**Inside Emberion: using quantum dots to transform infrared imaging**

By

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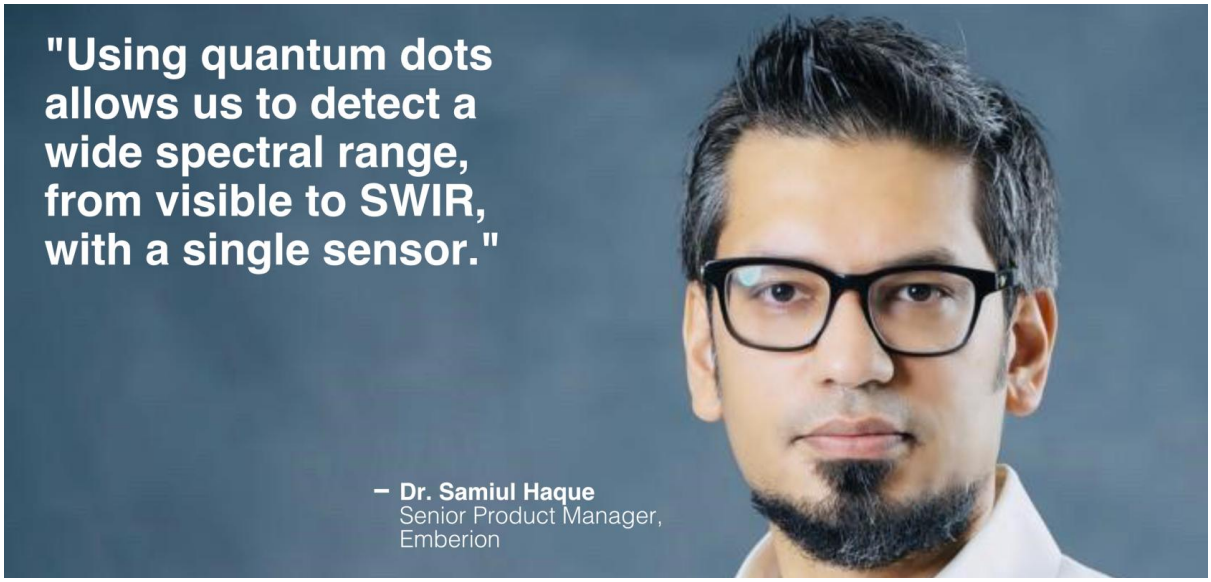



*Image: Emberion*

Senior Product Manager at Emberion, Dr. Samiul Haque, sits down with Imaging & Machine Vision Europe to discuss how the company's quantum dot sensors enhance infrared cameras, opening doors to new markets and applications.

**Imaging & Machine Vision Europe: Tell me about Emberion. What's your process for driving innovation in advanced infrared camera and sensor development?**

**Samiul Haque:** Emberion spun off from Nokia technologies in 2016 and is an independent company based in Espoo, Finland and Cambridge, UK, with a background in cutting-edge research and developing sensors and sensor technologies.

As a company, we design our own CMOS read-out integrated circuits (chip design) at the Espoo HQ, while the Cambridge office has expertise in quantum dot nanotechnology-based devices. Both of these design and manufacturing centres work as one team to integrate quantum dots with the custom-designed chip.

This allows the company to own its own IP, having the freedom to operate with unique design features and operate in various markets using diversified products. Emberion is one of few companies with an end-to-end design process, from the chip all the way to camera products including electronics, material deposition and hardware/software (HW/SW) integration.

The team thrives on innovation, believing in the development cycle with a unique design-based mindset. Our innovation pipeline drives our current and future roadmaps, which we continuously improve to create optimised solutions.

Collaborating closely, our product management and R&D teams deliver market- and customer-driven products. One of the company's visions, for example, is to design a tri-band image sensor chip that can simultaneously operate in the Vis / SWIR / Thermal, enabling the user to work in all infrared bands, with one single camera.

