Project profile

CATRENE
Cluster for Application and Technology Research in Europe on NanoElectronics

CA301 | High dynamic range low noise CMOS imagers (HiDRaLON)

PROJECT CONTRIBUTES TO

Communication	✔
Automotive and transport	✔
Health and aging society	✔
Safety and security	✔
Energy efficiency	
Digital lifestyle	✔
Design technology	
Sensors and actuators	
Process development	✔
Manufacturing science	
More than Moore	
More Moore	
Technology node	

TECHNOLOGY PLATFORM FOR PROCESS OPTIONS

Partners:

CRS iiMotion
e2v semiconductors
Fraunhofer IMS
Grass Valley
Helion
IMS Chips
Nikhef
Philips
Pilz
Thales Angenieux
TU Delft
Uni Burgundy
Viimagic

Project leader:

Klaas Jan Damstra
Grass Valley

Key project dates:

Start: March 2009
End: June 2012

Countries involved:

France
Germany
Israel
The Netherlands

The HiDRaLoN project will research, develop and demonstrate new methods that will enable the performance of professional CMOS imagers to exceed that of current charge-coupled device (CCD) imagers. This will involve increasing the dynamic range of CMOS sensor technology and reducing the noise level in imager subsystems. HiDRaLoN provides a opportunity for Europe to take the lead in design, manufacture and application of CMOS imagers. This will make it possible to overcome the existing dominance of CCD imagers from Japan with ability of European manufacturers to supply professional CMOS imagers for a wide range of applications in healthcare, road safety, entertainment and industrial control.

European companies pioneered CCD imaging technology for applications in a wide range of home and professional equipment but have lost this market segment to Japan. It took 25 years for the CCD market to reach maturity but there is now an opportunity to move to a higher level with CMOS imagers.

CMOS imagers are often used in mobile phone cameras, camcorders and digital still video and vision cameras. Each application and market segment has its own unique requirements; controlling the design of this key component will lead to high-performance, professional imaging products.

The main aim in the CATRENE CA301 HiDRaLoN project is to develop technologies able to deliver high dynamic range and high resolution CMOS sensors generating low noise images with good colour fidelity. HiDRaLoN increases the dynamic range to 120 dB and lowers the noise level by at least 50% to make CMOS imagers surpass today's CCDs while maintaining best practices from CCD manufacturing.

Five new imagers are planned for 3D imaging, medical, broadcast and industrial machine-vision markets, together with algorithms to correct flaws in the imagers and optics. Demonstrators will focus on general purpose imaging, medical and broadcast applications.

Advanced recording

HiDRaLoN will improve the performance of advanced image recording/capturing systems such as medical X-ray detectors, broadcast and 3D time-of-flight cameras. Improved image quality allows extraction of more detailed information, especially in the medical field as a first step towards functional imaging. Here, not only is the anatomy or structure of the body detected but also the health of organs at tissue level.

In the next five to ten years, CMOS imagers are expected to take over from CCD in most high-end visual-imaging markets. This project will develop CMOS imagers that will exceed the performance of CCD imagers currently used in high-end applications. The change from CCD to CMOS opens up the possibility for European companies to play an important role again and to obtain a significant market share.

There was a distinct advantage to owning both the foundry and the process technology In CCD imager manufacture. CMOS imagers benefit from the fact that ownership of the foundry process and the imager design process have separated over time. This means independent design companies can acquire their own CMOS imager design knowledge without having to own a factory.

HiDRaLoN will focus on new chip and pixel architectures leading to tested prototypes of advanced imagers. The project will cover the whole imaging process in each application. It will research silicon process-related pixel design and modelling, low-noise analogue read-out including analogue-to-digital conversion and multiplexing, smart architectures and modelling of thermal, optical and electrical crosstalk as well as optics found in systems-level image enhancement.

Better pictures

Pixel sizes in mobile phones have already been reduced to 1.4 x 1.4 μm^2 but mainly as four-transistor pixel structures with pinned photo-diodes and a curtain shutter. For faster moving objects, a snapshot or global shutter is needed with a five-transistor pixel architecture.

Noise and high dynamic range performances have to be improved to get the best out of the imagers for applications where humans look at the pictures in entertainment markets and to ease life in applications where algorithms extract information from the picture, as these rely on valid and robust image data in bright and dark regions under variable lighting conditions.

Current sensors with limited dynamic range suffer from saturation or lose frames during the inherent adaptation time, so limiting reaction times to milliseconds.

The diffraction limit of lenses is just below 3 μm. This means that for smaller pixels no further sharpness can be obtained. Mobile phones use smaller pixels but their imagers have the advantage of the Bayer colour pattern on top of the imager. This means that a spot in the original image is projected onto a set of 2 x 2 pixels in the imager with a red-green colour pattern on the top two pixels and a green-blue colour pattern on the bottom two pixels.

As a result, in the CMOS imager of a mobile phone with a pixel size of 1.4 x 1.4 μm^2, the actual pixel size in the final picture on the output is 2.8 x 2.8 μm^2 and so on the edge of the diffraction limit.

Medical imaging

X-ray image intensifiers with attached video cameras have been used traditionally for real-time image sequences in healthcare. More recently, X-ray detectors combining scintillators and amorphous silicon passive pixel photodiode arrays have been introduced. The scintillator converts X-ray quanta into clusters of visible photons, which are converted into electron-hole pairs by the photodiode – so-called indirect conversion.

The main advantage of using these detectors is compactness and very good contrast-to-noise ratio, especially for higher dose images. When amorphous silicon arrays are replaced by CMOS pixel arrays, new applications become possible such as very high dynamic range imaging where all required detail is available in a single image.

Today's computer tomography (CT) systems use energy-integrating detectors to provide anatomic images with high spatial resolution. However, material separation is often difficult, especially if a contrast agent is involved that has an absorption behaviour similar to bone or calcification.

HiDRaLoN is investigating photon-counting based spectral CT (PC-SCT) which exploits the energy dependence of the attenuation of X-rays within the human body. This will make it possible to separate different materials in an object – such as contrast agent and calcified plaque in a vessel – much better. Using new so-called targeted contrast agents, such an approach is expected to enable detection of vulnerable plaques known to be precursors of a heart attack.

Global markets

The success of HiDRaLoN will benefit healthcare, entertainment, and road and industrial safety. It will provide important advantages such as higher efficiency, fewer errors in medical diagnosis, a change from treatment to prevention, enhanced visual experience for TV viewers from unprecedented image quality, an additional pair of 'automatic' eyes on the road, better vision in a dark environment and improved recognition capabilities as well as improved safety and flexibility of assembly lines to safeguard operators and machines. Moreover, the results will open up global markets for European manufacturers.

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CATRENE focuses on delivering nano-/microelectronic solutions that respond to the needs of society at large, improving the economic prosperity of Europe and reinforcing the ability of its industry to be at the forefront of the global competition.