Abstract

Imaging of ultra-fast, time-correlated, molecular processes in physics and the life-sciences is placing increased demands on camera technology. A new detection paradigm is necessary whereby a solid-state sensor array of pixels sensitive to a single photon is assembled. Pixels composed of detectors called Single Photon Avalanche Diodes (SPADs) will be integrated for the first time in an advanced, deep-submicron CMOS process. Large arrays of SPADs interfacing to networks of parallel digital processing units on the same chip will provide record levels of timing accuracy, sensitivity and speed.

The MEGAFRAME 128x128 pixel prototype will be capable of a sustained 1,000,000 frames per second with 50 picosec time uncertainty. This will re-establish European excellence in the field of ultra-high speed video capture. To access and process the extremely high data rates generated by the pixel array, novel system architectures must be developed. Another essential advance is a highly reproducible optical concentrator array to reclaim the fill-factor lost to pixel-level infrastructure.

The new imaging system will be evaluated using emerging time-correlated methods such as Fluorescence Lifetime Imaging Microscopy and Correlation Spectroscopy, Förster Resonance Energy Transfer, and Voltage-Sensitive Dye imaging. Resolutions and frame rates at least ten times higher than today's solutions will be achieved. Mechanisms such as calcium signalling will be monitored on single cells at 1microsec steps for the first time. Future advances in proteomics, systems biology and drug discovery are dependent on such improved understanding of intra-cellular processes.

Major contributions to multi-processing architecture, flow-control engineering and fast phenomena observation are also expected. The consortium is a unique combination of imaging technology innovators, a leading European semiconductor manufacturer and a diverse end-user community from the life-sciences, physics and chemistry.
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