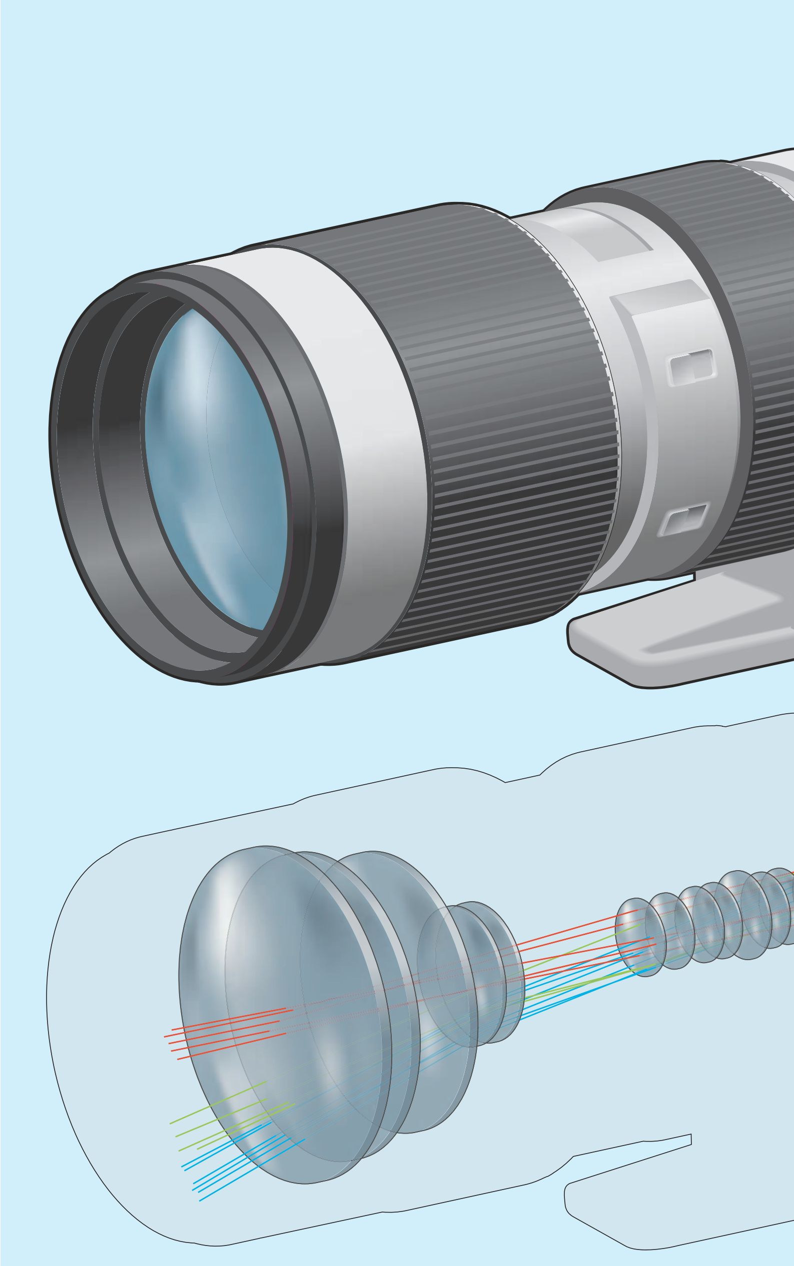
Focusing on the future



Smart vision systems are just one facet of imec's mission to harness the power of nanoelectronics.
By **Graham Pitcher.**

Since being established in 1984, imec has become one of the leading nanoelectronics research centres. The Belgian centre operates on a collaborative basis, using global partnerships to develop what it calls building blocks for a better life in a sustainable society.

While it believes Moore's Law based scaling will continue for another decade, imec is looking more towards integration to develop devices with extended functionality, including sensors, micro or nanoelectromechanical systems (MEMS or NEMS). However, it accepts this convergence will impact ic design, processing, integration and packaging.

Alongside pure cmos development, imec has a complementary programme called CMORE. This platform approach for application specific design and process codevelopment allows companies to build upon the basic cmos process by adding such technologies as MEMS, photonics and sensors.

