

The innovations pursued by Dr. Kim have not only been extremely valuable from a scientific and a business perspective; they have actually impacted the lives of billions of ordinary people – and will continue to do so for many years to come.

“Without these innovations, we would not be able to cater for today’s high-density, fast-storage memory requirements. Without them, there would be no such thing as artificial intelligence or the data centers that are used by companies such as Facebook, Amazon or Google to organize, process, store and disseminate large amounts of data. In other words: everybody gets exposed to the technologies we have been developing over the last three decades – across a whole spectrum of businesses and applications.”

The future: exploring new approaches to build memory – such as neuromorphic computing

One thing genuine innovators have in common, is that they are constantly on the look-out for new opportunities to explore. It is a universal truth that also reflects the mindset of Samsung’s Dr. Kim – who is already exploring ways to tackle the next big challenges in the semiconductor industry.

“When the development and expansion of memory technology is concerned, we already have a clear path forward,” Dr. Kim thinks. “The main question is how we can continue to develop processing (or computing) chips – knowing that current approaches, which make use of CPU and GPU resources, are not able to meet tomorrow’s requirements. So, somehow, we should invent new approaches. Neuromorphic computing, with CPUs getting replaced by neuromorphic chips that mimic the human brain, is one very promising route – and clearly one of imec’s focus areas.”
Believing in the future

Lastly, Dr. Kim calls out to the world with a special message of hope and trust: “It is my personal belief that there is no technical limitation to what we can achieve – even in terms of semiconductor scaling. Maybe, someday, we might hit a wall – but I am sure we’ll always find ways to circumvent and overcome any issues. After all, researchers must always believe in the future!”

Want to know more?

Imec’s Lifetime of Innovation Award was launched in 2015, in support of imec’s commitment to recognizing the prominent individuals who have made outstanding contributions to the industry. Previous recipients were Dr. Morris Chang in 2015 and Dr. Gordon Moore in 2016. Next year, ITF Belgium will take place on May 23rd and 24th – make sure to save those dates in your agenda already!

Biography Dr. Kinam Kim

Dr. Kinam Kim joined Samsung Electronics in 1981, and led the development and advancement of various memory technologies such as DRAM and NAND flash, and logic technologies such as Application Processor and Communication Modem. As CEO of Samsung Advanced Institute of Technology (SAIT), he spearheaded the research and development of technologies that have significantly impacted the semiconductor industry, such as graphene, carbon nanotubes and quantum dots, advanced materials, 3D fusion technologies, batteries and printed electronics.

Smart Health, Artificial intelligence

New implantable chip to hook up bionic arm to brain

Every year scores of people worldwide lose one or both of their arms in accidents. To help them return to a normal life, researchers are working to
A number of prototypes have been tried and tested, with growing success. But what is still lacking are the electronics that can interface between the patients’ nerves and the new arm so that they feel like it is their own: supersmall implantable electronics that pack enough intelligence and electrodes to allow a fine-grained contact between the prosthetics and the hundreds of available nerves. A new implantable chip designed at imec may prove to be that missing link, explains Dries Braeken, R&D manager at imec.

When someone loses an arm in a car or industrial accident, they are left with a stump. But their brains’ primary motor cortex still holds all the circuitry that used to drive that arm with its hand and fingers. That circuitry is the brain’s image of that arm. It creates what many patients experience as ghost itches and pain in a limb that is no longer there. But it also keeps sending signals to move the hand and fingers. When patients inadvertently want to shake someone’s hand or catch a ball that is thrown at them, the motor cortex initiates burst of electricity. These are passed down through the spinal cord, into the nerves that still serve the stump, and from there into the remaining muscles, which can be seen twitching.

All that is needed to help these patients, it seems, is to make a sufficiently sophisticated artificial arm with electromotors and sensors and fuse it with the stump.

To do so, however, a major multidisciplinary effort is required. It involves e.g. developing superlight and strong mechanics, integrating electromotors that allow the same forces and flexibility as human muscles, developing a biocompatible interface with the stump, and translating between human-generated and artificial signals.

A first generation of such smart prosthetics was designed to pick up the electrical signals from the remaining muscles, using these to drive the electromotors in the artificial arm. But patients equipped with such an artificial arm often experience it as a dead weight, an object that not really belongs to them. And therefore, they’d often rather not use it.

There are a number of reasons why they wouldn’t.

For one, these prosthetics do not allow the superfine finger control with which people interact with their environment and which they have learned through decades of finetuning. Patients can pick up a pen but they cannot write.

But even more important is the missing feedback. The artificial limb is not able to signal to the brain if it is touching a soft surface, picking up a burning coal, or applying just enough pressure to hold that Starbucks coffee cup but not crush it.

To create a more natural prosthetics experience, DARPA (the research agency of the USA army) set up the HAPTIX program, shorthand for ‘Hand Proprioception and Touch Interfaces’. The goal of the program is to create a prosthetic hand that moves and provides sensations just like a natural hand. It wants to do so by interfacing directly with the nerves instead of the muscles, to connect the biological and artificial circuitry through a permanent, implanted link that sends and reads electrical signals in two directions.
The nerves that run through our body are bundled and shielded in nerve fascicles, resembling how e.g. control and communication wiring in a building is bundled in a cable tray. Our arms and hands are controlled by two such bundles, called the median and ulnar fascicle. One promising technique that is developed and tested by HAPTIX is to integrate electrodes in a collar that fits around the 5mm thick bundles. But the challenge is to read and stimulate from the exact right nerves in the bundle without contacting them, nerves moreover that move and slide inside the fascicle. So there is an upper limit to the precision that can be reached with this method.

