SPADnet: Embedded Coincidence in a Smart Sensor Network for PET Applications

E. Charbon, C. Bruschini, C. Veerappan, D. Stoppa, N. Massari, M. Perenzoni, L. H. Braga, L. Gasparini, R. K. Henderson, R. Walker, S. East, L. Grant, B. Jatekos, E. Lorincz, F. Ujhelyi, G. Erdei, E. Gros d'Aillon, L. André, V. Reboud, L. Verger, P. Major, Z. Papp, and G. Nemeth

Medical diagnostics today takes advantage in great part of image sensing and reconstruction techniques. Early detection of several diseases – cancer, in particular – has benefitted from these techniques, thus contributing to save lives and to improve the quality of life of those affected. In this paper we present the first results from the SPADnet project (www.spadnet.eu) aimed at a new generation of large area image sensors, based on CMOS technology, that are networked to perform gamma-ray detection and coincidence to be used primarily in Positron Emission Tomography (PET).

SPADnet innovates in several areas of PET systems, from optical coupling to single-photon sensor architectures, from intelligent ring networks to reconstruction algorithms. In addition, SPADnet introduces the first computational model enabling to study the full chain from gamma photons to network coincidence detection through scintillation events, optical coupling, etc.

We have fabricated and tested the first version of the SPADnet photosensor, a fully digital CMOS SiPM with 8×16 pixels individually capable of photon time stamping and energy accumulation [1] . The sensor also provides a real-time output of the total detected energy at up to 100Msamples/s and on-chip discrimination of gamma events. These events can then be routed to the SPADnet ring network, operates at 2 Gbps providing real-time processing and coincidence determination; this architecture simplifies the construction of the overall system and allows the scaling of the system to larger arrays of detectors. This may result in better and faster image reconstruction. We show the first experimental results from the SPADnet sensor, along with the main project achievements in optimization of scintillation coupling, fill factor recovery through nano-imprinted optical concentrators, Gbps network, and reconstruction issues.

SPADnet will not only impact PET scalability but also performance robustness and cost; another advantage is the capability of being compatible with magnetic resonance imaging (MRI), thus prompting advances in multimodal imaging and medical diagnostics as a whole.

References

[1] L.H..C. Braga, L. Gasparini, L. Grant, R.K. Henderson, N. Massari, M. Perenzoni, D. Stoppa, R. Walker, "An 8×16-pixel 92kSPAD Time-Resolved Sensor with On-Pixel 64ps 12b TDC and 100MS/s Real-Time Energy Histogramming in 0.13µm CIS Technology for PET/MRI Applications", *IEEE International Solid-State Circuits Conference*, Feb. 2013.