One particular focus at imec is smart systems. It's a wide ranging term which encompasses systems that interact with people and the environment. Smart systems research covers such elements as cognitive radios, biomedical signal processing and energy harvesting. But one interesting avenue of research which promises to have a radical impact in an unexpected area is vision systems.

In particular, imec is conducting a development programme that could see the end of interchangeable lenses for digital single lens reflex (slr) cameras.

Leading the research work is Johan de Geyter, imec's department director for digital components. He said: "We want to create next generation vision systems using CMORE and our design expertise. But we can't rely on only improving one component, we have to combine application and technology system know how."

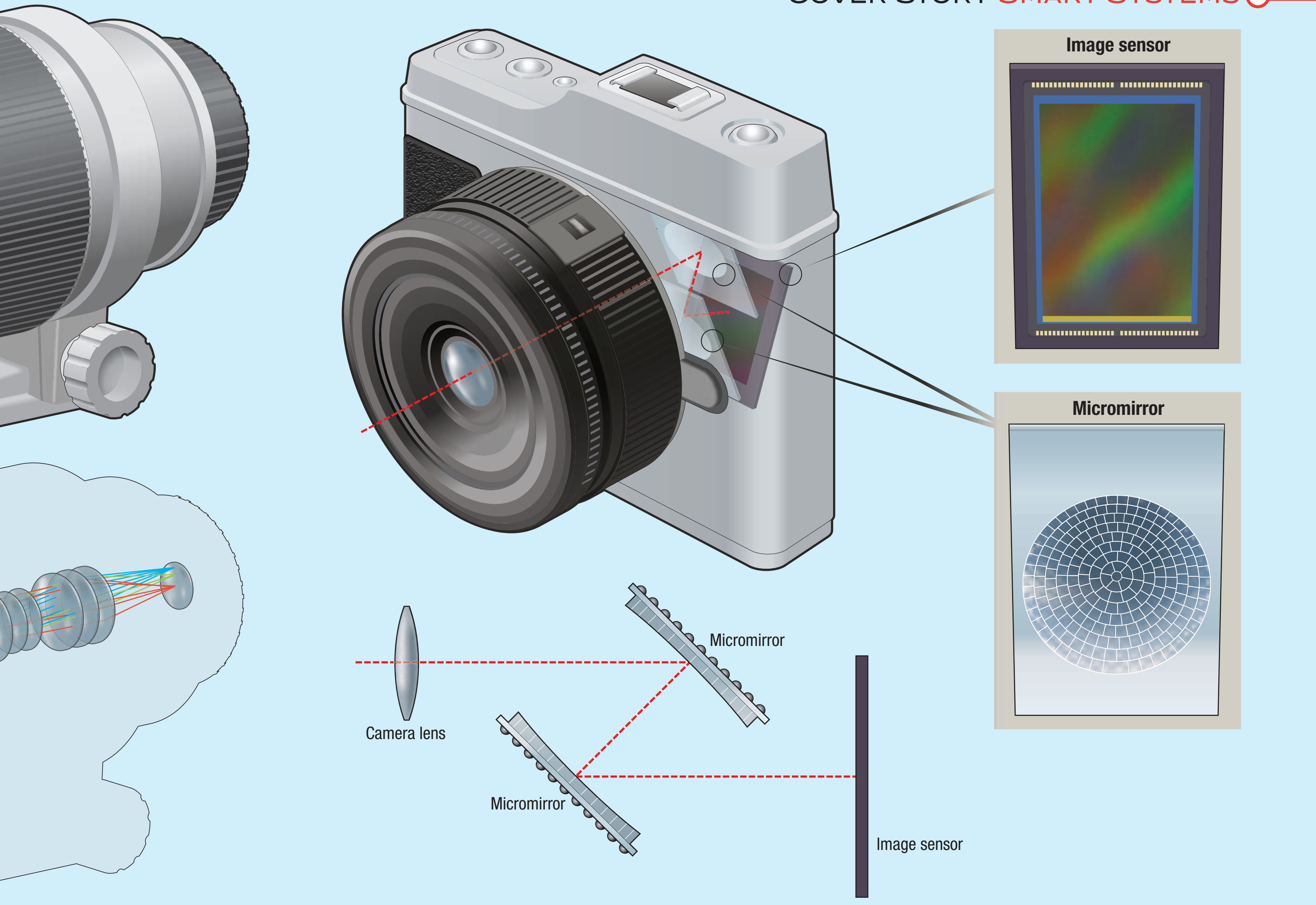
de Geyter: "Each tuneable micromirror will be different in size and shape."