A more precise approach might be to insert electronics into the fascicle to contact the individual nerves. It’s a method that carries more risk, needing precise microsurgery that places electrodes inside the fascicle but doesn’t damage the actual nerves. Four years ago, a first such electrode was implanted temporarily in a patient (https://actu.epfl.ch/news/amputee-feels-in-real-time-with-bionic-hand/). The test was successful but showed the need to create compact implantables that include much more intelligence and tightly-spaced contact points, i.e. electrodes that stimulate and read the individual nerves.

That is where the recently unveiled imec chip comes in.

Manufactured with the same silicon technology that has been fine-tuned to make today’s advanced computer chips, the new biochip is only 35um thick, thinner than an average hair. On its surface are 64 electrodes that allow stimulation and recording of nerves, with a possible extension to 128. Through a needle attached to the chip, the package can be precisely lodged inside a nerve bundle so that the electrodes come into close contact with individual nerves.

Imec’s experts made the chip in close collaboration with their colleagues from the University of Florida, a main contractor under the HAPTIX program. They selected imec because it offers two unique advantages over other R&D facilities. Unlike most R&D labs involved in chip technology, it also has the equipment and processes in place to do actual high-quality manufacturing. And unlike most other manufacturing sites, it has the flexibility to set up dedicated manufacturing processes for such innovative designs.

What was actually the biggest challenge was not manufacturing the chip itself but rather integrating it with the package. In recent years, imec has developed a series of comparable biochips, think of neuroprobes with hundreds of electrodes along a long flexible shaft. So its researchers knew how to design the prosthetics chip. But until now, they had never created a hermetically sealed, biocompatible and flexible package to serve as a long-term human implant.

To do so, the engineers sandwiched nanolayers with superior barrier properties with very thin flexible polymer layers. The final result is an ultrathin flexible electronic device with a thickness comparable to that of a human hair and suitable for minimally invasive implantation.

The first phase of the project has been successfully concluded, and will now be followed by a testing phase in which the prototype will be manufactured in larger volumes. The new prosthetics chip will then be tested at the University of Florida and possibly also at other labs, mainly to see how it behaves in a biological environment – if it remains sealed and functioning for an extended period. In the meantime, researchers can start looking how to convert all the signals from the nerves into useful signals for the prosthetics. And in the other direction, they should figure out which useful signals from the prosthetics’ sensors they can inject in the nerve system and where precisely these signals should go.
These studies are a first step towards a sensory-enhanced prosthetic. Although it will take another few years to develop a commercially available arm, results like those of the University of Florida and imec show that this type of prosthetic can be made, that patients will eventually get prosthetics that feel more embodied, and that even the full bionic prosthetics of science fiction movies may one day become a reality.

Want to know more?

This work was sponsored by the Defense Advanced Research Projects Agency’s (DARPA) Biological Technologies Office under the auspices of Dr. Doug Weber through the Space and Naval Warfare Systems Center, Pacific Grant/Contract No. N66001-15-C-4018 to the University of Florida.

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Biography Dries Braeken

Dries Braeken obtained his Masters degree in biomedical sciences and his PhD in medical sciences from the KU Leuven, Belgium, in 2004 and 2009 respectively. From 2009 to 2012 he worked as senior scientist in imec’s bioelectronics group. In 2012 he went on to become R&D team leader in the life sciences technology department, and in 2017 he became R&D manager and group leader.

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Data science and data security

Bringing a new level of security and privacy to cloud services

The imec.icon research project SEQUOIA has resulted in an innovative security framework that sets a new standard for shared data stores used by multitenant SaaS services.
Cloud service providers have a hard time implementing the right level of data security and privacy for their SaaS customers (Software as a Service). To help solve this challenge, imec has set up a unique collaboration with three companies that each brought a separate SaaS case to the table. Nicknamed SEQUOIA, the imec.icon research project has resulted in an innovative security framework that sets a new standard for shared data stores used by multitenant SaaS services. SEQUOIA allows fine-grained, attribute-based security rules in accordance with each customer’s own business logic. It has been implemented as an add-on to the data access middleware and can be plugged into proven, state-of-the-art middleware without the need to rebuild solutions from scratch. SEQUOIA was presented recently at ESSOSS17 (International Symposium on Engineering Secure Software and Systems) in Bonn.

**Security and privacy - a challenge for SaaS providers**

More and more companies organize part of their business through software services in the cloud. Take e.g. telecom corporations that create, view, and manage massive amounts of invoices. They can now do so through a SaaS service offered by a third party. This means they will create and manage their invoices through an interface application and a database that is run by a third party: the SaaS provider.

Today however, most of these services lack the inherent possibility to manage data based on customer-specific security or privacy considerations. As a result, an account manager at the telco, could e.g. query and see all possible invoices, irrespective of his role, assigned customers, or region.

A common way for a SaaS provider to solve this problem is to add and program each customer’s security logic in their SaaS application. But that is a solution that is most often not efficient, error-prone, difficult to audit and very expensive to manage and modify.

To make matters worse, this also makes it near impossible for the SaaS provider to have multitenant databases, i.e. databases shared by a number of its customers. To do so would force them to program and manage the security logic of various customers in one application, making audit and modification exponentially hard. So to be able to set up and guarantee at least a minimal level of security and privacy, SaaS providers are currently forced to set up separate installations per customer, which partly defies their business model.

**What is the goal of SEQUOIA and how does it improve the state-of-the-art?**

With SEQUOIA (Safe Query Operations for Cloud-Based SaaS Applications), the project partners aimed to create a generic security solution for SaaS providers, a solution that allows them to set up one multitenant database. At the same time, it also gives each of their SaaS customers the possibility to define fine-grained, attribute-based security rules in accordance with their own business logic. In the invoice example, the telco using SaaS would e.g. be able to define and modify its own restrictions on who can view and change invoices based on e.g. region, function, responsibility, or individual account manager portfolios.
As an example of how SaaS requests are processed today, take the situation where an account manager wants to see all open invoices under his authority. With today’s setup, his request will result in a general database query that will bring up all open invoices. Next, the SaaS application and its preprogrammed security logic will filter the results and display only those invoices that the particular account manager may view. Next to all the issues surrounding the rulebase, this makes the response time and performance dependent on the size of the database.