**IMVE: What are the key features of Emberion's VIS-SWIR cameras, and how do you differentiate your product offerings from those of competitors?**

**SH:** Our primary product, the Emberion Vis SWIR series, has many key differentiating features. It has a wide spectral range, from 400-2,000nm, a very high dynamic range of 120dB and a high speed of 400 fps full-frame, providing unique software and hardware compatibility for the markets.

Our main differentiator in terms of the technology is that our sensors are manufactured using a monolithic integration process which is highly scalable and compatible with the semiconductor process. There is no wafer bonding process which can be challenging and its not based on InGaAs.

Using quantum dots allows us to detect a wide spectral range, from visible to extended SWIR wavelengths, with one single sensor. It allows us to scale the pixel depending on customer requirements, and then drastically reduce the cost using optimum packaging design. This allows the technology to attract consumer, automotive or medical applications, to name a few.


*Camouflage detection: Jyri Hamalainen in uniform taken with both Vis and SWIR camera. Image: Emberion*

**IMVE: What are your main areas of R&D focus at the moment?**

**SH:** Our R&D department is focusing on multiple areas including new product variants that cater for various applications such as push broom sensors for enabling hyperspectral imaging, with unique features and dedicated sensors. We're also actively optimising the camera and sensor designs with the hardware/software/quantum dot material stack to support the product roadmap.

Our pipeline includes incremental developments like these but also disruptive ones that set us apart. One of these we're working on is a wafer-level packaging solution for the mass market with highly affordable, high-volume deployment. This would be under a non-recurring engineering (NRE) arrangement.

**IMVE: Tell me about any recent examples or case studies that demonstrate the capabilities of your advanced infrared cameras in end-user applications.**

**SH:** Our cameras have been evaluated in various applications across machine vision and defence markets. Optical sorting applications such as for recycling and food sorting are also important areas where Emberion cameras have the opportunity to reach their full potential, reaching speeds up to 400 fps full-frame and even faster.

Our products also cater to the sustainability markets by optimising recycling lines, where efficiency and quality of detection and sorting is important. Our extended range sensor, for example, detects PVC and other difficult materials, and we currently have MWIR technology in our innovation pipeline that can detect black plastics as well.

Meanwhile, for surveillance, we have another product variant optimised for an atmospheric condition window of between 1500 and 1700nm. This is important for border surveillance tasks in harsh environments such as snow, haze and fog.

*Image: Emberion*

**IMVE: What are the major challenges you've faced during product development, and how were they overcome?**

**SH:** There are always challenging aspects when developing unique or new products driven by innovation. One example that comes to mind is the initial adaptability of new technology, and that the ecosystem around it needs the right level of maturity.

When we started our journey with a broad spectral range sensor, for example, there were hardly any lens providers from 400-2000nm. Now the industry has adopted much more, and collaborating with the ecosystem is a fundamental task that needs to move forward in parallel.

**IMVE: How do you ensure your products are easy to integrate into new or existing systems?**

**SH:** We have a strict lifecycle management process involving qualification and a product integration roadmap, enabled by excellent teams of experts, engineers and a world-wide sales team all communicating and adhering to a continuous improvement process. Customer feedback is taken onboard and we dive deep into it to solve the problem, ensuring the customers can understand and integrate the technology into their own systems.

We rely on standard operating procedures (SOP), we are an ISO 9001-compliant company and we follow industry standards for infrared imaging. That all makes sure our customers are able to easily integrate our cameras. For example, the cameras are GigE Genicam compatible, which is widely used in machine vision.

Application-driven discussions with our industry partners and customers also allow us to understand their requirements, which is always a key driver to success. Emberion studies and ensures active relationships through projects with the customers in order to understand their needs. We follow industry standard protocols in order to cater for the existing markets but at the same time keep our innovation pipeline active so customers can integrate our cameras.