Photographers looking for the highest quality images will pay a lot of money for the right lens. But the big lenses favoured by professionals are not only expensive, they're heavy. A big telephoto lens can contain 20 complex lenses, measure 50cm in length and weigh 6kg. Not only that, getting the right zoom and focusing the image is generally a manual process and slow.

de Geyter is using adaptive optics to make a zoom lens system for digital slr cameras. When developed, the micromirror based system will offer full electronic control and no mechanical movement. The system is likely to be less than half the size of current lenses, but will provide twice the zoom range with the same quality.

What is surprising about the proposed system is its relative lack of complexity: just two micromirrors handle zoom and focus respectively. de Geyter believes the micromirror system will have wider application than just replacing telephoto lenses. "There are lenses everywhere," de Geyter pointed out, "in everything from mobile phones to telescopes. The idea of this project is to embed micromirrors into the optics of cameras to make the system more compact, better quality and to enable more features. It will also reduce cost."

The micromirrors being proposed are broadly similar to Texas Instruments' Digital Light Processing technology in that the surface of the chip is covered



with an array of individually steerable mirrors, each measuring about 8 x 10µm. "Each tuneable parabolic micromirror will be different in size and shape," de Geyter explained.

de Geyter believes the micromirror system will be small enough to be integrated into a standard camera housing.

Apart from reducing size and complexity, the system is likely to bring new features to cameras, including enhanced movement control and the ability to focus different areas of the image.

Today, depending on the particular lens, the photographer has to focus on a particular part of the image; the rest will be out of focus. The smart lens system could enable more than one optical axis. Not only might this allow multiple images to be captured from one shot, but it could also broaden the ability to capture panoramic images. And it also holds the prospect of all elements of an image being in focus – something achieved today by manipulating multiple images using software.

"The lens technology is already available," de Geyter noted, "and we are now building applications to prove the system can replace existing lenses."

de Geyter is also leading work on developing hyperspectral imaging (HSI). "Traditional machine vision relies on shape and colour to identify targets and we want to improve on that by adding multiple wavelength detection." The approach takes advantage of the fact that every material has a fingerprint. "Current RGB scans can classify different objects as being the same," he explained. "HSI uses a spectral classification to group items correctly."

HSI is already used in some sectors, including food processing, but de Geyter says the technology can be improved. "We believe we can add value to solutions by making more accurate estimates. Current HSI cameras are large, expensive and slow. We're looking to improve accuracy and reduce cost."

Where a current HSI system may scan at 180line/s, de Geyter believes a system can be built that scans at more than 8000line/s. The system uses a Fabry-Perot filter on top of the image sensor, along with a tuneable MEMS filter, providing a wavelength resolution of 0.1nm. The system is sampling 265 wavelengths and uses up to 10 of these to identify a material definitively.

A development of this technology is what imec is calling a melanoma pen. Using a controlled light source and an HSI module, imec believes real time analysis of skin blemishes could be possible.

"We're trying to make a prototype by the end of next year," he said, "and this will contain all the elements needed. Shrinking the device to a suitable size will take a couple more years and certification will be a crucial factor. But we could have a device on the market in five years."

The Smart System approach is also being applied to biomedical devices. Harmke de Groot, program director for ultra low power dsp and wireless, said the work is looking to help meet the needs of healthcare organisations as the population gets older. "A lot of diseases that killed before are now chronic diseases and technology can be applied to make sure patients are not in hospital unless necessary."

IMEC and research associate Holst Centre have already made ambulatory van den Hove: "Nanoelectronics will bring technology that will improve our quality of life."

devices, but these have relatively large batteries and are not physically flexible. Work is now underway to address power consumption in order to allow better form factors.