SEQUOIA, in contrast, will tailor the query before it is executed, so that only the right invoices are searched for and retrieved. This is much more efficient and secure. The rewriting and compacting of queries is done by an add-on module, at the level of the data access middleware, and is thus completely separated from the database or customer applications. The rules for rewriting are provided by each SaaS customer separately, who can enter them in a language that is easy to understand and audit. Each customer’s rules are thus managed and processed separately, no matter how many customers use the same application and database.

As a result, SEQUOIA allows SaaS providers to add value to their service without having to install new databases or middleware, or reprogram the applications. And each of the customers can add and manage its own rules, which makes a huge difference in terms of security and auditability.

**How SEQUOIA works**

SEQUOIA is set up as a middleware for scalable, attribute-based querying of multitenant, cloud-based databases. It is a security solution to enforce complex, custom authorization rules in search queries, with guarantees for safety, correctness and performance.

SEQUOIA is implemented as an add-on to the data access middleware, the API that sits between a database and the query source (customer application, web server...). The solution takes in a query, looks up the relevant security rules, translates these into restrictions that it injects into the query, and then compacts the query before it is sent on to the database. It can be added to proven, state-of-the-art data access middleware without having to rebuild a solution from scratch.

SEQUOIA includes an easy-to-use declarative language with which each SaaS customer can create its own access rule base based on attributes. This guarantees independence for application code, easy access, modification and audit. Because the rules are applied before querying, the performance is not affected by the size of the database.

SEQUOIA’s solution was validated in multiple storage and query architectures, for interactive and background querying, both with SQL structured queries and NoSQL unstructured querying. A proof-of-concept was implemented in state-of-the-art data access middleware and three demonstrators were built and validated in the application domains of the project partners, on top of MySQL, MS SQL, and ElasticSearch.
A win-win for the imec.icon project partners and an added value for SaaS providers

The SEQUOIA project was co-financed by imec and received project support from VLAIO, the Flemish Agency for Innovation & Entrepreneurship. Imec.icon projects support demand-driven, cooperative research involving imec researchers, industry partners or social-profit organizations. Together, they lay the foundation of digital solutions that find their way into breakthrough products.

The SEQUOIA team included two imec research groups (imec–DistriNet–KU Leuven and imec–IDLab–UGent) and three industrial partners. The imec researchers are specialized in security architectures and big data processing. The three industrial partners represent three separate SaaS use cases. UP-nxt manages customer administration data such as invoices, which have access ruled down to the level of single account managers or regions. Verizon has multitenant databases containing logs of managed IT infrastructure, access to which is extremely sensitive and restricted. And ESAS wants to set up a field service management where service engineers in the field can access their tasks, messages and statuses.

Through the experience they gained in the project, the SEQUOIA partners now have all the expertise and software to enhance their SaaS offering. They now work towards validating and including the new middleware into their live environments. From their point of view, they perceive the advantages of the SEQUOIA middleware as threefold:

- It mitigates the lingering doubt of customers about the security of multitenant cloud solutions. With the SEQUOIA technology, each customer will own, validate and audit its own rule base.
- It adds value to the SaaS offering and makes it attractive and competitive, again mainly because of the unique possibility and ease of setting up customer-specific rule bases.
- It greatly lowers operating costs, as SEQUOIA allows for one multitenant cloud installation, with no need for dedicated installations per business case.
Biography Bert Lagaisse

Bert Lagaisse is a senior researcher at imec–DistriNet–KU Leuven and industrial research manager for the Industrial Research Fund of KU Leuven. He leads the cloud and security middleware research tracks. As an expert in multi-tenant cloud architectures and SaaS security, he knows all ins and outs of the SEQUOIA project. Bert can be reached at bert.lagaisse@kuleuven.be.

Smart Industries

Flexible RFID Tags for a Smarter, Interconnected World

Imec has teamed up with Quad Industries and Agfa; a collaboration that resulted in a security badge application that combines plastic RFID tags with screen-printed antennas.

In a truly interconnected world, microchips will not only be embedded in vehicles, household appliances and health wearables, but also in cheaper consumer goods. Smart labels – integrated into products’ packaging, for example – could be used to track items from production till consumption, providing detailed information on a product’s freshness, origin, or preparation instructions. By combining the plastic RFID chips developed by imec and TNO in the frame of Holst Centre with cost-efficient, screen-printed antennas, smart labels may soon become reality. To explore this opportunity, imec has teamed up with Quad Industries and Agfa; a collaboration that resulted in a security badge application that combines plastic RFID tags with screen-printed antennas, both in the tags themselves and in the reader.
**Imec: the perks of plastic RFID chips**

Imec has been exploring the domain of plastic electronics for more than a decade and launched the first plastic microprocessor in 2012. And just last year, imec and Holst Centre received the “Best Product” Award at the Printed Electronics Europe Conference for a joint project with Cartamundi, a manufacturer of board games and playing cards that specializes in giving regular games a digital edge. Together, they developed a set of playing cards with integrated plastic RFID chips (with regular, commercial antennas), combining the joy of a traditional card game with the thrill of a computer game.

RFID (Radio Frequency Identification)-chips allow close-range communication with a dedicated read-out system. Traditional RFID chips are based on silicon CMOS technology, but imec’s plastic chips use thin-film transistor (TFT) technologies instead. The semiconductor, a thin film of metal-oxides (a blend of indium-gallium-zinc-oxide) has a low temperature budget enabling direct deposition on plastic foil, thus resulting in flexible chip technology.