One example is in hyperspectral imaging, where we are developing a push broom sensor for hyperspectral system integrators. As we design the CMOS ROIC (readout integrated circuit), we have the freedom to design and target specific application products for that integrator.

*SWIR 1920 nm image shows water contrast on coffee beans. Image: Emberion*

**IMVE: How do nanomaterial-based sensors enhance the performance of your cameras?**

**SH:** The nanomaterials are key to performance. These are primarily nanostructured semiconducting crystals, i.e. quantum dots which are sub 10 nm in diameter. These quantum dots have unique properties which allow them to absorb broad spectral wavelengths and can be monolithically integrated into the fabrication process on the wafer surface.

It's possible to tune the wavelength by varying the size of the dots up to 2500 nm. And with tunable spectral bands you can customise the excitonic peak, and SNR (signal-to-noise) performance can be very competitive.

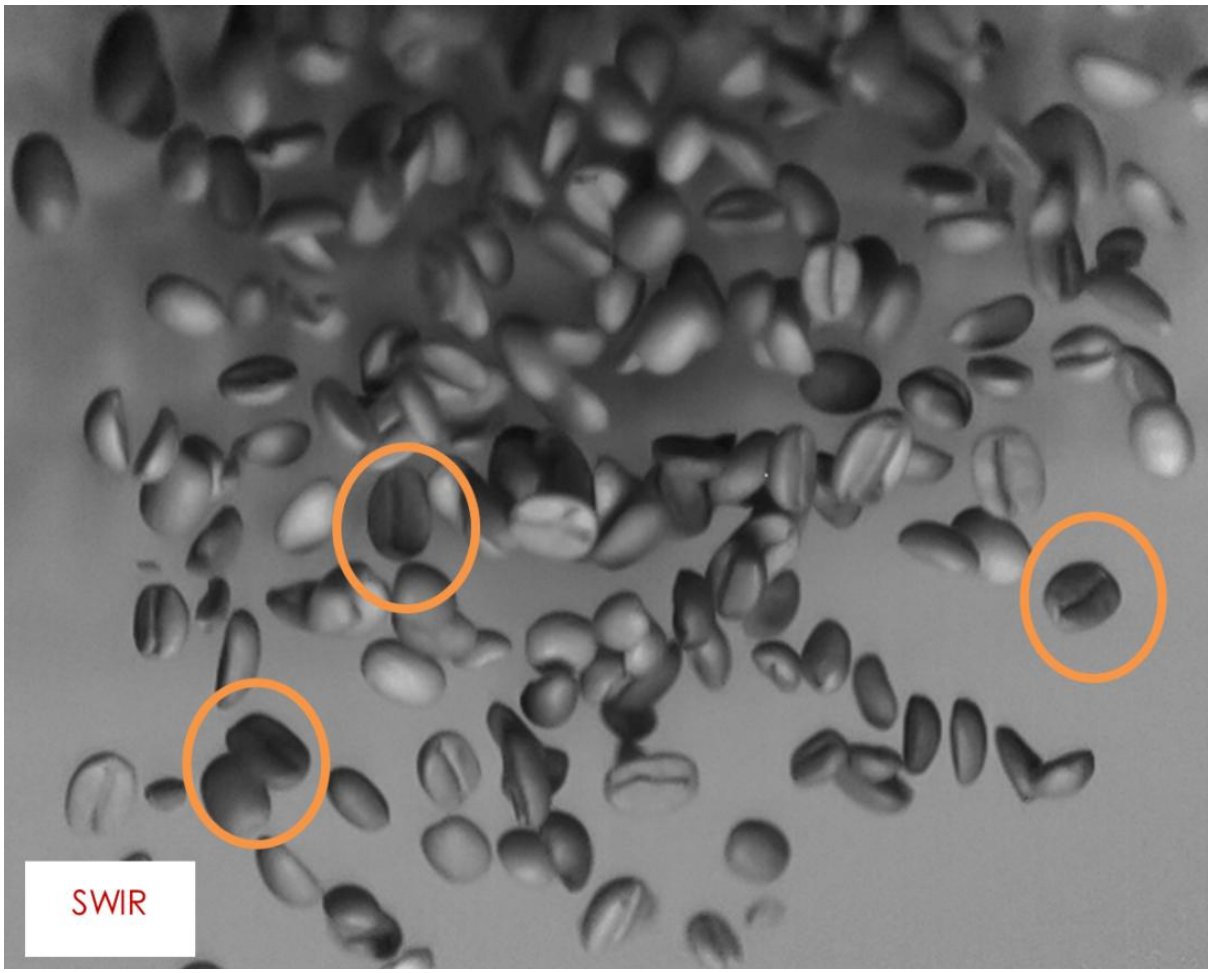
The nanomaterial stack design on the CMOS chip has enabled high performance, one of the fastest QD-based cameras with a very high dynamic range (>120db) and 400 fps full-frame images, which are unique features made possible by the technology.