However, even if such devices are made more convenient, the amount of signal processing required remains high. "Bio signals aren't clean," she said. "When people move around, you get motion related artefacts and, if you think about EEG signals, motion artefacts are hundreds of times larger than the signal you're looking for."

One way to reduce power consumption in such devices is to reduce the amount of data which needs to be transmitted. And that requires local signal processing. A benefit of this, apart from power consumption, is feedback can be given to the wearer.

Biomedical processors

de Groot's team is working on three biomedical processors: BioDSP; Bioflux; and ECG SoC. BioDSP, optimised for ECG and EEG application, is already available. It can reduce power consumption to 10μW when using a 0.7V supply. Bioflux features NXP's Coolflux dsp core. "We're focusing on making sure power consumption and leakage is reduced," de Groot continued. "The processor is only active for 0.13% of the time, so most of the power is consumed in stand by."

Bioflux takes advantage of some low voltage design techniques, including bias control and low voltage logic cells. A technology demonstrator is expected later this year.

The final processor, ECG SoC, will have advanced motion distortion removal functions, while memory and I/O footprint will be smaller because of analogue and digital codesign.

"This device includes an analogue front end and a digital back end," she explained. "But we're going back to a 0.18μm process." While this apparently backward move requires a higher voltage supply, de Groot said special techniques had been developed to keep power consumption down. "If we make the device in one technology, we can be clever enough with the digital part so that overall results will be better."

Interestingly, de Groot is considering operating the device at a sub threshold voltage. "This may well reduce dynamic power," she noted, "but leakage power will increase and becomes dominant."

Energy harvesting is one potential power source for ambulatory monitoring devices and another strand of imec's Smart Systems research. Ruud Vullers, principal researcher and micropower program manager, said the target was to generate 100μW/cm^2 through the harvesting of vibration, heat, light and rf energy. Beyond that, the work is looking to integrate energy storage solutions, including supercapacitors, and to develop cost effective fabrication techniques.

imec believes its melanoma pen concept, supporting real time analysis of skin blemishes, could be on the market in five years.

de Groot: "[With] EEG signals, motion artefacts are hundreds of times larger than the signal you're looking for."

"Batteries alone will not offer autonomy," he claimed, "and a 100μW load will only be supported for up to three months, so energy harvesting offers a solution."

Admitting energy harvesting is not new, Vullers contended that early devices were big, heavy and expensive. "Size and weight will be important, so we are looking to use MEMS technology to bring the cost down."

He envisages building harvesters on 6 or 8in wafers using a cmos compatible process. But this approach is likely to pose a number of challenges. "There are no device libraries," he pointed out, "and 3d design is non trivial. We will also have to develop some of the processing technology and pay attention to device yield and uniformity."

Further problems are likely to be found with materials. "Not all the materials we would like to use are clean room compatible," he continued. And packaging will be critical because it will be an integral part of the design.

Vullers is exploring electrostatic and piezo based vibration harvesters. Piezo technology currently generates more power and imec has recently generated 100μW using a vibration frequency of 572Hz. "We are now looking to generate 200μW," he added, "and if you can package these devices in a vacuum, it gives a big advantage."

The electrostatic approach requires a more complex design. It uses the principle that a voltage is generated when an electrode moves in a magnetic field. There is a fixed electrode at the bottom of the device, with a moving seismic mass. On top, but not touching, is an electret. The seismic mass must be allowed to move horizontally, but not vertically, which requires a spring system much stiffer in the Z direction.

The electret, which has a 2μm thick oxide layer, has been charged to 1kV and Vullers is confident this can be retained for more than 10 years. The arrangement has so far generated about 1μW.

Looking to capture heat, imec has developed a MEMS device which features SiGe thermocouples. Already, a thermopile 6μm high has been constructed and Vullers claimed the output was 258mV/K. "This equates to 10.32V/K/cm^2," he added. "On human bodies, we could be generating 1μW with a delta T of 3K."

For the future, the work will explore materials such as bismuth telluride and other new nanomaterials allowing lower contact resistance and higher output voltage.

imec's president and ceo Luc van den Hove concluded: "We are convinced that nanoelectronics will bring technology that will improve our quality of life and which will contribute to making the world more sustainable. While all of this will be enabled by progress in semiconductor technology, applications will need complex chips."