This plastic technology offers significant advantages. Kris Myny (principal member of technical staff - imec) explains: “Because our plastic chips are ultrathin and flexible, they can be invisibly integrated into virtually any product. You can wrap them around your wrist, fold them, or bend them any way you want.” This flexibility makes it possible to include electronics in products that could never be technologically enhanced before. For instance, the plastic tags could be integrated in paper packaging for food, in security documents or even in banknotes. Because the tags are so thin, they can really disappear into the product’s design.

From a commercial point of view, the main advantage of these thin-film microchips is cost-efficiency. Kris Myny: “When introduced in large scale foundry manufacturing, plastic chips have a unique cost advantage. This is because of the technological simplicity. Only a limited number of steps are needed to produce these plastic circuits. When mass produced, we see our chips evolving towards the cost of less than 1 eurocent. That’s about ten to hundred times cheaper than what you have on the market today. Such an ambitious scaling plan would of course require a strong ‘application pull’”, so we are working closely with application companies to define a vision on how this new technology can grow.”

**Quad Industries: printed electronics today**

Quad Industries specializes in printed electronics on different substrates, ranging from plastic to textile or even paper. Wim Christiaens (R&D Director, Quad Industries) explains: “The main advantages of printed electronics are that it’s cost-competitive and allows for direct integration of electronics in any material. Additive processing makes the production process faster and cheaper, and offers a revolutionary path to make any object smart.”

Today, Quad Industries still mainly makes use of silicon chips. Combining its technology with imec’s plastic chips would not only reduce costs even further, but would also open up new application opportunities because of the enhanced flexibility.
Security badge application: plastic RFID tags with screen-printed antennas

In 2015, a consortium of Flemish companies coordinated by Agfa started a new SIM-SOPPOM[1] project, i.e. Met@link. The project aims to use printed metallic inks for conductive functionalities to enhance the technological and economic feasibility of the Internet of Things and hybrid flexible electronics. The project partners recently demonstrated an application example of such technology, i.e. an access control system. The access badge contains one of imec's plastic RFID tags in combination with a screen-printed antenna. Screen-printed antennas have been successfully implemented on top of RFID tags before, but this time, the RFID reader also contains a screen-printed antenna. Previously, the reader always used a standard printed circuit board (PCB) antenna. Using a flexible screen-printed antenna instead allows optimal integration of the reader, even on curved or 3D shaped surfaces.

The cooperation between the Met@link partners was essential to make this demo possible and to overcome related hurdles. A first issue that needed to be tackled was the energy-efficiency of plastic chips: they are more power-hungry than regular silicon chips. Moreover, printed antennas typically have a higher resistance and suffer from high energy loss. Thus, the imec researchers first had to enhance the energy-efficiency of their plastic chip. The energy-efficiency advances of such plastic chips have been presented at ISSCC 2017, the flagship conference on circuit design, where a power consumption of only 7.5mW was exhibited for a complete plastic NFC bar code chip in contrast to an extrapolated power consumption of 250mW of previous work. Agfa, in turn, developed a new kind of ink consisting of silver nanoparticles. Because this advanced nanoparticle-based silver ink is a better conductor, it became easier for Quad Industries to print antennas that can function with imec’s plastic chip. All components then returned to Holst Centre where the antennas and chips were assembled to create complete RFID tags. The result is a flexible chip combined with a credit-card size antenna printed on plastic foil that is so thin that it can disappear into almost any product.

Flexible RFID chip with printed antenna
The next step is to use this combination of plastic RFID tag and a reader device with screen-printed antennas to develop new, more advanced applications. On top, the new approach also makes existing production processes more cost-efficient. Wim Christiaens “For Quad Industries this is an important step forward to simplify our production process. Using screen-printed antennas allows us to immediately print both our customized touchscreens and the antennas on the same plastic substrate. This way we can just print everything in one go.”

The read-out system with screen-printed antenna also features a customized printed touchscreen (developed by Quad Industries) with numerical keypad so visitors can gain access to the building by entering a code.

**Imagining a smarter, interconnected world**

Cheaper technology means more widespread technology. Smart supermarkets, for instance, might become reality soon. Plastic RFID tags with screen-printed antennas could bridge the gap between online and offline shopping. Online shops are able to track consumers’ thinking process: they can see what you’ve bought in the past, what you’ve clicked on and how many times, what you’ve moved to your virtual shopping cart and then removed again. This is valuable information that physical shops miss out on. A company like Quad Industries could, for instance, develop a smart shelf with an integrated RFID reader. If you then use cheap and flexible plastic RFID tags with screen-printed antennas in products’ packaging, you can track how many times each product is picked up and put back. It also makes it easier to monitor a shop’s stock or to check whether there are any items past the expiry date. Because plastic electronics can be mass produced via large-area manufacturing, this would hardly affect the products’ price. Thus, plastic RFID tags could become retailers’ new bar codes.

At the moment, imec’s plastic chips only contain a unique identifier that can be read by a custom read-out system or a smartphone. The next step is to integrate sensors, batteries, programmable memories and displays into these plastic tags. Once these extra functionalities have been added, we can really start to imagine a world where even every-day objects have become smart. For instance, one possible application is the creation of smart blisters - with small plastic RFID tags being integrated into pharmaceutical packaging. The chips could then track whether or not you’ve taken your daily medication and could send reminders to your smartphone if necessary. This kind of tag could also be used to track individual products throughout the entire transportation process: using sensors to monitor temperature and freshness. “The possibilities are almost endless. Because plastic electronics are so much cheaper and can be invisibly integrated into virtually any product, we can really let our imagination run wild,” says Kris Myny.
To pave the way for this Internet of Things, strategic partnerships between research and industry partners are essential. Kris Myny: “Quad Industries can integrate our technology in new, practical applications. They have the experience and customer base to do this.” Wim Christaens adds: “As a technology provider, we need to stay one step ahead of the market to provide innovative solutions to our customers. That’s why the cooperation with imec is so important to us. We’re both in Flanders, so working together is easy and we’re a good fit. The advantage of a project like Met@link is also that we’ve become acquainted with each other’s needs and possibilities. So we’re definitely interested in looking into future collaboration opportunities with imec.”