The other important point here is that nanomaterials can be deposited using standard semiconductor processes, and monolithically integrated on to the chip, i.e. by spin coating. This allows the process to be highly scalable and affordable, ultimately paving the way towards consumer products and the automotive industry, as well as the industrial machine vision & defence sectors. Furthermore, the nano materials help extend the spectral range to 2500 nm in the MWIR and LWIR, opening up a new generation of products in various spectral bands.

**IMVE: What kinds of support do you offer to your customers during (and after) installation?**

**SH:** We have dedicated product management and sales & support teams, who create an environment with continuous open dialogue. It's a learning process for both us and our clients, but products must ultimately meet both the technical and commercial requirements of the customer. We try to keep that balanced so it's a win-win scenario.

In terms of installation, Emberion cameras are easy to setup and we provide full instructions for standalone operations. Despite that, however, we still go a step further with our customers. The engineering team is involved during the feedback process and product lifecycle management is a process of continuous improvement. For us, customers always come first and our obsession to support and resolve custom issues (if there are any) is at the heart of our philosophy.




*Coffee bean detection with SWIR. Image: Emberion*

**IMVE: So customer feedback has a big influence on your business practices?**

**SH:** Absolutely, we started developing single pixel detectors but, after looking at the market position and listening to customer feedback, we moved towards image sensors. We developed the faster 400 fps camera based on feedback from customers needing optical sorting applications, for example. Seeing is believing, so we try and support the customer with active visits and demonstrations and support customer applications, whether they're B2B or B2C.

Another example is when we started the company we started working on LWIR but, looking at the target market and feedback we received from customers, there were other fundamental

industry issues that deserved more attention i.e. MWIR. So, we changed our focus to MWIR development.

**IMVE: Tell me about some of the emerging imaging and sensing trends you're particularly excited about engineering products for.**

**SH:** SWIR is still a growing market, and we will continue to see SWIR adopted in medical and automotive applications. Our newest release, for example, uses wafer level packaging for high-volume applications, and one day, we'll be able to target consumer level applications such as mobile devices, at an affordable price.

**IMVE: Are there any partnerships you can discuss that have been pivotal to your success?**

**SH:** We have extensive partnerships with various industry bodies and R&D units across the globe, and we've been working with lens manufacturers, lighting providers and research bodies to develop proprietary solutions.

**IMVE: You recently attended Photonics West. Are there any other upcoming events you plan to visit or exhibit at?**

**SH:** We will be at DCS & Automate in US and then Automatica in EU, DSEI in London and IDEF in Turkey. We balance between the defence and machine vision markets.

**IMVE: What do you think is the value in attending physical events in the current market climate?**

**SH:** Meeting customers (or potential customers) and live demonstrations still make a massive difference when it comes to showcasing technology working in the form a product. We try and keep the right balance between attending physical events and reaching out using digital marketing processes. It gives us the opportunity to meet industry leaders; learn about new and upcoming technologies, the market and competition; and engage ourselves in the photonics community.

Topics

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