Want to know more?

- Kris Myny won the poster award at the SIM User Forum 2017. Click here to see the poster, which gives more information on the demo developed within the Met@link project.
- Video that illustrates the future application possibilities of plastic RFID chips
  https://vimeo.com/109811830
- Video on Kris Myny's ERC Starting Grant project FLICs (716426); one of the key achievements of this project was making plastic chips more energy-efficient, enabling the combination with screen-printed antennas.
  https://www.youtube.com/watch?v=Oly5ttEm9wQ

[1] SIM is an independent innovation-initiative that aims to strengthen the competitive position of the Flemish material industry by stimulating scientific research and by encouraging collaboration between the industry and research institutions. The original aim of the SIM-SOPPOM program was to develop printed solar cells, but the scope was then broadened to include printed photonics, printed energy and printed electronics. Met@link is the first project that was defined within this expanded SOPPOM+ program.
Biography Kris Myny

Kris Myny received his MSc in Electrical Engineering from the Katholieke Hogeschool Limburg in 2002. In 2004 he joined imec’s research team and started working on the development of robust plastic circuitry. In 2013 he obtained a PhD at KU Leuven. He is now a Principal Member of Technical Staff at imec and specializes in circuit design for flexible thin-film transistor circuits. His work has been published and presented in numerous international journals and conferences and has received considerable press attention. He was listed as one of Belgium’s top tech pioneers by the business newspaper De Tijd. Last year he also received a prestigious ERC Starting Grant from the European Commission to enable his breakthrough research in thin-film transistor circuits.

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Biography Wim Christiaens

Wim Christiaens graduated as a MSc in Electrical Engineering at Ghent University in 2004. He then obtained a PhD in Electronics Engineering from Ghent University in 2009 for his work on the integration of passive and active components inside flexible circuit boards. In 2014 he joined Quad Industries as R&D director to coordinate all innovations with a strong focus on exploring new technologies and applications in the field of (screen-)printed electronics.
Chip technology and photonics enable smaller, faster and cheaper medical devices

The healthcare arena is on a clear path towards preventative and personalized medicine. Measurements of health status are essential in advising patients and healthcare professionals on the most appropriate preventive or curative measures. However, our ability to measure our health status is hampered by the complexity, cost and size of instrumentation required to acquire that data, and by the complexity of the analysis required to turn that data into actionable information.

But, semiconductor technologies have excelled at making extremely complex instrumentation and data analytics available at a much lower cost. Semiconductor technology can be tuned to enable health measurements anywhere, anytime, by anyone, and at very low cost.

Silicon to the rescue

The key theme to many advances in today’s healthcare research is highly individualized diagnosis and treatment. Not only will we need new tests that are more precise than anything we have today. We’ll also need to make testing so fast and cheap that we can test and treat all patients whenever there is a need. And this without overstretched the already heavily challenged healthcare budgets. More precise and affordable tests should make treatments more effective and thus will have a positive impact on the healthcare budget.

Here is a chance and a challenge for silicon process technology.

The past decades, we have mass-produced complex electronic chips at ever greater performance for ever lower cost. And while we were doing that, we have also learned how to make silicon work with light, how to make silicon surfaces biocompatible, or how to do micromachining and microfluidics. All using the same cost-efficient manufacturing processes.

Today, we can scale silicon components to the same scale as cells and biomolecules. So we’re reaching out, building an interface between silicon chips and biology. The results we obtain in the labs are picked up by companies and are already integrated in the first commercial products. DNA sequencing machines, miniaturized diagnostic tests using disposable photonic chips, accurate body monitoring sensors, brain stimulation probes ...
Silicon technology is one of the most promising solutions for low-cost, sensitive and specific measurements of a large number of biomarkers. It will play a key role in enabling very powerful instrumentation that will facilitate both discovery in the lab and routine diagnostics anywhere and anytime.

**Chip technology has given us ever-faster and smarter computers, smartphones, sensors and will keep on doing this in the future.** We will need further scaling of the chips building blocks for faster and better data communication, computation and storage in large server plants. And, last but not least, chip technology will enable a revolution in healthcare.

**An extra flavor: silicon photonics**

You probably make daily use of photonics: glass fibers make that you can use the internet and watch tv without any problems. These fibers send data with the help of light, which is much more faster and energy efficient than within the standard digital cables.

And, you can do the same on a chip. With ultra-small ‘fibers’ and waveguiding structures you can send light on the chip and make it perform all sorts of tasks such as transporting and manipulating data. Also bio applications are possible. Indeed, light is the most used probe in medical diagnostic testing. Just think of micro- and spectroscopes. Based on light, you can count and visualize cells, measure the characteristics of biological tissues, determine DNA sequences etc. In contrast to datacommunication applications that use near-infrared wavelengths, biological applications use visible light.

Biophotonics on chip is a relatively new research domain that will be very important for diagnostics, therapy and follow up. Doctors will be able to analyze a tissue sample without having to use big (fluorescence) microscope and will study a tissue sample without big spectroscopes.

It is an enormous challenge to make compact optical systems that can perform a medical task in an efficient and reliable way. If you can make your optical circuits out of silicon, just as electronic computer chips, then it becomes possible to integrate the photonic circuits with electronic ones, resulting in a smart and compact system. In fact, in the visible range photonic waveguide materials such as silicon nitride combine easily with standard photodetectors, imagers and sensor arrays. Also, this combination can be mass produced very cost effectively and hundreds and thousands of these sensor systems can work in parallel, resulting in an extremely high throughput of testing.
Based on photonic-electronic hybrid chips, one can make revolutionary healthcare solutions, with the main characteristic of being compact, smart, low-cost and easy to use. Let me give you a few examples of the work we are doing in our research center, imec, that combines the power of integrated photonics and electronics in life sciences.

**Electroceuticals and brain probes**

One of the examples that explain how healthcare can benefit from silicon technology is in the field of implantable electronics that measure and interact with nerves and brain cells.

Such implants can be used therapeutically. There is, e.g. already a proven technique called ‘deep brain stimulation’ to mitigate tremors in Parkinson’s patients. Other technologies referred to as electroceuticals aim to interact with the peripheral nerve system running through our body, connecting organs. The ultimate goal here is to have a technology that can be used to improve the quality of life of people with neurodegenerative diseases, spinal cord injuries, pain management. These implantable probes need to be thin, flexible and biocompatible threads with thousands of electrodes to transmit and modulate neural signals.

Equally important, we need probes that help us better understand the effect of those electroceutical therapies, probes that can directly measure what goes on in a brain. How healthy neural cells relay signals and react on external stimuli. And how this mechanism is distorted by neurodegenerative diseases such as Alzheimer’s disease. Making such breakthrough probes, we can measure the activity of brain cells of living animals. The silicon-based probes have more integrated electrodes and signal processing than was possible until now. The probes allow to chart brain activity with an unprecedented detail.

Next to these multi-electrode probes, researchers from imec have added another instrument to the brain research toolbox: a probe that can stimulate the activity of brain cells by shining light on them. The probes can be used for ‘optogenetics’, a technique combining genetics and optics. Optogenetics was called one of the breakthroughs of the decade by the magazine ‘Science’ in 2010 and more recently a top 10 emerging technology by the World Economic Forum. With the technique, scientists single out a specific type of cell by adding a string of DNA to its genetic material that makes the cells sensitive to light. This DNA, coming from fluorescent algae, instructs the cells to synthesize a protein that forms an ion channel in the membrane of the brain cells. And that ion channel is light sensitive: light with a specific wavelength will cause the channel to open or close, changing the electrical activity of that brain cell while leaving others unaltered.

Imec finetuned its ‘lightning’ neuroprobes for use with two types of proteins: channelrhodopsin and halorhodopsin. The first reacts to blue light (470nm) and increases the electrical activity of the cell; the second reacts to yellow light (590nm) and decreases the activity of a cell. This technique can be used either in vitro or in vivo to stimulate brain cells very precisely and locally and to measure the effects of stimulation. It’s a unique tool for brain researchers to understand the complexity of the brain.
With silicon technology, one can make neuroprobes for therapeutics and brain research, with more integrated electrodes, photonic waveguides and signal processing than standard neuroprobes.

DNA sequencing

Within a foreseeable space of time, determining someone’s genetic code will be as normal as doing a CT scan. Every child will be able to have his or her genetic passport from birth. In fact through prenatal testing of fetal DNA in maternal blood, pregnant woman will get analyzed even before deliver. It will become the foundation for a healthy life. Also, we will be ‘sequenced’ several times during your life. DNA sequencing will become so accurate that you’ll be able to use a blood sample to go looking for ‘rare’ DNA coming from a tumor or an infection. DNA sequencing is the digitization of life.

At imec, we’re developing silicon photonic chips that read DNA molecules in a massively parallel way with minimal preparatory steps. With these chips, DNA sequencing can become a routine diagnostic test. Already today, the cost of the sequencing equipment is falling; the quantity of DNA that can be analyzed per hour – the throughput – is also increasing. We are using our expertise in nanophotonics, CMOS sensors, integration and chip production to improve this equipment. And we are working on it with various major players, too. For example, Pacific Biosciences has been able to reduce the cost of its equipment by 50% and their chips are generating 7 times more information as the result of our working together.

In addition to lowering the cost of the equipment and increasing throughput, we are also making progress towards ‘long reads’ – in which long strands of DNA can be read. This compares with earlier techniques in which the DNA was divided into small pieces, multiplied and then complicated bioinformatic algorithms are needed to restore the information. The advantage of ‘long reads’ is that we can put together a person’s entire genetic map much more accurately and quickly than before. It also makes it possible to detect structural variations. These are pieces of code that are repeated in the genome at specific places. Any abnormalities in this pattern may also lead to health problems.
There are various technologies on the market, as well as equipment in all shapes and sizes – from large DNA-sequencers like they use at Pacific Biosciences, down to small handheld devices such as the MinION from Oxford Nanopore Technologies. So different technologies will live side by side, each one for a different specific market. Small, wearable devices may be important if you want to test diseases such as Ebola in remote areas, whereas the large equipment is useful for producing complete genetic maps quickly and accurately. In all those cases photonic chip technology is particularly important for making these systems more compact, faster and less expensive.

**Cell inspection and sorting**

A third example of silicon- and photonics-based innovation for life sciences is the cell sorter chip that imec is developing. It’s a chip-sized detective that may find rare cells in a blood or urine sample in a faster and cheaper way than is possible with existing tools. Moreover, this ‘liquid biopsy’ diagnosis tool will be much more compact than existing tools, and much easier to use and less invasive than interventional biopsies. The secret: a smart combination of silicon photonic technology, lens-free microscopy, and ultra-small steam bubbles.

It would allow medical doctors to do complicated tests on the fly, e.g. screening blood cells in a patient’s blood sample. Think of an oncologist, who would immediately be able to see if a patient has tumor cells roaming in his blood, a potential sign of metastatic cancer. He would regularly check after a patient’s chemotherapy if the number of tumor cells in the blood has diminished, and if the treatment has to be continued or changed. Cured patients will love to screen their blood regularly when the biopsies are less painful and metastasis can be discovered earlier.

Such a high-throughput ‘cell sorter’ chip would not only lead to faster diagnosis. It could also allow a simple way to isolate tumor cells in order to sequence their DNA and start a treatment based on the characteristics of the specific tumor type. Since treating cancer is like chasing a moving target that mutates itself, regular sequencing of these rare cells becomes increasingly important to adapt therapies. Or used in stem cell therapy, where patient cells are used for culturing and deriving novel types of cell based treatments, it could be deployed to check the quality of the cells as well as to filter out cells which may be dangerous for patients.

For visualizing and identifying cells, the cell sorter uses optical waveguides to measure cell signals. A waveguide illuminates the cells in the fluidic channel one by one as they pass. An image sensor placed under the channel captures the emitted or scattered pattern of the light that has passed through the cells.

A microfluidic switch is used to separate the cells of various types. The switch is based on small, star-like heating elements. These heating elements create steam bubbles that push the cells into the right channel. Sorting with these jet flow generators takes about 100 microseconds per cell. Both this speed and the fact that no moving elements are used, is a great advantage of this device for robust and automated cell processing.

This concept and prototype of a cell sorter becomes extremely powerful if you consider the parallelization that is possible with the silicon chip technology. Whereas the first prototype had only one microfluidic channel, the next ones were extended to tens or even hundreds of channels that function in parallel and thus can sort hundred thousand and even millions of cells. That way, it becomes possible to attain an unseen throughput for cell analysis and sorting.
‘Cell sorter’ 5 channel flow cytometry chip that identifies and sorts 5,000 cells per second per channel.

**Biography Liesbet Lagae**

**Liesbet Lagae** is co-founder and currently Program Director of the Life Science Technologies in imec. In this role, she oversees the emerging R&D, the public funded activities and early business creation. She holds a PhD degree from the KU Leuven, Belgium for her work on Magnetic Random Access Memories obtained under an IWT grant. As a young group leader, she has initiated the field of molecular and cellular biochips leveraging silicon technologies at IMEC, Belgium. The life science program has grown from emerging activities to a mature business line that provides smart silicon chip solutions to the life science industry. Applications include medical diagnostics, point-of-care solutions, DNA sequencing, cytometry, bioreactors, neuroprobes, implants. She holds a prestigious ERC consolidator grant for developing a platform on single cell analysis and sorting and she coordinates the PIX4LIFE pilot line consortium aiming to port photonic IC technology in the visible range to life sciences. She has (co-) authored 125 peer-reviewed papers in international journals and holds 15 patents in the field. She is also part-time professor in nanobiotechnology at KU Leuven/Physics department.
A breakthrough camera solution for harsh weather conditions

By integrating a hyperspectral filter on top of a gated CMOS imager sensor, the European-funded I-ALLOW project resulted in a unique solution for competitively-priced video surveillance.

Video monitoring is an expanding industry; security and surveillance cameras have become ubiquitous and are used in a wide variety of contexts. One of the limitations of current camera solutions is that image quality deteriorates drastically in low-lighting and harsh weather conditions (fog, snow, rain, etc.). By integrating a hyperspectral filter on top of a gated CMOS imager sensor, the European-funded I-ALLOW project resulted in a prototype solution for competitively-priced video surveillance that ensures high visibility in any situation and enables distance targeting as well as integrated video content analysis.

Tackling the limitations of outdoor video surveillance

It’s crucial that we can rely on security and surveillance cameras 24/7, regardless of any external circumstances. Even if something happens in the middle of a dark and foggy night, we still need to be able to monitor incidents closely. Yet, most current video surveillance solutions are unable to provide high-quality images in this kind of situation. And the few high-end professional cameras that can do this are often too expensive or too big to be widely implemented.

The I-ALLOW project, funded by the EU under the H2020 program, has tackled this problem. The result is a prototype camera that uses a novel hyperspectral filter combining both conventional color (RGB) and near-infrared (NIR) vision, which allows you to virtually see through smoke, fog, rain, etc. Moreover, because of the gated imager sensor, the camera enables distance targeting, which means that you can choose to focus solely on objects that are further away without being distracted by details nearby.

The prototype was developed within an international consortium, bringing together the expertise of four partners, i.e. Aitek (Italy), BrightWayVision (Israel), Proprs Ltd (UK) and imec (Belgium). The collaboration resulted in a demonstrator camera that is ready to be fine-tuned and commercialized. The technology readiness level of the prototype is estimated at TRL level 5 to 6, meaning that it has been tested in a relevant environment and performed close to the expected level. The final prototype was tested in three diverse contexts, with the support of the Maritime Office in Gdynia (Poland), Tecnositaf (Italy), and SNCF (France).
Combining cutting-edge technology: a gated CMOS imager sensor with hyperspectral filter

The solution developed within the I-ALLOW project is based on an innovative CMOS imager sensor, developed by BrightWay Vision. This sensor combines two advanced features. First, the camera sends out a pulsed near-infrared (NIR) signal, invisible to the human eye. These light waves reflect against the objects they encounter so the signal returns in the direction of the camera. The sensor then captures the returning light waves and, based on the known speed of light, automatically determines how far away an object is (time-of-flight). This is combined with a second innovative feature, i.e. the gated principle. The gated sensor uses the pulsed NIR light to focus solely on objects at a predefined distance.

This is useful in cases where it’s important not to clutter images with irrelevant information closer to the camera. For instance, in traffic, the headlights of an oncoming car may obscure the camera’s view. By adapting the camera’s exposure time in such a way that you ignore the first light wave signals that are sent back and only start capturing the signals after, for example, 3 milliseconds, the headlights will not be part of your image, thus rendering an uncluttered view of oncoming traffic. In the same way, the gated principle can be used to ‘see’ through smog, fog, rain, snow, etc.

Using infrared pulses would normally require a dedicated infrared sensor, but in this project imec developed a novel hyperspectral filter that combines both NIR and conventional color (RGB) filters on a single chip. Leveraging their background in CMOS scaling, the imec researchers were able to deposit and pattern these filters directly on top of the CMOS sensor pixels at wafer level. This specific application was extra challenging as it required the researchers to combine imec technology with external components. The color filter in this application, for instance, came from an external foundry and was combined with imec’s NIR filter. To make this work, imec researchers needed to adapt the design of the filters to make sure they matched.

Combining NIR and RGB filters also implies that a trade-off needed to be found between the number of NIR and RGB tiles in the pattern that is repeated on the imager sensor. BrightWay Vision designed two potential patterns: the first one appears to be the most interesting one in this context as it provides slightly more infrared information. They also developed an advanced demosaicing algorithm to make sure that both the RGB and the NIR image can be rendered in the same resolution.

Imec deposits the RGB and NIR filter on top of BrightWay Vision’s gated CMOS imager sensor at wafer level.
A third partner, Aitec, was then responsible for building the camera around this advanced imager sensor. They integrated all the components and developed advanced software for video analysis, specifically targeted at security camera applications.

**Advanced testing in three use cases**

One of the strengths of the I-ALLOW project is that the prototype has been tested in three diverse contexts in close cooperation with international industry partners.

The first context in which the camera was successfully tested is in the Polish harbor of Gdynia. The camera was installed on top of a surveillance tower that provides navigational instructions to ships entering the harbor and on a ship that was making its way through a canal. The advantage of the I-ALLOW solution is that clear vision is guaranteed even at night or in harsh weather conditions where regular cameras fall short.

In a second testing environment, the camera was placed inside an Italian road tunnel. The advantages brought by the I-ALLOW system in this case are two-fold. The first benefit is that the system offers automatic video content analysis. Thus, the control room and other drivers can be alerted automatically in case an accident occurs inside the tunnel. The gated imager ensures good video quality, even in situations where regular cameras fail, e.g. when there is a lot of smoke development.

Finally, the camera was also tested in French railway stations. In this context, the system can be used for a variety of purposes. It can be mounted on top of a train to provide a clearer image in difficult weather conditions, but it could also be placed somewhere along the tracks to locate potential trespassers, or it could be used for surveilling the railway station itself, e.g. for tracking suspicious individuals. In this case, the NIR filter is important to ensure good visibility - even at night or on rainy, foggy days. The color filter can then be used to provide additional details.

In all of these situations, regular cameras are already in use today. The problem is that in harsh weather conditions their video quality becomes so poor that it no longer provides an added value. To a certain extent, current hyperspectral cameras could also offer a solution here, but of course these are very expensive and – due to their size – rather cumbersome to use. The I-ALLOW solution on the other hand could be produced at a competitive price and is about the same size as a regular surveillance camera, making it easy to integrate it in a wide variety of contexts.

**The road ahead: customized hyperspectral filters**

The practical tests have proven that the security camera demonstrator developed within the I-ALLOW project offers commercial opportunities. Additionally, the project allowed each individual partner to further fine-tune their own expertise.

Imec, for instance, already had a lot of experience with more generic hyperspectral camera systems, offered as off-the-shelf cameras. In the framework of the I-ALLOW project, this know-how was used to develop a hyperspectral filter adapted to a specific security camera application, customizing it to work with BrightWay Vision’s gated CMOS sensor. The expertise imec acquired in this project creates opportunities for other use cases and application domains.
Want to know more?

- Learn more on imec’s expertise in hyperspectral imaging on this page.
- Read this paper for more information on the technology that imec and BrightWay Vision developed together.
- The I-ALLOW project is funded by the EU under the H2020 program (contract number: 645262). For more information, check the I-ALLOW project website.

Preface July 2017

Each month, our CEO reflects on his life and work and discusses the topics described in that month’s imec magazine issue.

Pushing boundaries

This month our colleagues Ludo Deferm and Lode Lauwers went on a business trip to South Korea, accompanied by princess Astrid and more than 250 business people and academics. The economic mission was a success and resulted in 15 contracts between Korean and Belgian partners. The Flemish Minister of Economy, Pilippe Muylters, and our colleagues also got the opportunity to visit the Samsung factory in Dongtan where they were welcomed by Dr. Kinam Kim himself.
Think of DRAM and NAND flash memories and Application Processor Communication Modems. More recent research conducted by Dr. Kim and his team focuses on graphene, carbon nanotubes, quantum dots, 3D fusion, batteries and printed electronics — i.e. the technology that will shape our future. At the imec technology forum last month I had the honor of presenting Dr. Kinam Kim with imec’s Lifetime of Innovation Award. We also had the opportunity to interview him for an article in this month’s imec magazine.

Working with Samsung and, more specifically, Dr. Kinam Kim, means meeting high standards. At every meeting, we are challenged to continuously push boundaries. Luckily, this is exactly what imec and its partners excel at. For instance, take a look at our excellent results in the field of memory and processor chips, which were demonstrated at the latest VLSI conference: gate-all-around transistors with strained germanium, smaller than 10 nm; transistors with extremely low contact resistance thanks to the implementation of gallium ions; and a unique vertical transistor for NAND memory based on a new material and architecture.

New transistor materials, architectures and process steps… until 2007 this was my world and my passion. Since I became imec’s CEO, this passion has grown exponentially and has expanded to include other research domains as well. In this way, I’ve become really fascinated by our life science research. Chip technology can have a significant impact on our health. For example, we’ve recently developed an implantable chip that can function as the ‘missing link’ between an artificial arm/leg and the patient’s still functioning nerves. By connecting these two worlds in a more accurate way, prostheses will feel much more natural, to the extent that patients can even get a sense of ‘feeling’ in their fingers.

During the last Board of Directors’ meeting, I was also brought up to speed with other health-related news from our spin-off miDIAGNOSTICS. Researchers at imec and John Hopkins University have managed to develop a very compact system that can count cells in a blood sample extremely fast and accurately, using imec’s ultrasmall lensefree microscope. MiDIAGNOSTICS will commercialize this application. It’s a beautiful example of how chip technology can also make a difference in other application domains.
Luc Van den hove,
General director and imec CEO